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State of the Market Report for PJM

Monitoring Analytics, LLC

Independent
Market Monitor
for PJM

5.13.2021

2021

Preface

The PJM Market Monitoring Plan provides:

The Market Monitoring Unit shall prepare and submit contemporaneously to the Commission, the State Commissions, the PJM Board, PJM Management and to the PJM Members Committee, annual state-of-the-market reports on the state of competition within, and the efficiency of, the PJM Markets, and quarterly reports that update selected portions of the annual report and which may focus on certain topics of particular interest to the Market Monitoring Unit. The quarterly reports shall not be as extensive as the annual reports. In its annual, quarterly and other reports, the Market Monitoring Unit may make recommendations regarding any matter within its purview. The annual reports shall, and the quarterly reports may, address, among other things, the extent to which prices in the PJM Markets reflect competitive outcomes, the structural competitiveness of the PJM Markets, the effectiveness of bid mitigation rules, and the effectiveness of the PJM Markets in signaling infrastructure investment. These annual reports shall, and the quarterly reports may include recommendations as to whether changes to the Market Monitoring Unit or the Plan are required.¹

Accordingly, Monitoring Analytics, LLC, which serves as the Market Monitoring Unit (MMU) for PJM Interconnection, L.L.C. (PJM),² and is also known as the Independent Market Monitor for PJM (IMM), submits this *2021 Quarterly State of the Market Report for PJM: January through March*.³

¹ PJM Open Access Transmission Tariff (OATT) Attachment M (PJM Market Monitoring Plan) § VI.A. Capitalized terms used herein and not otherwise defined have the meaning provided in the OATT, PJM Operating Agreement, PJM Reliability Assurance Agreement (RAA), the Consolidated Transmission Owners Agreement (CTOA) or other tariffs that PJM has on file with the Federal Energy Regulatory Commission (FERC or Commission).

² OATT Attachment M.

³ All references to this report should refer to the source as Monitoring Analytics, LLC, and should include the complete name of the report: *2021 Quarterly State of the Market Report for PJM: January through March*.

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Introduction

Q1 2021 in Review

Reliability is a core goal of PJM. Maintaining and improving competitive markets should also be a core goal of PJM. The goal of competition in PJM is to provide customers reliable wholesale power at the lowest possible price, but no lower. The PJM markets have done that. The PJM markets work, even if not perfectly. The results of PJM markets were reliable in the first three months of 2021. The results of the energy market were competitive in the first three months of 2021. The results of the last base capacity auction, run in 2018 for 2021/2022, were not competitive, but the Commission is now addressing one of the underlying issues, the overstated offer cap in the capacity market. The PJM markets bring customers the benefits of competition. But the PJM markets, and wholesale power markets in the U.S., continue to face challenges that potentially threaten the viability of competitive wholesale power markets. The value of markets is under attack, from those who assert that energy prices are too low and from those who assert that markets are incompatible with decarbonization of the power sector. Organized, competitive wholesale power markets are the best way to facilitate the least cost path to decarbonization. Markets provide incentives for innovation and efficiency. Renewables can compete, without guaranteed long term contracts. Innovation will occur in renewable technologies in unpredictable and beneficial ways.

Energy, capacity and transmission charges are the three largest components of the total price per MWh of wholesale power, comprising 97.2 percent of the total price per MWh in the first three months of 2021. The cost of capacity has been a larger share of the total price per MWh of wholesale power than the cost of transmission service. But starting in the third quarter of 2019, for the first time since the start of the RPM capacity market design in 2007, the cost of transmission in the total price per MWh of wholesale power is greater than the cost of capacity. Nonetheless, the capacity market design continues to receive more attention.

There are two key changes to the PJM energy markets that could significantly increase energy market prices in ways not consistent with competitive markets.

Fast start pricing will create an inefficient wedge between the competitive price and the effective price if and when it is implemented. The MMU has recommended that PJM post both sets of prices prior to implementation so that market participants can understand and prepare for the impacts. The extended ORDC is a form of administrative pricing that will affect prices in a majority of hours and that will go into effect on June 1, 2022, unless the Commission changes its order. Under the rules for the extended ORDC, PJM energy market prices can exceed \$14,000 per MWh in emergency conditions. While appropriate shortage pricing is important, there is no demonstrated benefit of imposing extreme prices for either long term generation incentives to invest in reliable capacity or customer incentives to curtail usage during an emergency.

The Minimum Offer Price Rule (MOPR) has been a contentious issue in PJM markets. Both FERC and the states have significant and overlapping authority affecting wholesale power markets. While FERC's MOPR approach was designed to ensure that subsidies did not affect the wholesale power markets, the states have ultimate authority over the generation choices made in the states. Accommodation of the states' authority over generation is required, given the overlapping authorities of the Commission and the states.

With the expected elimination of the current MOPR rules, the capacity market design must accommodate the choices made by states to subsidize renewable or clean resources in a way that maximizes the role of competition, to ensure that customers pay the lowest amount possible, consistent with state goals and the costs of providing the desired resources. Such an approach can take several forms, but none require the dismantling of the PJM capacity market design. The PJM capacity market design can adapt to a wide range of state supported resources and state programs. As a simple starting point, states can continue to support selected resources using a range of payment structures and those resources could participate in the capacity auctions. As a broader and more comprehensive option, PJM could create a demand curve for clean resources based on the quantity of such resources identified by one or more states and clear a market for clean resources as part of the capacity market clearing process.

If PJM markets are going to continue to be sustainable, it is essential that the basic structure of the current capacity market remain, including the single definition of reliability for the PJM market, the incorporation of transmission constraints and locational supply and demand fundamentals, and a clear definition of capacity and the contribution of capacity to reliability. The basic structure of the capacity market also includes a must offer and a must buy requirement that are essential and have been demonstrated to be essential to limiting market power and operating a competitive market. The PJM Capacity Market has never been nor was it ever intended to be a residual market, as evidenced by the must buy and must sell provisions of the market rules. Reliability is only definable at the level of the entire PJM market, including locational differences based on transmission constraints. The market reflects the interactions across free flowing ties throughout the entire network. There are transmission constraints that prevent the lowest cost capacity from providing reliability in constrained areas. Locational prices reflect the combination of transmission constraints and local supply and demand conditions.

Purely bilateral markets are characterized by a lack of transparency, a corresponding asymmetry in access to information that favors market sellers, and the resultant ability of sellers to exercise market power. Transparent clearing markets are the best way to facilitate bilateral contracts.

It is also essential that the contribution of different types of capacity be calculated in a comparable manner. The contribution of one MW of solar or wind resources is not the same as the contribution of one MW of a gas fired combined cycle resource. Capacity must be defined in a homogeneous manner so that the clearing price is the same for all MW of capacity that provide the same contribution to reliability. Capacity should be offered and cleared in the capacity market only at a MW level that reflects its contribution to reliability. For most wind and solar resources that means a capacity value appropriately derated from the nameplate capability.

It is essential to get the derating factors or ELCC values right. PJM currently uses default derating factors by technology type with the option to use unit specific data. PJM's proposal to use calculated Effective Load Carrying

Capability (ELCC) as a replacement for the derating factors was badly flawed and was rejected by the Commission. Fixing the PJM approach to ELCC is a manageable task if there is a shared goal of letting markets reflect the actual, marginal contribution of all types of capacity to reliability without assumptions that arbitrarily favor some resource types.

Renewable energy was a relatively small share of PJM total energy and capacity in the first three months of 2021 but many renewable projects are under development. While renewables currently make up the majority of both projects and nameplate MW in the interconnection queue, historical completion rates and derating factors must be accounted for when evaluating the share of capacity resources that are likely to be contributed by renewables and by thermal resources. Of the 20,775.6 MW of combined cycle projects in the queue, 13,660.7 MW (65.8 percent) are expected to go in service based on historical completion rates as of March 31, 2021, providing both energy and capacity at that level. Of the 134,968.2 MW of renewable projects in the queue, only 18,847.6 MW (14.0 percent) are expected to go in service based on historical completion rates and be available to supply energy. Of those 18,847.6 MW, only 7,506.5 MW (5.6 percent of the total) are expected to be capacity resources, based on the average derate factors for wind and solar.

If more PJM states decide that carbon is a pollutant with a negative value, a market approach to carbon is preferred to an inefficient technology or unit specific subsidy approach or inconsistent RPS rules that in some cases subsidize carbon emitting resources. Delaware, Maryland and New Jersey were members of RGGI in 2020. Virginia joined RGGI on January 1, 2021. Pennsylvania is preparing to join RGGI, and Illinois is discussing a carbon price. Implementation of a carbon price is a market approach which would let market participants respond in efficient and innovative ways to the price signal rather than relying on planners to identify specific technologies or resources to be subsidized. Implementation of a carbon price using RGGI or a similar market mechanism by the states would mean that the states control the carbon price and that no FERC approval would be required and no PJM rule changes would be required. The carbon price would become part of the marginal costs of power plants and the impacts on production

and consumption decisions would be market based. States would control the resulting revenues. This is the case regardless of the number of PJM states that join RGGI or a similar market.

The MMU continues to recommend that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to all PJM states in order to permit states to consider the development of a multistate framework that could benefit all states: for REC market design; for potential agreement on carbon pricing; for potential agreement on the distribution of carbon pricing revenues; and for coordination with PJM wholesale markets.

One of the benefits of competitive power markets is that changes in input prices and changes in the balance of supply and demand are reflected immediately in energy prices. Energy prices increased significantly in the first three months of 2021, but remained almost 20 percent below the five year average for the first three months of 2015 through 2019. Energy prices were lower in 2020 than in any year since PJM markets were established in 1999. The load-weighted, average, real-time LMP was 55.3 percent higher in the first three months of 2021 than in the first three months of 2020, \$30.84 per MWh versus \$19.85 per MWh. Of the \$10.99 per MWh increase, 95.9 percent was a direct result of higher fuel costs. The primary contributor to the increase in energy prices was higher natural gas prices, especially in February. Load also rose due to colder winter weather and the economic recovery. PJM load increased by 4.9 percent compared to the first three months of 2020, and load increased by 2.2 percent even after controlling for the impact of weather.

As input prices change, markets react immediately. In 2020, coal fired generation was markedly less competitive with gas fired generation. Higher energy prices and higher gas costs made coal units more economic in the first three months of 2021. The share of total PJM energy produced from coal increased from 18.0 percent in the first three months of 2020 to 25.1 percent in the first three months of 2021 while the share of energy produced from natural gas decreased from 40.0 to 34.6 percent. Even with the reduction in the first three months of 2021, gas fired generation produces more energy than

any other source. The role of gas fired generation highlights the importance of ensuring that PJM has current, detailed and complete information on the gas supply arrangements of all generators and that PJM consider rules requiring capacity resources to have firm fuel supplies. It is also essential that FERC consider and address the implications of the inconsistencies between the gas pipeline business model and the power producer business model and the issue of market power in the gas commodity market under extreme weather conditions.

Net revenue is a key measure of overall market performance as well as a measure of the incentive to invest in new generation to serve PJM markets. Theoretical net revenues from the energy market increased for all unit types in the first three months of 2021 compared to the first three months of 2020. Theoretical net revenues increased by 55 percent for a new combustion turbine, 32 percent for a new combined cycle, 9,549 percent for a new coal unit, and 53 percent for a new nuclear plant.

The competitiveness of energy market prices cannot be taken for granted. Despite low average marginal unit markups in the first three months of 2021, 4.0 percent of marginal units set price with positive markups, in some cases over \$150 per MWh, despite failing the Three Pivotal Supplier (TPS) test in the real-time energy market. This was the result of documented flaws in the application of offer capping when units fail the TPS test. PJM also schedules and pays uplift to units that fail the TPS test without requiring that units use flexible operating parameters. In addition to the existing issues with market power mitigation, the definition of a competitive energy offer is now overstated through the inclusion of major maintenance costs which do not vary in the short run with energy output and are not short run marginal costs. Further, the use of and applicability of fuel cost policies have been undermined. Fuel cost policies ensure that the costs in generator offers are clearly defined and are verifiable and systematic. Fuel cost policies are essential to effective and accurate market power mitigation. Some generation owners prefer to not have clearly defined costs in order to exercise market power and in order to avoid taking responsibility for the accuracy of their offers.

The details of PJM markets matter. It is essential that PJM focus on getting the details right even when market participants do not agree. For example, PJM is in the process of addressing a significant price formation issue in the real time process for defining prices and the underlying process for dispatching the system (SCED/LPC). PJM has not implemented available improvements to combined cycle modeling and has postponed systematic improvements to combined cycle modeling. PJM continues to pay uplift to units that do not meet uplift eligibility requirements, including not following dispatch. PJM has left incorrect capital recovery factors (CRF) in the tariff resulting in overpayments to black start units and potential issues in the capacity market. PJM does not enforce the must offer rule requiring capacity resources to offer their full ICAP in the day-ahead energy market. PJM proposes to allow generators' use of real-time values (RTV) to avoid using their physical unit specific parameters required as part of the capacity performance incentives in the capacity market, undermining the market power protections to mitigate inflexible parameters that are currently in the PJM tariff.

The evolution of wholesale power markets is far from complete. The market design can be improved and made more efficient and more competitive. PJM and its market participants will need to continue to work constructively to refine the competitive market design and to ensure the continued effectiveness of PJM markets in providing customers wholesale power at the lowest possible price, but no lower.

PJM Market Summary Statistics

Table 1-1 shows selected summary statistics describing PJM markets.

Table 1-1 PJM market summary statistics: January through March, 2020 and 2021¹

	Jan-Mar 2020	Jan-Mar 2021	Percent Change
Average Hourly Load Plus Exports (MW)	90,093	95,236	5.7%
Average Hourly Generation Plus Imports (MW)	91,698	97,075	5.9%
Peak Load (MW)	116,761	114,457	(2.0%)
Installed Capacity at March 31 (MW)	185,189	183,779	(0.8%)
Load Weighted Average Real Time LMP (\$/MWh)	\$19.85	\$30.84	55.4%
Total Congestion Costs (\$ Million)	\$85.1	\$121.0	42.2%
Total Uplift Credits (\$ Million)	\$7.2	\$34.4	377.8%
Total PJM Billing (\$ Billion)	\$8.11	\$10.40	28.2%

PJM Market Background

The PJM Interconnection, L.L.C. (PJM) operates a centrally dispatched, competitive wholesale electric power market that, as of March 31, 2021, had installed generating capacity of 183,779 megawatts (MW) and 1,036 members including market buyers, sellers and traders of electricity in a region including more than 65 million people in all or parts of 13 states (Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia) and the District of Columbia (Figure 1-1).^{2 3 4}

As part of the market operator function, PJM coordinates and directs the operation of the transmission grid and plans transmission expansion improvements to maintain grid reliability in this region.

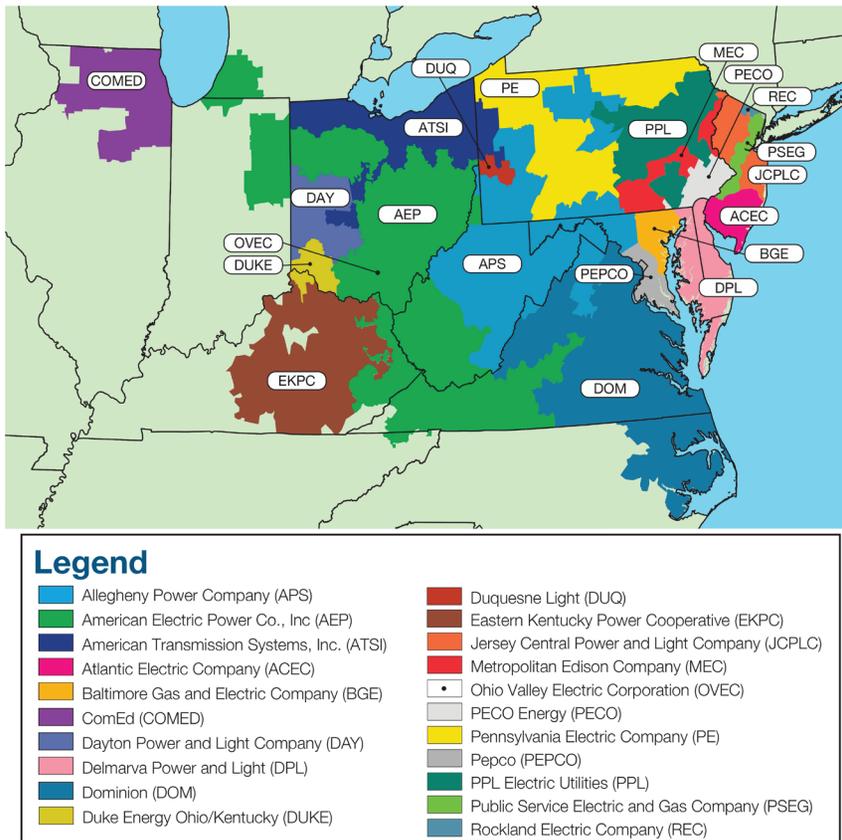
¹ In Table 1-1, Average Hourly Load includes load and exports, and Average Hourly Generation includes generation and imports. Versions of this table prior to the 2020 Quarterly State of the Market Report for PJM: January through June did not include exports or imports in these calculations.

² See PJM. "Member List," which can be accessed at: <<http://pjm.com/about-pjm/member-services/member-list.aspx>>.

³ See PJM. "Who We Are," which can be accessed at: <<http://pjm.com/about-pjm/who-we-are.aspx>>.

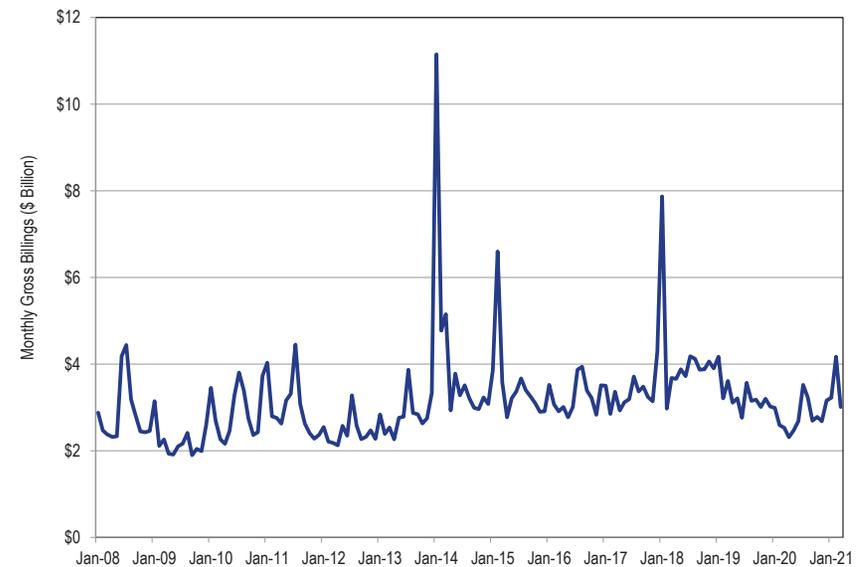
⁴ See the 2019 State of the Market Report for PJM, Volume II, Appendix A: "PJM Overview" for maps showing the PJM footprint and its evolution prior to 2020.

Figure 1-1 PJM's footprint and its 21 control zones



In the first three months of 2021, PJM had total billings of \$10.40 billion, an increase of 28.2 percent from \$8.11 billion in the first three months of 2020 (Figure 1-2).⁵

Figure 1-2 PJM reported monthly billings (\$ Billion): 2008 through March 2021



PJM operates the day-ahead energy market, the real-time energy market, the Reliability Pricing Model (RPM) capacity market, the regulation market, the synchronized reserve market, the day-ahead scheduling reserve (DASR) market and the financial transmission rights (FTRs) markets.

PJM introduced energy pricing with cost-based offers and market-clearing nodal prices on April 1, 1998, and market-clearing nodal prices with market-based offers on April 1, 1999. PJM introduced the Daily Capacity Market on January 1, 1999, and the Monthly and Multimonthly Capacity Markets for the January through May 1999 period. PJM implemented FTRs on May 1, 1999.

⁵ Monthly and year to date billing values are provided by PJM.

PJM implemented the day-ahead energy market and the regulation market on June 1, 2000. PJM modified the regulation market design and added a market in Synchronized Reserve on December 1, 2002. PJM introduced an Auction Revenue Rights (ARR) allocation process and an associated Annual FTR Auction effective June 1, 2003. PJM introduced the RPM capacity market effective June 1, 2007. PJM implemented the DASR market on June 1, 2008. PJM introduced the Capacity Performance capacity market design effective on August 10, 2015, with the Base Residual Auction for 2018/2019.^{6 7}

Conclusions

This report assesses the competitiveness of the markets managed by PJM in the first three months of 2021, including market structure, participant behavior and market performance. This report was prepared by and represents the analysis of the Independent Market Monitor for PJM, also referred to as the Market Monitoring Unit or MMU.

For each PJM market, the market structure is evaluated as competitive or not competitive, and participant behavior is evaluated as competitive or not competitive. Most important, the outcome of each market, market performance, is evaluated as competitive or not competitive.

The MMU also evaluates the market design for each market. The market design serves as the vehicle for translating participant behavior within the market structure into market performance. This report evaluates the effectiveness of the market design of each PJM market in providing market performance consistent with competitive results.

Market structure refers to the cost, demand, and ownership structure of the market. The three pivotal supplier (TPS) test is the most relevant measure of market structure because it accounts for the ownership of assets and the

⁶ See also the *2019 State of the Market Report for PJM*, Volume II, Appendix A: "PJM Overview."

⁷ Analysis of 2021 market results requires comparison to prior years. During calendar years 2004 and 2005, PJM conducted the phased integration of five control zones: ComEd, American Electric Power (AEP), The Dayton Power & Light Company (DAY), Duquesne Light Company (DUQ) and Dominion. In June 2011, PJM integrated the American Transmission Systems, Inc. (ATSI) Control Zone. In January 2012, PJM integrated the Duke Energy Ohio/Kentucky (DUKE) Control Zone. In June 2013, PJM integrated the Eastern Kentucky Power Cooperative (EKPC). In December 2018, PJM integrated the Ohio Valley Electric Corporation (OVEC). By convention, control zones bear the name of a large utility service provider working within their boundaries. The nomenclature applies to the geographic area, not to any single company. For additional information on the integrations, their timing and their impact on the footprint of the PJM service territory prior to 2020, see *2019 State of the Market Report for PJM*, Volume 2, Appendix A: "PJM Overview."

relationship among the pattern of ownership, the resource costs, and the market demand using actual market conditions with both temporal and geographic granularity. Market shares and the related Herfindahl-Hirschman Index (HHI) are also measures of market structure.

Participant behavior refers to the actions of individual market participants, also sometimes referred to as participant conduct.

Market performance refers to the outcomes of the market. Market performance results from the behavior of market participants within a market structure, mediated by market design.

Market design means the rules under which the entire relevant market operates, including the software that implements the market rules. Market rules include the definition of the product, the definition of short run marginal cost, rules governing offer behavior, market power mitigation rules, and the definition of demand. Market design is characterized as effective, mixed or flawed. An effective market design provides incentives for competitive behavior and permits competitive outcomes. A mixed market design has significant issues that constrain the potential for competitive behavior to result in competitive market outcomes, and does not have adequate rules to mitigate market power or incent competitive behavior. A flawed market design produces inefficient outcomes which cannot be corrected by competitive behavior.

Energy Market Conclusion

The Market Monitoring Unit (MMU) analyzed measures of market structure, participant conduct and market performance, including market size, concentration, pivotal suppliers, offer behavior, markup, and price. The MMU concludes that the PJM energy market results were competitive in the first three months of 2021.

Table 1-2 The energy market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Partially Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Effective

- The aggregate market structure was evaluated as partially competitive because the aggregate market power test based on pivotal suppliers indicates that the aggregate day-ahead market structure was not competitive on every day. The hourly HHI (Herfindahl-Hirschman Index) results indicate that the PJM aggregate energy market in the first three months of 2021 was unconcentrated by FERC HHI standards. Average HHI was 738 with a minimum of 607 and a maximum of 919 in the first three months of 2021. The peaking segment of supply was highly concentrated. The fact that the average HHI and the maximum hourly HHI are in the unconcentrated range does not mean that the aggregate market was competitive in all hours. As demonstrated for the day-ahead market, it is possible to have pivotal suppliers in the aggregate market even when the HHI level is not in the highly concentrated range. It is possible to have an exercise of market power even when the HHI level is not in the highly concentrated range. The number of pivotal suppliers in the energy market is a more precise measure of structural market power than the HHI. The HHI is not a definitive measure of structural market power.
- The local market structure was evaluated as not competitive due to the highly concentrated ownership of supply in local markets created by transmission constraints and local reliability issues. The results of the three pivotal supplier (TPS) test, used to test local market structure, indicate the existence of market power in local markets created by transmission constraints. The local market performance is competitive as a result of the application of the TPS test. While transmission constraints create the potential for the exercise of local market power, PJM's application of the three pivotal supplier test identified local market power and resulted in offer capping to force competitive offers, correcting for structural issues

created by local transmission constraints. There are, however, identified issues with the definition of cost-based offers and the application of market power mitigation to resources whose owners fail the TPS test that need to be addressed because unit owners can exercise market power even when they fail the TPS test.

- Participant behavior was evaluated as competitive because the analysis of markup shows that marginal units generally make offers at, or close to, their marginal costs in both the day-ahead and real-time energy markets, although the behavior of some participants both routinely and during periods of high demand represents economic withholding. The ownership of marginal units is concentrated. The markups of pivotal suppliers in the aggregate market and of many pivotal suppliers in local markets remain unmitigated due to the lack of aggregate market power mitigation and the flawed implementation of offer caps for resources that fail the TPS test. The markups of those participants affected LMP.
- Market performance was evaluated as competitive because market results in the energy market reflect the outcome of a competitive market, as PJM prices are set, on average, by marginal units operating at, or close to, their marginal costs in both day-ahead and real-time energy markets, although high markups for some marginal units did affect prices.
- Market design was evaluated as effective because the analysis shows that the PJM energy market resulted in competitive market outcomes. In general, PJM's energy market design provides incentives for competitive behavior and results in competitive outcomes. In local markets, where market power is an issue, the market design identifies market power and causes the market to provide competitive market outcomes in most cases although issues with the implementation of market power mitigation and development of cost-based offers remain. The role of UTCs in the day-ahead energy market continues to cause concerns. Market design implementation issues, including inaccuracies in modeling of the transmission system and of generator capabilities as well as inefficiencies in real-time dispatch and price formation, undermine market efficiency in the energy market.

PJM markets are designed to promote competitive outcomes derived from the interaction of supply and demand in each of the PJM markets. Market design itself is the primary means of achieving and promoting competitive outcomes in PJM markets. One of the MMU's core functions is to identify actual or potential market design flaws.⁸ The approach to market power mitigation in PJM has focused on market designs that promote competition (a structural basis for competitive outcomes) and on mitigating market power in instances where the market structure is not competitive and thus where market design alone cannot mitigate market power. FERC relies on effective market power mitigation when it approves market sellers to participate in the PJM market at market based rates.⁹ In the PJM energy market, market power mitigation occurs primarily in the case of local market power. When a transmission constraint creates the potential for local market power, PJM applies a structural test to determine if the local market is competitive, applies a behavioral test to determine if generator offers exceed competitive levels and applies a market performance test to determine if such generator offers would affect the market price.¹⁰ There are, however, identified issues with the application of market power mitigation to resources whose owners fail the TPS test that can result in the exercise of local market power even when market power mitigation rules are applied. These issues need to be addressed. Some units with market power have positive markups and some have inflexible parameters, which means that the cost-based offer was not used and that the process for offer capping units that fail the TPS test does not consistently result in competitive market outcomes in the presence of market power. There are issues related to the definition of gas costs includable in energy offers that need to be addressed. There are issues related to the level of maintenance expense includable in energy offers that need to be addressed. There are currently no market power mitigation rules in place that limit the ability to exercise market power when aggregate market conditions are tight and there are pivotal suppliers in the aggregate market. Aggregate market power needs to be addressed. Market design must reflect appropriate incentives for competitive behavior, the application of local market power

⁸ OATT Attachment M (PJM Market Monitoring Plan).

⁹ See *Refinements to Horizontal Market Power Analysis for Sellers in Certain Regional Transmission Organization and Independent System Operator Markets*, Order No. 861, 168 FERC ¶ 61,040 (July 18, 2019); *order on reh'g*, Order No. 861-A; 170 FERC ¶ 61,106 (2020).

¹⁰ The market performance test means that offer capping is not applied if the offer does not exceed the competitive level and therefore market power would not affect market performance.

mitigation needs to be fixed, the definition of a competitive offer needs to be fixed, and aggregate market power mitigation rules need to be developed. The importance of these issues is amplified by the rules permitting cost-based offers in excess of \$1,000 per MWh.

Capacity Market Conclusion

The Market Monitoring Unit (MMU) analyzed market structure, participant conduct and market performance in the PJM Capacity Market, including supply, demand, concentration ratios, pivotal suppliers, volumes, prices, outage rates and reliability.¹¹ The conclusions are a result of the MMU's evaluation of the last Base Residual Auction, for the 2021/2022 Delivery Year.

Table 1-3 The capacity market results were not competitive

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Not Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Not Competitive	
Market Performance	Not Competitive	Mixed

- The aggregate market structure was evaluated as not competitive. For almost all auctions held from 2007 to the present, the PJM region failed the three pivotal supplier test (TPS), which is conducted at the time of the auction.¹² Structural market power is endemic to the capacity market.
- The local market structure was evaluated as not competitive. For almost every auction held, all LDAs have failed the TPS test, which is conducted at the time of the auction.¹³
- Participant behavior was evaluated as not competitive in the 2021/2022 RPM Base Residual Auction. Market power mitigation measures were applied when the capacity market seller failed the market power test for the auction, the submitted sell offer exceeded the defined offer cap, and

¹¹ The values stated in this report for the RTO and LDAs refer to the aggregate level including all nested LDAs unless otherwise specified. For example, RTO values include the entire PJM market and all LDAs. Rest of RTO values are RTO values net of nested LDA values.

¹² In the 2008/2009 RPM Third Incremental Auction, 18 participants in the RTO market passed the TPS test. In the 2018/2019 RPM Second Incremental Auction, 35 participants in the RTO market passed the test.

¹³ In the 2012/2013 RPM Base Residual Auction, six participants included in the incremental supply of EMAAC passed the TPS test. In the 2014/2015 RPM Base Residual Auction, seven participants in the incremental supply in MAAC passed the TPS test. In the 2021/2022 RPM First Incremental Auction, two participants in the incremental supply in EMAAC passed the TPS test. In the 2021/2022 RPM Second Incremental Auction, two participants in the incremental supply in EMAAC passed the TPS test.

the submitted sell offer, absent mitigation, would increase the market clearing price. But the net CONE times B offer cap under the capacity performance design, in the absence of 30 performance assessment hours, exceeds the competitive level and should be reevaluated for each BRA. In the 2021/2022 RPM Base Residual Auction, some participants' offers were above the competitive level. The MMU recognizes that these market participants followed the capacity market rules by offering at less than the stated offer cap of Net CONE times B. But Net CONE times B is not a competitive offer when the expected number of performance assessment intervals is zero or a very small number and the nonperformance charge rate is defined as Net CONE/30. Under these circumstances, a competitive offer, under the logic defined in PJM's capacity performance filing, is net ACR. That is the way in which most market participants offered in this and prior capacity performance auctions.

- Market performance was evaluated as not competitive based on the 2021/2022 RPM Base Residual Auction. Although structural market power exists in the Capacity Market, a competitive outcome can result from the application of market power mitigation rules. The outcome of the 2021/2022 RPM Base Residual Auction was not competitive as a result of participant behavior which was not competitive, specifically offers which exceeded the competitive level.
- Market design was evaluated as mixed because while there are many positive features of the Reliability Pricing Model (RPM) design and the capacity performance modifications to RPM, there are several features of the RPM design which still threaten competitive outcomes. These include the definition of DR which permits inferior products to substitute for capacity, the replacement capacity issue, the definition of unit offer parameters, the inclusion of imports which are not substitutes for internal capacity resources, and the definition of the default offer cap.
- PJM did not run the 2022/2023 Base Residual Auction in May 2019, the 2023/2024 Base Residual Auction in May 2020, or the 2022/2023 First Incremental Auction in September 2020 because the capacity market design was found to be not just and reasonable by FERC and a final market design had not been approved.

Tier 2 Synchronized Reserve Market Conclusion

The MMU analyzed measures of market structure, conduct and performance for the PJM Synchronized Reserve Market for the first three months of 2021.

Table 1-4 The tier 2 synchronized reserve market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Regional Markets	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Mixed

- The tier 2 synchronized reserve market structure was evaluated as not competitive because of high levels of supplier concentration.
- Participant behavior was evaluated as competitive because the market rules require cost-based offers.
- Market performance was evaluated as competitive because the interaction of participant behavior with the market design results in competitive prices.
- Market design was evaluated as mixed. Market power mitigation rules result in competitive outcomes despite high levels of supplier concentration. However, tier 1 reserves are inappropriately compensated when the nonsynchronized reserve market clears with a nonzero price.

Day-Ahead Scheduling Reserve Market Conclusion

The MMU analyzed measures of market structure, conduct and performance for the PJM DASR Market for the first three months of 2021.

Table 1-5 The day-ahead scheduling reserve market results were competitive

Market Element	Evaluation	Market Design
Market Structure	Not Competitive	
Participant Behavior	Mixed	
Market Performance	Competitive	Mixed

- The DASR market would have failed a three pivotal supplier test in 18 hours in the first three months of 2021.

- Participant behavior was evaluated as mixed because while most offers were equal to marginal costs, a significant proportion of offers reflected economic withholding.
- Market performance was evaluated as competitive because there were adequate offers in every hour to satisfy the requirement and the clearing prices reflected those offers, although there is concern about offers above the competitive level affecting prices. The day-ahead scheduling reserve market clearing price was above \$0 in 34 hours in the first three months of 2021. In 90.0 percent of hours when the clearing price was above \$0, the clearing price was the offer price of the marginal unit. In the remaining 10.0 percent of hours, the price included lost opportunity cost.
- Market design was evaluated as mixed because the DASR product does not include performance obligations. Offers should be based on opportunity cost only, to ensure competitive outcomes and that market power cannot be exercised.

Regulation Market Conclusion

The MMU analyzed measures of market structure, conduct and performance for the PJM Regulation Market for the first three months of 2021.

Table 1-6 The regulation market results were not competitive

Market Element	Evaluation	Market Design
Market Structure	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Not Competitive	Flawed

- The regulation market structure was evaluated as not competitive because the PJM Regulation Market failed the three pivotal supplier (TPS) test in 89.1 percent of the hours in the first three months of 2021.
- Participant behavior in the PJM Regulation Market was evaluated as competitive in the first three months of 2021 because market power mitigation requires competitive offers when the three pivotal supplier test is failed, although the inclusion of a positive margin raises questions.

- Market performance was evaluated as not competitive, because all units are not paid the same price on an equivalent MW basis.
- Market design was evaluated as flawed. The market design has failed to correctly incorporate a consistent implementation of the marginal benefit factor in optimization, pricing and settlement. The market results continue to include the incorrect definition of opportunity cost. The result is significantly flawed market signals to existing and prospective suppliers of regulation.

FTR Auction Market Conclusion

The Market Monitoring Unit (MMU) analyzed measures of market structure, participant conduct and market performance, including market size, concentration, offer behavior, and price. The MMU concludes that the PJM FTR auction market results were partially competitive in the first three months of 2021.

Table 1-7 The FTR auction markets results were partially competitive

Market Element	Evaluation	Market Design
Market Structure	Competitive	
Participant Behavior	Partially Competitive	
Market Performance	Partially Competitive	Flawed

- Market structure was evaluated as competitive. The ownership of FTR obligations is unconcentrated for the individual years of the 2020/2023 Long Term FTR Auction, the 2020/2021 Annual FTR Auction and each period of the Monthly Balance of Planning Period Auctions. The ownership of FTR options is moderately or highly concentrated for every Monthly FTR Auction period and moderately concentrated for the 2020/2021 Annual FTR Auction. Ownership of FTRs is disproportionately (75.4 percent) by financial participants. The ownership of ARR is unconcentrated.
- Participant behavior was evaluated as partially competitive as a result of the behavior of GreenHat Energy, LLC. ARR holders who are the sellers of FTRs are not permitted to participate in the market clearing.

- Market performance was evaluated as partially competitive because of the flaws in the market design. Sellers, the ARR holders, cannot set a sale price. Buyers can reclaim some of their purchase price after the market clears if the product does not meet a profitability target. The market resulted in a substantial shortfall in congestion payments to load and significant and unsupportable disparities among zones in the share of congestion returned to load. FTR purchases by financial entities remain persistently profitable in part as a result of the flaws in the market design.
- Market design was evaluated as flawed because there are significant and fundamental flaws with the basic ARR/FTR design. The FTR auction market is not actually a market because the sellers have no independent role in the process. ARR holders cannot determine the price at which they are willing to sell rights to congestion revenue. Buyers have the ability to reclaim some of the price paid for FTRs after the market clears. The market design is not an efficient or effective way to ensure that the rights to all congestion revenues are assigned to load. The product sold to FTR buyers is incorrectly defined as target allocations rather than a share of congestion revenue. ARR holders' rights to congestion revenues are not correctly defined because the contract path based assignment of congestion rights is inadequate and incorrect. Ongoing PJM subjective intervention in the FTR market that affects market fundamentals is also an issue and a symptom of the fundamental flaws in the design. The product, the quantity of the product and the price of the product are all incorrectly defined.
- The fact that load is not able to define its willingness to sell FTRs or the prices at which it is willing to sell FTRs and the fact that sellers are required to return some of the cleared auction revenue to FTR buyers when FTR profits are not adequate, means that the FTR design does not actually function as a market and is evidence of basic flaws in the market design.

Role of MMU

FERC assigns three core functions to MMUs: reporting, monitoring and market design.¹⁴ These functions are interrelated and overlap. The PJM Market Monitoring Plan establishes these functions, providing that the MMU is responsible for monitoring: compliance with the PJM Market Rules; actual or potential design flaws in the PJM Market Rules; structural problems in the PJM Markets that may inhibit a robust and competitive market; the actual or potential exercise of market power or violation of the market rules by a Market Participant; PJM's implementation of the PJM Market Rules or operation of the PJM Markets; and such matters as are necessary to prepare reports.¹⁵

Reporting

The MMU performs its reporting function primarily by issuing and filing annual and quarterly state of the market reports; regular reports on market issues, such as RPM auction reports; reports responding to requests from regulators and other authorities; and ad hoc reports on specific topics. The state of the market reports provide a comprehensive analysis of market structure, participant conduct and market performance for the PJM markets. State of the market reports and other reports are intended to inform PJM, the PJM Board, FERC, other regulators, other authorities, market participants, stakeholders and the general public about how well PJM markets achieve the competitive outcomes necessary to realize the goals of regulation through competition, and how the markets can be improved.

The MMU presents reports directly to PJM stakeholders, PJM staff, FERC staff, state commission staff, state commissions, other regulatory agencies and the general public. Report presentations provide an opportunity for interested parties to ask questions, discuss issues, and provide feedback to the MMU.

¹⁴ 18 CFR § 35.28(g)(3)(ii); see also *Wholesale Competition in Regions with Organized Electric Markets*, Order No. 719, FERC Stats. & Regs. ¶31,281 (2008) ("Order No. 719"), *order on reh'g*, Order No. 719-A, FERC Stats. & Regs. ¶31,292 (2009), *reh'g denied*, Order No. 719-B, 129 FERC ¶ 61,252 (2009).

¹⁵ OATT Attachment M § IV; 18 CFR § 1c.2.

Monitoring

To perform its monitoring function, the MMU screens and monitors the conduct of Market Participants under the MMU's broad purview to monitor, investigate, evaluate and report on the PJM Markets.¹⁶ The MMU has direct, confidential access to FERC.¹⁷ The MMU may also refer matters to the attention of state commissions.¹⁸

The MMU monitors market behavior for violations of FERC Market Rules and PJM Market Rules, including the actual or potential exercise of market power.¹⁹ The MMU will investigate and refer "Market Violations," which refer to any of "a tariff violation, violation of a Commission-approved order, rule or regulation, market manipulation, or inappropriate dispatch that creates substantial concerns regarding unnecessary market inefficiencies..."^{20 21 22} The MMU also monitors PJM for compliance with the rules, in addition to market participants.²³

An important component of the monitoring function is the review of inputs to mitigation. The actual or potential exercise of market power is addressed in part through *ex ante* mitigation rules incorporated in PJM's market clearing software for the energy market, the capacity market and the regulation market. If a market participant fails the TPS test in any of these markets its offer is set

16 OATT Attachment M § IV.

17 OATT Attachment M § IV.K.3.

18 OATT Attachment M § IV.H.

19 OATT § I.1 ("FERC Market Rules" mean the market behavior rules and the prohibition against electric energy market manipulation codified by the Commission in its Rules and Regulations at 18 CFR §§ 1c.2 and 35.37, respectively; the Commission-approved PJM Market Rules and any related proscriptions or any successor rules that the Commission from time to time may issue, approve or otherwise establish... "PJM Market Rules" mean the rules, standards, procedures, and practices of the PJM Markets set forth in the PJM Tariff, the PJM Operating Agreement, the PJM Reliability Assurance Agreement, the PJM Consolidated Transmission Owners Agreement, the PJM Manuals, the PJM Regional Practices Document, the PJM-Midwest Independent Transmission System Operator Joint Operating Agreement or any other document setting forth market rules.")

20 FERC defines manipulation as engaging "in any act, practice, or course of business that operates or would operate as a fraud or deceit upon any entity." 18 CFR § 1c.2(a)(3). Manipulation may involve behavior that is consistent with the letter of the rules, but violates their spirit. An example is market behavior that is economically meaningless, such as equal and opposite transactions, which may entitle the transacting party to a benefit associated with volume. Unlike market power or rule violations, manipulation must be intentional. The MMU must build its case, including an inference of intent, on the basis of market data.

21 OATT § I.1.

22 The MMU has no prosecutorial or enforcement authority. The MMU notifies FERC when it identifies a significant market problem or market violation. OATT Attachment M § IV.I.1. If the problem or violation involves a market participant, the MMU discusses the matter with the participant(s) involved and analyzes relevant market data. If that investigation produces sufficient credible evidence of a violation, the MMU prepares a formal referral and thereafter undertakes additional investigation of the specific matter only at the direction of FERC staff. *Id.* If the problem involves an existing or proposed law, rule or practice that exposes PJM markets to the risk that market power or market manipulation could compromise the integrity of the markets, the MMU explains the issue, as appropriate, to FERC, state regulators, stakeholders or other authorities. The MMU may also initiate, participate as a party or provide information or testimony in regulatory or other proceedings.

23 OATT Attachment M § IV.C.

to the lower of its price-based or cost-based offer. This prevents the exercise of market power and ensures competitive pricing, provided that the cost-based offer accurately reflects short run marginal cost.

If cost-based offers do not accurately reflect short run marginal cost, the market power mitigation process does not ensure competitive pricing in PJM markets. The MMU evaluates the fuel cost policy for every unit as well as the other inputs to cost-based offers. PJM Manual 15 does not clearly or accurately describe the short run marginal cost of generation. Manual 15 should be replaced with a straightforward description of the components of cost offers based on short run marginal costs and the correct calculation of cost offers. The MMU evaluates every offer in each capacity market (RPM) auction using data submitted to the MMU through web-based data input systems developed by the MMU.²⁴

The MMU also reviews operational parameter limits included with unit offers, evaluates compliance with the requirement to offer into the energy and capacity markets, evaluates the economic basis for unit retirement requests and evaluates and compares offers in the day-ahead and real-time energy markets.^{25 26 27 28}

The MMU reviews offers and inputs in order to evaluate whether those offers raise market power concerns. Market participants, not the MMU, determine and take responsibility for offers that they submit and the market conduct that those offers represent. If the MMU has a concern about an offer, the MMU may raise that concern with FERC or other regulatory authorities. FERC and other regulators have enforcement and regulatory authority that they may exercise with respect to offers submitted by market participants. PJM also reviews offers, but it does so in order to determine whether offers comply with the PJM tariff and manuals. PJM, in its role as the market operator, may reject an offer that fails to comply with the market rules. The respective reviews performed by the MMU and PJM are separate and non-sequential.

24 OATT Attachment M-Appendix § II.E.

25 OATT Attachment M-Appendix § II.B.

26 OATT Attachment M-Appendix § II.C.

27 OATT Attachment M-Appendix § IV.

28 OATT Attachment M-Appendix § VII.

The PJM markets monitored by the MMU include market related procurement processes conducted by PJM, such as for Black Start resources included in the PJM system restoration plan.^{29 30}

The MMU also monitors transmission planning, interconnections and rules for vertical market power issues, and with the introduction of competitive transmission development policy in Order No. 1000, horizontal market power issues.³¹

Market Design

In order to perform its role in PJM market design, the MMU evaluates existing and proposed PJM Market Rules and the design of the PJM Markets.³² The MMU initiates and proposes changes to the design of such markets or the PJM Market Rules in stakeholder or regulatory proceedings.³³ In support of this function, the MMU engages in discussions with stakeholders, State Commissions, PJM Management, and the PJM Board; participates in PJM stakeholder meetings or working groups regarding market design matters; publishes proposals, reports or studies on such market design issues; and makes filings with the Commission on market design, market rules and market rule implementation issues, including complaints or petitions.³⁴ The MMU also recommends changes to the PJM Market Rules to the staff of the Commission's Office of Energy Market Regulation, State Commissions, and the PJM Board.³⁵ The MMU may provide in its annual, quarterly and other reports "recommendations regarding any matter within its purview."³⁶

New Recommendations

Consistent with its core function to "[e]valuate existing and proposed market rules, tariff provisions and market design elements and recommend proposed rule and tariff changes," the MMU recommends specific enhancements to existing market rules and implementation of new rules that are required for competitive results in PJM markets and for continued improvements in the functioning of PJM markets.³⁷

In this *2021 Quarterly State of the Market Report for PJM: January through March*, the MMU includes two new recommendations.

New Recommendation from Section 3, Energy Market

- The MMU recommends that PJM stop capping the system marginal price in RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh. (Priority: Medium. New recommendation. Status: Not adopted.)

New Recommendation from Section 10, Ancillary Services

- The MMU recommends that the \$12.00 margin adder be eliminated from the definition of the cost based regulation offer because it is a markup and not a cost. (Priority: Medium. New recommendation. Status: Not adopted.)

²⁹ OATT Attachment M-Appendix § II(p).

³⁰ OATT Attachment M-Appendix § III.

³¹ OA Schedule 6 § 1.5.

³² OATT Attachment M § IV.D.

³³ *Id.*

³⁴ *Id.*; see also, e.g., 171 FERC ¶ 61,039; 167 FERC ¶ 61,084 at PP 70-76, *reh'g denied*, 168 FERC ¶ 61,141.

³⁵ *Id.*

³⁶ OATT Attachment M § VI.A.

³⁷ 18 CFR § 35.28(g)(3)(ii)(A); see also OATT Attachment M § IV.D.

Total Price of Wholesale Power

The total price of wholesale power is the total price per MWh of wholesale electricity in PJM markets.³⁸ The total price is an average price. Prices vary by location and time period. The total price includes the price of energy, capacity, transmission service, ancillary services, and administrative fees, regulatory support fees and uplift charges billed through PJM systems. Table 1-8 shows the average price, by component, for the first three months of 2020 and 2021.

The total billing values shown in Table 1-8 are the total price per MWh, by category, multiplied by the total load. This total is different from the total billing that PJM reports as shown in Figure 1-2. PJM's reported total billing represents the total dollars that pass through the PJM settlement process. There are issues with the PJM total billing calculations. The PJM total billing calculation includes all billing line item charges including monthly billing adjustments for the month in which PJM makes the adjustment rather than the month to which the adjustment applies. Rather than adding positive and negative spot market and congestion charges, PJM calculates the average of the absolute value of the positive and negative charges. PJM also makes adjustments to eliminate certain transmission owners' network charges and monthly bilateral corrections.

Each of the components in Table 1-8 is defined in PJM's Open Access Transmission Tariff (OATT) and PJM Operating Agreement and each is collected through PJM's billing system.

Components of Total Price

- The Energy component is the real-time, load weighted, average PJM locational marginal price (LMP).
- The Capacity component is the average price per MWh of Reliability Pricing Model (RPM) payments.

³⁸ Accounting load is used in the calculation of total price because accounting load is the load customers pay for in PJM settlements. The use of accounting load with losses before June 1, and without losses after June 1, 2007, is consistent with PJM's calculation of LMP. Before June 1, 2007, transmission losses were included in accounting load. After June 1, 2007, transmission losses were excluded from accounting load and losses were addressed through the incorporation of marginal loss pricing in LMP.

- The Transmission Service Charges component is the average price per MWh of network integration charges, and firm and nonfirm point to point transmission service.³⁹
- The Energy Uplift (Operating Reserves) component is the average price per MWh of day-ahead and balancing operating reserves and synchronous condensing charges.⁴⁰
- The Reactive component is the average cost per MWh of reactive supply and voltage control from generation and other sources.⁴¹
- The Regulation component is the average cost per MWh of regulation procured through the PJM Regulation Market.⁴²
- The PJM Administrative Fees component is the average cost per MWh of PJM's monthly expenses for a number of administrative services, including Advanced Control Center (AC²) and OATT Schedule 9 funding of FERC, OPSI, CAPS and the MMU.
- The Transmission Enhancement Cost Recovery component is the average cost per MWh of PJM billed (and not otherwise collected through utility rates) costs for transmission upgrades and projects, including annual recovery for the TrAIL and PATH projects.⁴³
- The Capacity (FRR) component is the average cost per MWh under the Fixed Resource Requirement (FRR) Alternative for an eligible LSE to satisfy its Unforced Capacity obligation.⁴⁴
- The Emergency Load Response component is the average cost per MWh of the PJM Emergency Load Response Program.⁴⁵
- The Day-Ahead Scheduling Reserve component is the average cost per MWh of Day-Ahead scheduling reserves procured through the day-ahead scheduling reserve market.⁴⁶

³⁹ OATT §§ 13.7, 14.5, 27A & 34.

⁴⁰ OA Schedules 1 §§ 3.2.3 & 3.3.3.

⁴¹ OATT Schedule 2 and OA Schedule 1 § 3.2.3B. The line item in Table 1-8 includes all reactive services charges.

⁴² OA Schedules 1 §§ 3.2.2, 3.2.2A, 3.3.2, & 3.3.2A; OATT Schedule 3.

⁴³ OATT Schedule 12.

⁴⁴ RAA Schedule 8.1.

⁴⁵ OATT PJM Emergency Load Response Program.

⁴⁶ OA Schedules 1 §§ 3.2.3A.01 & OATT Schedule 6.

- The Transmission Owner (Schedule 1A) component is the average cost per MWh of transmission owner scheduling, system control and dispatch services charged to transmission customers.⁴⁷
- The Synchronized Reserve component is the average cost per MWh of synchronized reserve procured through the Synchronized Reserve Market.⁴⁸
- The Black Start component is the average cost per MWh of black start service.⁴⁹
- The RTO Startup and Expansion component is the average cost per MWh of charges to recover AEP, ComEd and DAY's integration expenses.⁵⁰
- The NERC/RFC component is the average cost per MWh of NERC and RFC charges, plus any reconciliation charges.⁵¹
- The Economic Load Response component is the average cost per MWh of day-ahead and real-time economic load response program charges to LSEs.⁵²
- The Transmission Facility Charges component is the average cost per MWh of Ramapo Phase Angle Regulators charges allocated to PJM Mid-Atlantic transmission owners.⁵³
- The nonsynchronized reserve component is the average cost per MWh of non-synchronized reserve procured through the Non-Synchronized Reserve Market.⁵⁴
- The Emergency Energy component is the average cost per MWh of emergency energy.⁵⁵

47 OATT Schedule 1A.

48 OA Schedule 1 § 3.2.3A.01; PJM OATT Schedule 6.

49 OATT Schedule 6A. The line item in Table 1-8 includes all Energy Uplift (Operating Reserves) charges for Black Start.

50 OATT Attachments H-13, H-14 and H-15 and Schedule 13.

51 OATT Schedule 10-NERC and OATT Schedule 10-RFC.

52 OA Schedule 1 § 3.6.

53 OA Schedule 1 § 5.3b.

54 OA Schedule 1 § 3.2.3A.001.

55 OA Schedule 1 § 3.2.6.

Table 1-8 shows that energy, capacity and transmission charges are the three largest components of the total price per MWh of wholesale power, comprising 97.2 percent of the total price per MWh in the first three months of 2021. The cost of capacity has been a larger share of the total price per MWh of wholesale power than the cost of transmission service. Starting in the third quarter of 2019, for the first time since the start of the PJM RPM Capacity Market in 2007, the cost of transmission in the total price per MWh of wholesale power is greater than the cost of capacity.

Table 1-8 Total price per MWh by category: January through March, 2020 and 2021^{56 57 58 59}

Category	Jan - Mar 2020 \$/MWh	Jan - Mar 2020 (\$ Millions)	Jan - Mar 2020 Percent of Total	Jan - Mar 2021 \$/MWh	Jan - Mar 2021 (\$ Millions)	Jan - Mar 2021 Percent of Total	Percent Change
Load Weighted Energy	\$19.85	\$3,710	47.0%	\$30.84	\$5,985	57.6%	55.3%
Capacity	\$9.32	\$1,742	22.1%	\$8.91	\$1,730	16.7%	(4.4%)
Capacity	\$9.32	\$1,742	22.1%	\$8.91	\$1,730	16.7%	(4.4%)
Capacity (FRR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Capacity (RMR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Transmission	\$11.87	\$2,217	28.1%	\$12.27	\$2,381	22.9%	3.4%
Transmission Service Charges	\$11.20	\$2,094	26.5%	\$11.56	\$2,244	21.6%	3.2%
Transmission Enhancement Cost Recovery	\$0.57	\$107	1.4%	\$0.62	\$120	1.2%	7.7%
Transmission Owner (Schedule 1A)	\$0.09	\$17	0.2%	\$0.09	\$18	0.2%	2.9%
Transmission Seams Elimination Cost Assignment (SECA)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Transmission Facility Charges	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Ancillary	\$0.65	\$121	1.5%	\$0.74	\$144	1.4%	14.1%
Reactive	\$0.47	\$87	1.1%	\$0.48	\$94	0.9%	3.5%
Regulation	\$0.08	\$16	0.2%	\$0.13	\$24	0.2%	49.6%
Black Start	\$0.09	\$16	0.2%	\$0.09	\$17	0.2%	0.7%
Synchronized Reserves	\$0.01	\$2	0.0%	\$0.04	\$9	0.1%	278.8%
Non-Synchronized Reserves	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Day Ahead Scheduling Reserve (DASR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Administration	\$0.50	\$94	1.2%	\$0.59	\$114	1.1%	16.8%
PJM Administrative Fees	\$0.46	\$87	1.1%	\$0.55	\$107	1.0%	18.5%
NERC/RFC	\$0.03	\$6	0.1%	\$0.04	\$7	0.1%	4.1%
RTO Startup and Expansion	\$0.00	\$1	0.0%	\$0.00	\$0	0.0%	(100.0%)
Energy Uplift (Operating Reserves)	\$0.04	\$7	0.1%	\$0.17	\$34	0.3%	359.6%
Demand Response	\$0.00	\$1	0.0%	\$0.00	\$0	0.0%	(78.6%)
Load Response	\$0.00	\$1	0.0%	\$0.00	\$0	0.0%	(78.6%)
Emergency Load Response	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Emergency Energy	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Total Price	\$42.23	\$7,892	100.0%	\$53.53	\$10,388	100.0%	26.7%
Total Load (GWh)	186,881			194,067			3.8%
Total Billing (\$ Billions)	\$7.89			\$10.39			31.6%

⁵⁶ Note: The totals in this table include after the fact billing adjustments and may not match totals presented in past reports.

⁵⁷ The total billing in this table does not match the PJM reported total billing due to differences in calculation methods. For example, PJM accounts for all adjustments in the month billed, whereas the totals presented in these tables account for those adjustments in the month for which the adjustment was applied.

⁵⁸ The total prices in this table are load weighted average system prices per MWh by category, even if each category is not charged on a per MWh basis.

⁵⁹ The MMU publishes monthly detail of these components of PJM price. See <http://www.monitoringanalytics.com/data/pjm_price.shtml>.

Table 1-9 shows the inflation adjusted average price, by component, for the first three months of 2020 and 2021. To obtain the inflation adjusted average prices, the individual components' prices are deflated using the US Consumer Price Index for all items, Urban Consumers (with a base period of January 1998).⁶⁰

Table 1-9 Inflation adjusted total price per MWh by category: January through March, 2020 and 2021⁶¹

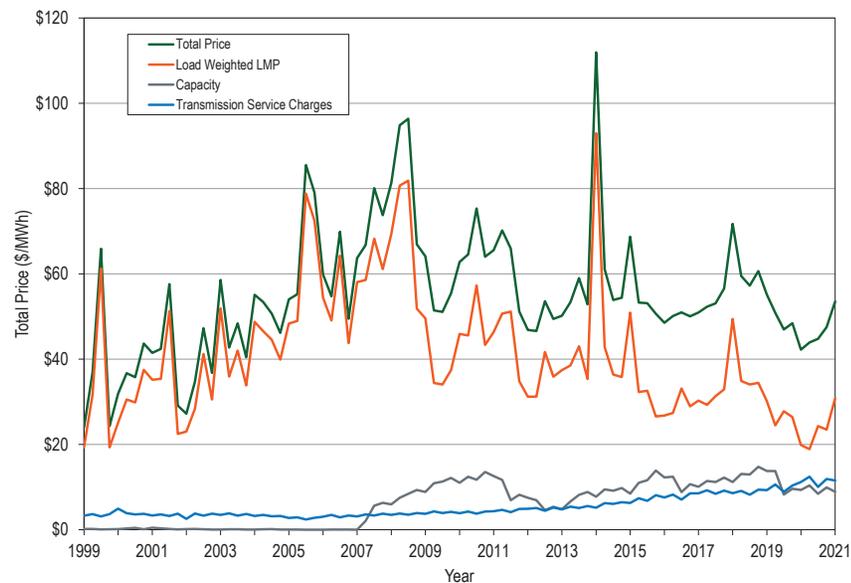
Category	Jan-Mar 2020 \$/MWh	Jan-Mar 2020 (\$ Millions)	Jan-Mar 2020 Percent of Total	Jan-Mar 2021 \$/MWh	Jan-Mar 2021 (\$ Millions)	Jan-Mar 2021 Percent of Total	Percent Change
Load Weighted Energy	\$12.42	\$2,322	47.0%	\$18.94	\$3,676	57.6%	52.5%
Capacity	\$5.83	\$1,090	22.1%	\$5.47	\$1,062	16.7%	(6.2%)
Capacity	\$5.83	\$1,090	22.1%	\$5.47	\$1,062	16.7%	(6.2%)
Capacity (FRR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Capacity (RMR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Transmission	\$7.42	\$1,388	28.1%	\$7.54	\$1,462	22.9%	1.5%
Transmission Service Charges	\$7.01	\$1,310	26.5%	\$7.10	\$1,378	21.6%	1.3%
Transmission Enhancement Cost Recovery	\$0.36	\$67	1.4%	\$0.38	\$73	1.2%	5.7%
Transmission Owner (Schedule 1A)	\$0.06	\$10	0.2%	\$0.06	\$11	0.2%	0.9%
Transmission Seams Elimination Cost Assignment (SECA)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Transmission Facility Charges	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Ancillary	\$0.41	\$76	1.5%	\$0.46	\$88	1.4%	12.0%
Reactive	\$0.29	\$55	1.1%	\$0.30	\$58	0.9%	1.5%
Regulation	\$0.05	\$10	0.2%	\$0.08	\$15	0.2%	46.9%
Black Start	\$0.05	\$10	0.2%	\$0.05	\$10	0.2%	(1.1%)
Synchronized Reserves	\$0.01	\$1	0.0%	\$0.03	\$5	0.1%	270.3%
Non-Synchronized Reserves	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Day Ahead Scheduling Reserve (DASR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Administration	\$0.31	\$59	1.2%	\$0.36	\$70	1.1%	14.6%
PJM Administrative Fees	\$0.29	\$54	1.1%	\$0.34	\$66	1.0%	16.3%
NERC/RFC	\$0.02	\$4	0.1%	\$0.02	\$4	0.1%	2.3%
RTO Startup and Expansion	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	(100.0%)
Energy Uplift (Operating Reserves)	\$0.02	\$4	0.1%	\$0.11	\$21	0.3%	351.1%
Demand Response	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	(83.3%)
Load Response	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	(83.3%)
Emergency Load Response	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Emergency Energy	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Total Price	\$26.43	\$4,939	100.0%	\$32.88	\$6,380	100.0%	24.4%
Total Load (GWh)	186,881			194,067			3.8%
Total Billing (\$ Billions)	\$4.94			\$6.38			29.2%

⁶⁰ US Consumer Price Index for all items, Urban Consumers (base period: January 1998), published by *Bureau of Labor Statistics*. <<http://download.bls.gov/pub/time.series/cu/cu.data.1.AllItems>> (April 13, 2021).

⁶¹ Note: The totals in this table include after the fact billing adjustments and may not match totals presented in past reports.

Figure 1-3 shows the contributions of load-weighted energy, capacity and transmission service charges to the total price of wholesale power for each quarter since 1999.

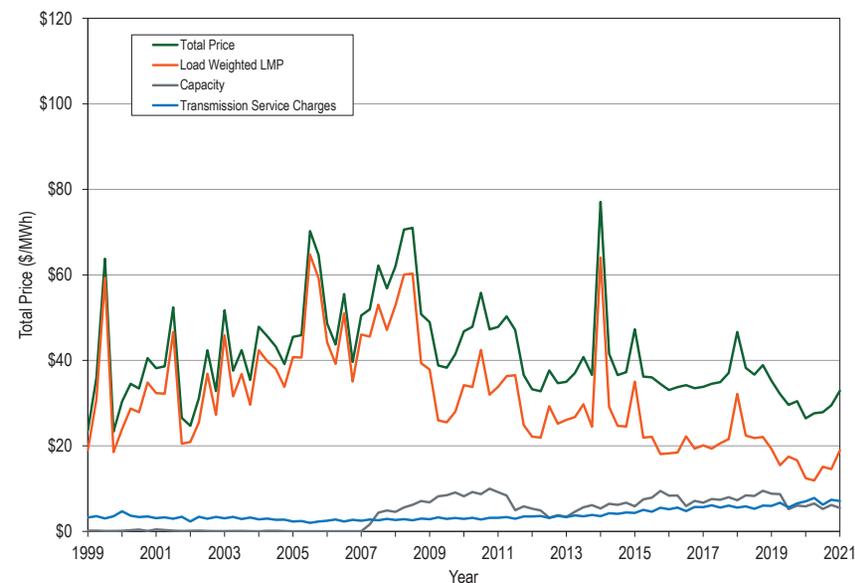
Figure 1-3 Top three components of quarterly total price (\$/MWh): January 1999 through March 2021⁶²



62 Note: The totals presented in this figure include after the fact billing adjustments and may not match totals presented in past reports.

Figure 1-4 shows the inflation adjusted contributions of load-weighted energy, capacity and transmission service charges to the total price of wholesale power for each quarter since 1999.⁶³

Figure 1-4 Inflation adjusted top three components of quarterly total price (\$/MWh): January 1999 through March 2021⁶⁴

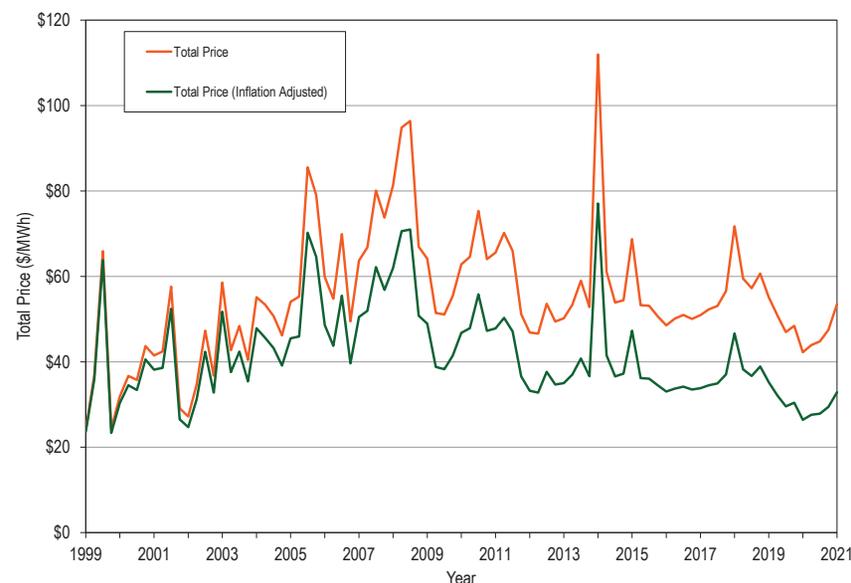


63 US Consumer Price Index for all items, Urban Consumers (base period: January 1998), published by Bureau of Labor Statistics. <<http://download.bls.gov/pub/time.series/cu/cu.data.1.AllItems>> (April 13, 2021).

64 Note: The totals presented in this figure include after the fact billing adjustments and may not match totals presented in past reports.

Figure 1-5 shows the total price of wholesale power and the inflation adjusted total price of wholesale power for each quarter since 1999.⁶⁵

Figure 1-5 Quarterly total price and quarterly inflation adjusted total price (\$/MWh): January 1999 through March 2021⁶⁶



⁶⁵ US Consumer Price Index for all items, Urban Consumers (base period: January 1998), published by Bureau of Labor Statistics. <<http://download.bls.gov/pub/time.series/cu/cu.data.1.AllItems>> (April 13, 2021).

⁶⁶ Note: The totals presented in this figure include after the fact billing adjustments and may not match totals presented in past reports.

Section Overviews

Overview: Section 3, Energy Market

Supply and Demand

Market Structure

- **Supply.** The average hourly day-ahead supply was 170,016 MW for the 2019/2020 winter, and 167,982 MW for the 2020/2021 winter. The average onpeak hourly offered real-time supply was 140,120 MW for the 2019/2020 winter, and 144,457 MW for the 2020/2021 winter. In the first three months of 2021, 703.2 MW of new resources were added in the energy market, and 430.4 MW of resources were retired.
- PJM average hourly real-time cleared generation in the first three months of 2021 increased by 5.9 percent from the first three months of 2020, from 90,675 MWh to 96,005 MWh.
- PJM average hourly day-ahead demand in the first three months of 2021, including DECs and up to congestion transactions, decreased by 5.3 percent from the first three months of 2020, from 108,144 MWh to 102,372 MWh.
- **Demand.** The PJM system real-time hourly peak load in the first three months of 2021 was 114,457 MWh in the HE 0900 on January 29, 2021, which was 2,303 MWh, 2.0 percent, lower than the PJM peak load in the first three months of 2020, which was 116,761 MWh in the HE 0800 on January 22, 2020.
- The PJM system real-time hourly peak load plus exports in the first three months of 2021 was 126,546 MWh in the HE 0900 on February 17, 2021. There were 113,294 MWh load in PJM and 13,252 MWh of exports.
- PJM average hourly real-time load in the first three months of 2021 increased by 5.0 percent from the first three months of 2020, from 85,608 MWh to 89,887 MWh.
- PJM average hourly day-ahead demand in the first three months of 2021, including load, DECs and up to congestion transactions, decreased by

5.3 percent from the first three months of 2020, from 108,144 MWh to 102,372 MWh.

Market Behavior

- **Generator Offers.** In the day-ahead market in the first three months of 2021, 22.4 percent of offered MW were must run, 31.1 percent were the economic minimum MW of dispatchable units, 45.6 percent were offered as dispatchable MW, and 0.8 percent were offered as emergency maximum MW.
- **Virtual Offers and Bids.** Any market participant in the PJM Day-Ahead Energy Market can use increment offers, decrement bids, up to congestion transactions, import transactions and export transactions as financial instruments that do not require physical generation or load. The hourly average submitted increment offer MW decreased by 11.1 percent and cleared MW decreased by 6.6 percent in the first three months of 2021 compared to the first three months of 2020. The hourly average submitted decrement offer MW increased by 56.4 percent and cleared MW increased by 53.1 percent in the first three months of 2021 compared to the first three months of 2020. The hourly average submitted up to congestion bid MW decreased by 44.2 percent and cleared MW decreased by 55.2 percent in the first three months of 2021 compared to the first three months of 2020.

Market Performance

- **Generation Fuel Mix.** In the first three months of 2021, coal units provided 25.1 percent, nuclear units 32.7 percent and natural gas units 34.4 percent of total generation. Compared to the first three months of 2020, generation from coal units increased 45.6 percent, generation from natural gas units decreased 9.4 percent and generation from nuclear units decreased 1.0 percent. The shares of coal and natural gas returned to 2019 levels.
- **Fuel Diversity.** The fuel diversity of energy generation for the first three months of 2021, measured by the fuel diversity index for energy (FDI_e), increased 3.2 percent compared to the first three months of 2020.

- **Marginal Resources.** In the PJM Real-Time Energy Market in the first three months of 2021, coal units were 18.0 percent and natural gas units were 69.4 percent of marginal resources. In the first three months of 2020, coal units were 17.5 percent and natural gas units were 73.4 percent of marginal resources.

In the PJM Day-Ahead Energy Market in the first three months of 2021, up to congestion transactions were 37.7 percent, INCs were 16.7 percent, DECAs were 24.8 percent, and generation resources were 20.5 percent of marginal resources. In the first three months of 2020, up to congestion transactions were 48.5 percent, INCs were 16.2 percent, DECAs were 12.6 percent, and generation resources were 22.5 percent of marginal resources.

- **Prices.** PJM load-weighted, average, real-time LMP in the first three months of 2021 increased 55.3 percent from the first three months of 2020, from \$19.85 per MWh to \$30.84 per MWh, a similar level to the first three months of 2019.

PJM load-weighted, average day-ahead LMP in the first three months of 2021 increased 57.0 percent from the first three months of 2020, from \$20.12 per MWh to \$31.58 per MWh.

- **Components of LMP.** In the PJM Real-Time Energy Market in the first three months of 2021, 14.0 percent of the load-weighted LMP was the result of coal costs, 56.0 percent was the result of gas costs and 2.8 percent was the result of the cost of emission allowances.

In the PJM Day-Ahead Energy Market, in the first three months of 2021, 33.4 percent of the load-weighted LMP was the result of gas costs, 24.4 percent was the result of DEC bids, 14.0 percent was the result of coal costs, 11.2 percent was the result of INC offers, -0.2 percent was the result of markup, and 1.5 percent was the result of up to congestion transaction offers.

- **Price Convergence.** Hourly and daily price differences between the day-ahead and real-time energy markets fluctuate continuously and substantially from positive to negative. The difference between average day-ahead and real-time prices was -\$0.50 per MWh in the first three months of 2021, and -\$0.24 per MWh in the first three months of 2020.

The difference between average day-ahead and real-time prices, by itself, is not a measure of the competitiveness or effectiveness of the day-ahead energy market.

Scarcity

- There were four intervals with five minute shortage pricing in the first three months of 2021. There were no emergency actions that resulted in Performance Assessment Intervals in the first three months of 2021.
- There were 420 five minute intervals, or 1.6 percent of all five minute intervals in the first three months of 2021 for which at least one RT SCED solution showed a shortage of reserves, and 96 five minute intervals, or 0.4 percent of all five minute intervals in the first three months of 2021 for which more than one RT SCED solution showed a shortage of reserves. PJM triggered shortage pricing for four five minute intervals.

Competitive Assessment

Market Structure

- **Aggregate Pivotal Suppliers.** The PJM energy market, at times, requires generation from pivotal suppliers to meet load, resulting in aggregate market power even when the HHI level indicates that the aggregate market is unconcentrated.
- **Local Market Power.** In the first three months of 2021, 12 control zones experienced congestion resulting from one or more constraints binding for 25 or more hours. For six out of the top 10 congested facilities (by real-time binding hours) in the first three months of 2021, the average number of suppliers providing constraint relief was three or less. There is a high level of concentration within the local markets for providing relief to the most congested facilities in the PJM Real-Time Energy Market. The local market structure is not competitive.

Market Behavior

- **Offer Capping for Local Market Power.** PJM offer caps units when the local market structure is noncompetitive. Offer capping is an effective

means of addressing local market power when the rules are designed and implemented properly. Offer capping levels have historically been low in PJM. In the day-ahead energy market, for units committed to provide energy for local constraint relief, offer-capped unit hours increased from 0.8 percent in the first three months of 2020 to 0.9 percent in the first three months of 2021. In the real-time energy market, for units committed to provide energy for local constraint relief, offer-capped unit hours increased from 0.7 percent in the first three months of 2020 to 1.2 percent in the first three months of 2021. While overall offer capping levels have been low, there are a significant number of units with persistent structural local market power that would have a significant impact on prices in the absence of local market power mitigation.

The analysis of the application of the TPS test to local markets demonstrates that it is working to identify pivotal owners when the market structure is noncompetitive and to ensure that owners are not subject to offer capping when the market structure is competitive. There are, however, identified issues with the application of market power mitigation to resources whose owners fail the TPS test that can result in the exercise of local market power. These issues need to be addressed.

- **Offer Capping for Reliability.** PJM also offer caps units that are committed for reliability reasons, including for reactive support. In the day-ahead energy market, for units committed for reliability reasons, offer-capped unit hours increased from 0.00 percent in the first three months of 2020 to 0.03 percent in the first three months of 2021. In the real-time energy market, for units committed for reliability reasons, offer-capped unit hours increased from 0.00 percent in the first three months of 2020 to 0.03 percent in the first three months of 2021. The low offer cap percentages do not mean that units manually committed for reliability reasons do not have market power. All units manually committed for reliability have market power and all are treated as if they had market power. These units are not capped to their cost-based offers because they tend to offer with a negative markup in their price-based offers, particularly at the economic minimum level, which means that PJM's offer capping process results in the use of the price-based offer for commitment.

- **Frequently Mitigated Units (FMU) and Associated Units (AU).** One unit qualified for an FMU adder for the months of September and October, 2019. In 2020, five units qualified for an FMU adder in at least one month. In the first three months of 2021, one unit qualified for an FMU adder in January.
- **Markup Index.** The markup index is a summary measure of participant offer behavior for individual marginal units. While the average markup index in the real-time market was -0.2 in the first three months of 2021, some marginal units did have substantial markups. The highest markup for any marginal unit in the real-time market in the first three months of 2021 was more than \$200 per MWh when using unadjusted cost-based offers.

While the average markup index in the day-ahead market was 0.03 in the first three months of 2021, some marginal units did have substantial markups. The highest markup for any marginal unit in the day-ahead market in the first three months of 2021 was more than \$80 per MWh when using unadjusted cost-based offers.

- **Markup.** The markup frequency distributions show that a significant proportion of units make price-based offers less than the cost-based offers permitted under the PJM market rules. This behavior means that competitive price-based offers reveal actual unit marginal costs and that PJM market rules permit the inclusion of costs in cost-based offers that are not short run marginal costs.

The markup behavior shown in the markup frequency distributions also shows that a substantial number of units were offered with high markups, consistent with the exercise of market power. Markup for coal and gas fired units decreased in the first three months of 2021.

Market Performance

- **Markup.** The markup conduct of individual owners and units has an identifiable impact on market prices. Markup is a key indicator of the competitiveness of the energy market.

In the PJM Real-Time Energy Market in the first three months of 2021, the unadjusted markup component of LMP was -\$0.33 per MWh or 1.1 percent of the PJM load-weighted, average LMP. March had the highest peak markup component, \$0.16 per MWh, or 0.58 percent of the real-time, peak hour load-weighted, average LMP.

In the PJM Day-Ahead Energy Market, INCs, DECs and UTCs have zero markups. In the first three months of 2021, the markup component of LMP was -\$0.07 per MWh or -0.2 percent of the PJM day-ahead load-weighted, average LMP. February had the highest unadjusted peak markup component, \$2.13 per MWh.

Participant behavior was evaluated as competitive because the analysis of markup shows that marginal units generally make offers at, or close to, their marginal costs in both the day-ahead and real-time energy markets, although the behavior of some participants represents economic withholding.

- **Markup and Local Market Power.** Comparison of the markup behavior of marginal units with TPS test results shows that for 4.2 percent of real-time marginal unit intervals in the first three months of 2021 the marginal unit had local market power as determined by the TPS test and a positive markup. The fact that units with market power had a positive markup means that the cost-based offer was not used, that a higher price-based offer was used, and that the process for offer capping units that fail the TPS test does not consistently result in competitive market outcomes in the presence of market power.
- **Markup and Aggregate Market Power.** In the first three months of 2021, pivotal suppliers in the aggregate market set prices with high markups for some real-time market intervals.

Section 3 Recommendations

Market Power

- The MMU recommends that the market rules explicitly require that offers in the energy market be competitive, where competitive is defined to be the short run marginal cost of the units. The short run marginal

cost should reflect opportunity cost when and where appropriate. The MMU recommends that the level of incremental costs includable in cost-based offers not exceed the short run marginal cost of the unit. (Priority: Medium. First reported 2009. Status: Not adopted.)

Fuel Cost Policies

- The MMU recommends that PJM require that all fuel cost policies be algorithmic, verifiable, and systematic, and accurately reflect short run marginal costs. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that the tariff be changed to allow units to have fuel cost policies that do not include fuel procurement practices, including fuel contracts. Fuel procurement practices, including fuel contracts, may be used as the basis for fuel cost policies but should not be required. (Priority: Low. First reported 2018. Status: Adopted 2020.)
- The MMU recommends that PJM change the fuel cost policy requirement to apply only to units that will be offered with non-zero cost-based offers. The PJM market rules should require that the cost-based offers of units without an approved fuel cost policy be set to zero. (Priority: Low. First reported 2018. Status: Adopted 2020.)
- The MMU recommends that the temporary cost method be removed and that all units that submit nonzero cost-based offers be required to have an approved fuel cost policy. (Priority: Low. First reported 2020. Status: Not adopted.)
- The MMU recommends that the penalty exemption provision be removed and that all units that submit nonzero cost-based offers be required to follow their approved fuel cost policy. (Priority: Medium. First reported 2020. Status: Not adopted.)

Cost-Based Offers

- The MMU recommends that Manual 15 (Cost Development Guidelines) be replaced with a straightforward description of the components of cost-based offers based on short run marginal costs and the correct calculation

of cost-based offers. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends removal of all use of FERC System of Accounts in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all use of cyclic starting and peaking factors from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all labor costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all maintenance costs from the Cost Development Guidelines. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that market participants be required to document the amount and cost of consumables used when operating in order to verify that the total operating cost is consistent with the total quantity used and the unit characteristics. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends, given that maintenance costs are currently allowed in cost-based offers, that market participants be permitted to include only variable maintenance costs, linked to verifiable operational events and that can be supported by clear and unambiguous documentation of the operational data (e.g. run hours, MWh, MMBtu) that support the maintenance cycle of the equipment being serviced/replaced. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends explicitly accounting for soak costs and changing the definition of the start heat input for combined cycles to include only the amount of fuel used from first fire to the first breaker close in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends the removal of nuclear fuel and nonfuel operations and maintenance costs that are not short run marginal costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends revising the pumped hydro fuel cost calculation to include day-ahead and real-time power purchases. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends revisions to the calculation of energy market opportunity costs to incorporate all time based offer parameters and all limitations that impact the opportunity cost of generating unit output. (Priority: Medium. First reported 2016. Status: Adopted 2020.)
- The MMU recommends removing the catastrophic designation for force majeure fuel supply limitations in Schedule 2. (Priority: Medium. First reported 2016. Status: Not adopted.)

Market Power: TPS Test and Offer Capping

- The MMU recommends that the rules governing the application of the TPS test be clarified and documented. The TPS test application in the day-ahead energy market is not documented. (Priority: High. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM require every market participant to make available at least one cost schedule based on the same hourly fuel type(s) and parameters at least as flexible as their offered price schedule. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that markup be constant across the full MWh range of price and cost-based offers. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that offer capping be applied to units that fail the TPS test in the real-time market that were not offer capped at the time of commitment in the day-ahead market or at a prior

time in the real-time market. (Priority: High. First reported 2020. Status: Not adopted.)

- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, and during high load conditions such as cold and hot weather alerts or more severe emergencies, that the operating parameters in the cost-based offer and the price-based parameter limited schedule (PLS) offer be at least as flexible as the operating parameters in the available price-based non-PLS offer, and that the price-MW pairs in the price-based PLS offer be exactly equal to the price-based non-PLS offer. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation, that PJM always enforce parameter limited values by committing units only on parameter limited schedules, when the TPS test is failed or during high load conditions such as cold and hot weather alerts or more severe emergencies. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM retain the \$1,000 per MWh offer cap in the PJM energy market except when cost-based offers exceed \$1,000 per MWh, and retain other existing rules that limit incentives to exercise market power. (Priority: High. First reported 1999. Status: Partially adopted, 1999, 2017.)
- The MMU recommends the elimination of FMU and AU adders. FMU and AU adders no longer serve the purpose for which they were created and interfere with the efficient operation of PJM markets. (Priority: Medium. First reported 2012. Status: Partially adopted, 2014.)

Offer Behavior

- The MMU recommends that resources not be allowed to violate the ICAP must offer requirement. The MMU recommends that PJM enforce the ICAP must offer requirement by assigning a forced outage to any unit that is derated in the energy market below its committed ICAP without an outage that reflects the derate. (Priority: Medium. First reported 2020. Status: Not adopted.)

- The MMU recommends that storage and intermittent resources be subject to an enforceable ICAP must offer rule that reflects the limitations of these resources. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that capacity resources not be allowed to offer any portion of their capacity market obligation as maximum emergency energy. (Priority: Medium. First reported 2012. Status: Not adopted.)

Capacity Performance Resources

- The MMU recommends that capacity performance resources be held to the OEM operating parameters of the capacity market CONE reference resource for performance assessment and energy uplift payments and that this standard be applied to all technologies on a uniform basis. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that the parameters which determine nonperformance charges and the amounts of uplift payments should reflect the flexibility goals of the capacity performance construct. The operational parameters used by generation owners to indicate to PJM operators what a unit is capable of during the operating day should not determine capacity performance assessment or uplift payments. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM not include the balancing ratios calculated for localized Performance Assessment Intervals (PAIs) in the capacity market default offer cap, and only include those events that trigger emergencies at a defined zonal or higher level. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM clearly define the business rules that apply to the unit specific parameter adjustment process, including PJM's implementation of the tariff rules in the PJM manuals to ensure market sellers know the requirements for their resources. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the tariff to clarify that all generation resources are subject to unit specific parameter limits on their cost-based offers using the same standard and process as capacity

performance capacity resources. (Priority: Medium. First reported 2018. Status: Not adopted.)

- The MMU recommends that PJM institute rules to assess a penalty for resources that choose to submit real-time values that are less flexible than their unit specific parameter limits or approved parameter limit exceptions based on tariff defined reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM not approve temporary exceptions that are based on pipeline tariff terms that are not routinely enforced, and based on inferior transportation service procured by the generator. (Priority: Medium. First reported 2019. Status: Not adopted.)

Accurate System Modeling

- The MMU recommends that PJM approve one RT SCED case for each five minute interval to dispatch resources during that interval using a five minute ramp time, and that PJM calculate prices using LPC for that five minute interval using the same approved RT SCED case. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM explicitly state its policy on the use of transmission penalty factors including: the level of the penalty factors; the triggers for the use of the penalty factors; the appropriate line ratings to trigger the use of penalty factors; the allowed duration of the violation; the use of constraint relaxation logic; and when the transmission penalty factors will be used to set the shadow price. (Priority: Medium. First reported 2015. Status: Partially adopted 2020.)
- The MMU recommends that PJM routinely review all transmission facility ratings and any changes to those ratings to ensure that the normal, emergency and load dump ratings used in modeling the transmission system are accurate and reflect standard ratings practice. (Priority: Low. First reported 2013. Status: Partially adopted.)
- The MMU recommends that PJM not use closed loop interface or surrogate constraints to artificially override nodal prices based on fundamental LMP logic in order to: accommodate rather than resolve the inadequacies of the

demand side resource capacity product; address the inability of the power flow model to incorporate the need for reactive power; accommodate rather than resolve the flaws in PJM's approach to scarcity pricing; or for any other reason. (Priority: Medium. First reported 2013. Status: Not adopted.)

- The MMU recommends that PJM not use CT price setting logic to modify transmission line limits to artificially override the nodal prices that are based on fundamental LMP logic in order to reduce uplift. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that if PJM believes it appropriate to implement CT price setting logic, PJM first initiate a stakeholder process to determine whether such modification is appropriate. PJM should file any proposed changes with FERC to ensure review. Any such changes should be incorporated in the PJM tariff. (Priority: Medium. First reported 2016. Status: Partially adopted.)
- The MMU recommends that PJM update the outage impact studies, the reliability analyses used in RPM for capacity deliverability, and the reliability analyses used in RTEP for transmission upgrades to be consistent with the more conservative emergency operations (post contingency load dump limit exceedance analysis) in the energy market that were implemented in June 2013. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM include in the tariff or appropriate manual an explanation of the initial creation of hubs, the process for modifying hub definitions and a description of how hub definitions have changed.^{67 68} (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that all buses with a net withdrawal be treated as load for purposes of calculating load and load-weighted LMP, even if the MW are settled to the generator. The MMU recommends that during hours when a load bus shows a net injection, the energy injection be treated as generation, not negative load, for purposes of calculating generation

⁶⁷ According to minutes from the first meeting of the Energy Market Committee (EMC) on January 28, 1998, the EMC unanimously agreed to be responsible for approving additions, deletions and changes to the hub definitions to be published and modeled by PJM. Since the EMC has become the Market Implementation Committee (MIC), the MIC now appears to be responsible for such changes.

⁶⁸ There is currently no PJM documentation in the tariff or manuals explaining how hubs are created and how their definitions are changed. The general definition of a hub can be found in the PJM.com Glossary <<http://www.pjm.com/Glossary.aspx>>.

and load-weighted LMP, even if the injection MW are settled to the load serving entity. (Priority: Low. First reported 2013. Status: Not adopted.)

- The MMU recommends that PJM identify and collect data on available behind the meter generation resources, including nodal location information and relevant operating parameters. (Priority: Low. First reported 2013. Status: Partially adopted.)
- The MMU recommends that PJM document how LMPs are calculated when demand response is marginal. (Priority: Low. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM not allow nuclear generators which do not respond to prices or which only respond to manual instructions from the operator to set the LMPs in the real-time market. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM increase the coordination of outage and operational restrictions data submitted by market participants via eDART/eGADs and offer data submitted via Markets Gateway. (Priority: Low. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM model generators' operating transitions, including soak time for units with a steam turbine, configuration transitions for combined cycles, and peak operating modes. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM clarify, modify and document its process for dispatching reserves and energy when SCED indicates that supply is less than total demand including forecasted load and reserve requirements. The modifications should define: a SCED process to economically convert reserves to energy; a process for the recall of energy from capacity resources; and the minimum level of synchronized reserves that would trigger load shedding. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM stop capping the system marginal price in RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh. (Priority: Medium. New recommendation. Status: Not adopted.)

Transparency

- The MMU recommends that PJM market rules require the fuel type be identified for every price and cost schedule and PJM market rules remove nonspecific fuel types such as other or co-fire other from the list of fuel types available for market participants to identify the fuel type associated with their price and cost schedules. (Priority: Medium. First reported 2015. Status: Adopted 2019.)
- The MMU recommends that PJM allow generators to report fuel type on an hourly basis in their offer schedules and to designate schedule availability on an hourly basis. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM clearly define the criteria for operator approval of RT SCED cases used to send dispatch signals to resources and for pricing, to minimize operator discretion and implement a rule based, scheduled approach. (Priority: High. First reported 2018. Status: Partially adopted.)

Virtual Bids and Offers

- The MMU recommends eliminating up to congestion (UTC) bidding at pricing nodes that aggregate only small sections of transmission zones with few physical assets. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating INC, DEC, and UTC bidding at pricing nodes that allow market participants to profit from modeling issues. (Priority: Medium. First reported 2020. Status: Not adopted.)

Section 3 Conclusion

The MMU analyzed key elements of PJM energy market structure, participant conduct and market performance in the first three months of 2021, including aggregate supply and demand, concentration ratios, aggregate pivotal supplier results, local three pivotal supplier test results, offer capping, markup, marginal units, participation in demand response programs, virtual bids and offers, loads and prices.

PJM average hourly real-time load in the first three months of 2021 increased by 5.0 percent from the first three months of 2020, from 85,608 MWh to 89,887 MWh. The relationship between supply and demand, regardless of the specific market, along with market concentration and the extent of pivotal suppliers, is referred to as the supply-demand fundamentals or economic fundamentals or market structure. The market structure of the PJM aggregate energy market is partially competitive because aggregate market power does exist for a significant number of hours. The HHI is not a definitive measure of structural market power. The number of pivotal suppliers in the energy market is a more precise measure of structural market power than the HHI. It is possible to have pivotal suppliers in the aggregate market even when the HHI level is not in the highly concentrated range. Even a low HHI may be consistent with the exercise of market power with a low price elasticity of demand. The current market power mitigation rules for the PJM energy market rely on the assumption that the ownership structure of the aggregate market ensures competitive outcomes. This assumption requires that the total demand for energy can be met without the supply from any individual supplier or without the supply from a small group of suppliers. This assumption is not correct. There are pivotal suppliers in the aggregate energy market at times. High markups for some units demonstrate the potential to exercise market power both routinely and during high demand conditions. The existing market power mitigation measures do not address aggregate market power. The MMU is developing an aggregate market power test and will propose market power mitigation rules to address aggregate market power.

The three pivotal supplier test is applied by PJM on an ongoing basis for local energy markets in order to determine whether offer capping is required for transmission constraints.⁶⁹ However, there are some issues with the application of market power mitigation in the day-ahead energy market and the real-time energy market when market sellers fail the TPS test. Many of these issues can be resolved by simple rule changes.

The enforcement of market power mitigation rules is undermined if the definition of a competitive offer is not correct. A competitive offer is equal to

⁶⁹ The MMU reviews PJM's application of the TPS test and brings issues to the attention of PJM.

short run marginal costs. The significance of competition metrics like markup is also undermined if the definition of a competitive offer is not correct. The definition of a competitive offer, under the PJM Market Rules, is not currently correct. The definition, that all costs that are related to electric production are short run marginal costs, is not clear or correct. All costs and investments for power generation are related to electric production. Under this definition, some unit owners include costs that are not short run marginal costs in offers, especially maintenance costs. This issue can be resolved by simple rule changes to incorporate a clear and accurate definition of short run marginal costs.

Prices are a key outcome of markets. Prices vary across hours, days and years for multiple reasons. Price is an indicator of the level of competition in a market. In a competitive market, prices are directly related to the marginal cost to serve load at a given time. The pattern of prices within days and across months and years illustrates how prices are directly related to supply and demand conditions and thus also illustrates the potential significance of the impact of the price elasticity of demand on prices. Energy market results in the first three months of 2021 generally reflected supply-demand fundamentals, although the behavior of some participants both routinely and during high demand periods represents economic withholding. Economic withholding occurs when generator offers are greater than competitive levels. There are additional issues in the energy market including the uncertainties about the pricing and availability of natural gas, the way that generation owners incorporate natural gas costs in offers, and the lack of adequate incentives for unit owners to take all necessary actions to acquire fuel, staff their units, and operate rather than economically withhold or physically withhold.

Prices in PJM are not too low. Prices in PJM are the result of input prices, consistent with a competitive market. Low natural gas prices have been a primary cause of low PJM energy market prices. There is no evidence to support the need for a significant change to the calculation of LMP, such as fast start pricing or the extended ORDC. Fast start pricing and the extended ORDC will disconnect pricing from dispatch instructions and create greater reliance on uplift as an incentive to follow PJM's instructions. The extended

ORDCs will create shortage pricing when no reserve shortages exist. Rather than undercutting the basic LMP logic that is core to market efficiency, it would make more sense to directly address the design of RT SCED/LPC, scarcity pricing, operator actions and the design of reserve markets. PJM has made progress in addressing the timing of RT SCED and LPC and accepting shortage pricing in some cases when SCED shows a shortage, but more progress is needed.

The PJM defined inputs to the dispatch tools, particularly the RT SCED, have substantial effects on energy market outcomes. Transmission line ratings, transmission penalty factors, load forecast bias, hydro resource schedules, and unit ramp rate adjustments change the dispatch of the system, affect prices, and can create significant price increases through transmission line limit violations or restrictions on the resources available to resolve constraints. The automated adjustment of ramp rates by PJM, called Degree of Generator Performance (DGP), modifies the values offered by generators and limits the MW available to the RT SCED. Rather than sending dispatch signals consistent with resource offers and holding resources accountable when they fail to follow them, DGP accommodates resources that do not follow dispatch. PJM should evaluate its interventions in the market, consider whether the interventions are appropriate, and provide greater transparency to enhance market efficiency.

The objective of efficient short run price signals is to minimize system production costs, not to minimize uplift. Repricing the market to reflect commitment costs prioritizes minimizing uplift over minimizing production costs. The tradeoff exists because when commitment costs are included in prices, the price signal no longer equals the short run marginal cost and therefore no longer provides the correct signal for efficient behavior for market participants making decisions on the margin, whether resources, load, interchange transactions, or virtual traders. This tradeoff will be created by PJM's fast start pricing proposal as approved by FERC and would be created in a much more extensive form by PJM's convex hull pricing proposal and the pending reserve pricing changes.⁷⁰

⁷⁰ See 173 FERC ¶ 61,244 (2020).

Units that start in one hour are not actually fast start units, and their commitment costs are not marginal in a five minute market. The differences between the actual LMP and the fast start LMP will distort the incentive for market participants to behave competitively and to follow PJM's dispatch instructions. PJM will pay new forms of uplift in an attempt to counter the distorted incentives. The magnitude of the new payments and their effects on behavior are not well understood.

The fast start pricing and convex hull solutions would undercut LMP logic rather than directly addressing the underlying issues. The solution is not to accept that the inflexible CT should be paid or set price based on its commitment costs rather than its short run marginal costs. The question of why units make inflexible offers should be addressed directly. Are units inflexible because they are old and inefficient, because owners have not invested in increased flexibility or because they serve as a mechanism for the exercise of market power? The question of why the unit was built, whether it was built under cost of service regulation and whether it is efficient to retain the unit should be answered directly. The question of how to provide market incentives for investment in flexible units and for investment in increased flexibility of existing units should be addressed directly. The question of whether inflexible units should be paid uplift at all should be addressed directly. Marginal cost pricing without paying excess uplift to inflexible units would create incentives for market participants to provide flexible solutions including replacing inefficient units with flexible, efficient units.

With or without a capacity market, energy market design must permit scarcity pricing when such pricing is consistent with market conditions and constrained by reasonable rules to ensure that market power is not exercised. Scarcity pricing can serve two functions in wholesale power markets: revenue adequacy and price signals. Scarcity pricing for revenue adequacy, as in PJM's ORDC proposal, is not required in PJM. Scarcity pricing for price signals that reflect market conditions during periods of scarcity is required in PJM. Scarcity pricing is also part of an appropriate incentive structure facing both load and generation owners in a working wholesale electric power market design. Scarcity pricing must be designed to ensure that market prices

reflect actual market conditions, that scarcity pricing occurs with transparent triggers based on measured reserve levels and transparent prices, that scarcity pricing only occurs when scarcity exists, and that there are strong incentives for competitive behavior and strong disincentives to exercise market power. Such administrative scarcity pricing is a key link between energy and capacity markets. Administrative scarcity pricing that establishes scarcity pricing in about 85 percent of hours, as PJM's ORDC proposal would, is not scarcity pricing but simply a revenue enhancement mechanism, which could have unintended consequences in an emergency, as was the case in ERCOT in February 2021. PJM's pending ORDC changes are not consistent with efficient market design and are just a revenue enhancement mechanism.

The PJM Capacity Market is explicitly designed to provide revenue adequacy and the resultant reliability. However, the explicit balancing mechanism that included net revenues directly in unit offers in the prior capacity market design is not present in the Capacity Performance design. The nature of a direct and explicit energy pricing net revenue true up mechanism in the capacity market should be addressed if energy revenues are expected to increase as a result of scarcity events, as a result of increased demand for reserves, or as a result of PJM's inappropriate proposals related to fast start pricing and the inclusion of maintenance expenses as short run marginal costs. The true up mechanism must address both cleared auctions and subsequent auctions. There are also significant issues with PJM's scarcity pricing rules, including the absence of a clear trigger based on measured reserve levels (the current triggers are based on estimated reserves) and the lack of adequate locational scarcity pricing options.

The overall energy market results support the conclusion that energy prices in PJM are set, generally, by marginal units operating at, or close to, their marginal costs, although this was not always the case in the first three months of 2021 or prior years. In the first three months of 2021, marginal units were predominantly combined cycle gas generators with low fuel costs. The frequency of combined cycle gas units as the marginal unit type has risen rapidly, from 32.9 percent in the first three months of 2016 to 65.5 percent in the first three months of 2021. Overdue improvements in generator

modeling in the energy market would allow PJM to more efficiently commit and dispatch combined cycle plants and to fully reflect the flexibility of these units. New combined cycle units have placed competitive pressure on less efficient generators, and the market has reliably served load with less congestion, less uplift, and less markup as a result. This is evidence of generally competitive behavior and competitive market outcomes, although the behavior of some participants represents economic withholding. Given the structure of the energy market which can permit the exercise of aggregate and local market power, the change in some participants' behavior is a source of concern in the energy market and provides a reason to use correctly defined short run marginal cost as the sole basis for cost-based offers and a reason for implementing an aggregate market power test and correcting the offer capping process for resources with local market power. The MMU concludes that the PJM energy market results were competitive in the first three months of 2021.

Overview: Section 4, Energy Uplift

Energy Uplift Credits

- **Types of credits.** In the first three months of 2021, energy uplift credits were \$34.4 million, including \$4.5 million in day-ahead generator credits, \$20.4 million in balancing generator credits, \$4.5 million in lost opportunity cost credits, and \$4.2 million in local constraint control credits.
- **Types of units.** In the first three months of 2021, coal units received 75.5 percent of day-ahead generator credits, and combustion turbines received 92.8 percent of balancing generator credits and 98.4 percent of lost opportunity cost credits.
- **Economic and Noneconomic Generation.** In the first three months of 2021, 88.7 percent of the day-ahead generation eligible for operating reserve credits was economic and 60.2 percent of the real-time generation eligible for operating reserve credits was economic.
- **Day-Ahead Unit Commitment for Reliability.** In the first three months of 2021, 0.2 percent of the total day-ahead generation MWh was scheduled

as must run for reliability by PJM, of which 74.6 percent received energy uplift payments.

- **Concentration of Energy Uplift Credits.** In the first three months of 2021, the top 10 units receiving energy uplift credits received 27.9 percent of all credits and the top 10 organizations received 79.5 percent of all credits. The HHI for day-ahead operating reserves was 7592, the HHI for balancing operating reserves was 3402 and the HHI for lost opportunity cost was 7044, all of which are classified as highly concentrated.
- **Lost Opportunity Cost Credits.** Lost opportunity cost credits increased by \$3.0 million or 191.0 percent, in the first three months of 2021 compared to the first three months of 2020, from \$1.5 million to \$4.5 million. Some combustion turbines and diesels are scheduled day-ahead but not requested in real time, and receive day-ahead lost opportunity cost credits as a result. This was the source of 99.5 percent of the \$4.5 million. The day-ahead generation paid LOC credits for this reason decreased by 130.5 GWh or 73.6 percent during 2021, compared to 2020, from 177.4 GWh to 46.9 GWh.
- **Following Dispatch.** Some units are incorrectly paid uplift despite not meeting uplift eligibility requirements, including not following dispatch, not having the correct commitment status, or not operating with proper offer parameters. Since 2018, the MMU has made cumulative resettlement requests for overpaid units that total \$12.1 million, of which PJM has resettled 11.4 percent.

Energy Uplift Charges

- **Energy Uplift Charges.** Total energy uplift charges increased by \$27.2 million, or 378.5 percent, in the first three months of 2021 compared to the first three months of 2020, from \$7.2 million to \$34.4 million.
- **Energy Uplift Charges Categories.** The increase of \$27.2 million in the first three months of 2021 was comprised of a \$4.2 million increase in day-ahead operating reserve charges, a \$22.3 million increase in balancing operating reserve charges, and a \$0.7 million increase in reactive services charges.

- **Average Effective Operating Reserve Rates in the Eastern Region.** Day-ahead load paid \$0.020 per MWh, real-time load paid \$0.067 per MWh, DECs and UTCs paid \$0.265 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.245 per MWh.
- **Average Effective Operating Reserve Rates in the Western Region.** Day-ahead load paid \$0.020 per MWh, real-time load paid \$0.053 per MWh, DECs and UTCs paid \$0.225 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.205 per MWh in the first three months of 2021.
- **Reactive Services Rates.** PPL was the only zone with local voltage support rates, excluding reactive capability payments. PPL had a rate of \$0.064 per MWh.

Geography of Charges and Credits

- In the first three months of 2021, 87.6 percent of all uplift charges allocated regionally (day-ahead operating reserves and balancing operating reserves) were paid by transactions at control zones, 3.2 percent by transactions at hubs and aggregates, and 9.2 percent by transactions at interchange interfaces.
- In the first three months of 2021, generators in the Eastern Region received 55.7 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In the first three months of 2021, generators in the Western Region received 41.9 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In the first three months of 2021, external generators received 2.4 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.

Section 4 Recommendations

- The MMU recommends that uplift be paid only based on operating parameters that reflect the flexibility of the benchmark new entrant unit

(CONE unit) in the PJM Capacity Market. (Priority: High. First reported 2018. Status: Not adopted.)

- The MMU recommends that PJM initiate an analysis of the reasons why a significant number of combustion turbines and diesels scheduled in the day-ahead energy market are not called in real time when they are economic. (Priority: Medium. First Reported 2012. Status: Partially adopted, 2019.)
- The MMU recommends that PJM develop and implement an accurate metric to define when a unit is following dispatch to determine eligibility to receive balancing operating reserve credits and for assessing generator deviations. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM designate units whose offers are flagged for fixed generation in Markets Gateway as not eligible for uplift. Units that are flagged for fixed generation are not dispatchable. Following dispatch is an eligibility requirement for uplift compensation. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating intraday segments from the calculation of uplift payments and returning to calculating the need for uplift based on the entire 24 hour operating day. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends the elimination of day-ahead uplift to ensure that units receive an energy uplift payment based on their real-time output and not their day-ahead scheduled output. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends enhancing the current energy uplift allocation rules to reflect the recommended elimination of day-ahead uplift, the timing of commitment decisions and the commitment reasons. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends reincorporating the use of net regulation revenues as an offset in the calculation of balancing operating reserve credits. (Priority: Medium. First reported 2009. Status: Not adopted.)

- The MMU recommends that self-scheduled units not be paid energy uplift for their startup cost when the units are scheduled by PJM to start before the self-scheduled hours. (Priority: Low. First reported 2013. Status: Not adopted. Stakeholder process.)
- The MMU recommends three modifications to the energy lost opportunity cost calculations:
 - The MMU recommends calculating LOC based on 24-hour daily periods for combustion turbines and diesels scheduled in the day-ahead energy market, but not committed in real time. (Priority: Medium. First reported 2014. Status: Not adopted.)
 - The MMU recommends that units scheduled in the day-ahead energy market and not committed in real time should be compensated for LOC based on their real-time desired and achievable output, not their scheduled day-ahead output. (Priority: Medium. First reported 2015. Status: Not adopted.)
 - The MMU recommends that only flexible fast start units (startup plus notification times of 10 minutes or less) and units with short minimum run times (one hour or less) be eligible by default for the LOC compensation to units scheduled in the day-ahead energy market and not committed in real time. Other units should be eligible for LOC compensation only if PJM explicitly cancels their day-ahead commitment. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that up to congestion transactions be required to pay energy uplift charges for both the injection and the withdrawal sides of the UTC. (Priority: High. First reported 2011. Status: Partially adopted.)
- The MMU recommends eliminating the use of internal bilateral transactions (IBTs) in the calculation of deviations used to allocate balancing operating reserve charges. (Priority: High. First reported 2013. Status: Adopted 2018.⁷¹)
- The MMU recommends allocating the energy uplift payments to units scheduled as must-run in the day-ahead energy market for reasons other than voltage/reactive or black start services as a reliability charge to real-time load, real-time exports and real-time wheels. (Priority: Medium. First reported 2014. Status: Not adopted. Stakeholder process.)
- The MMU recommends that the total cost of providing reactive support be categorized and allocated as reactive services. Reactive services credits should be calculated consistent with the balancing operating reserve credit calculation. (Priority: Medium. First reported 2012. Status: Not adopted. Stakeholder process.)
- The MMU recommends including real-time exports and real-time wheels in the allocation of the cost of providing reactive support to the 500 kV system or above, in addition to real-time load. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends modifications to the calculation of lost opportunity costs credits paid to wind units. The lost opportunity costs credits paid to wind units should be based on the lesser of the desired output, the estimated output based on actual wind conditions and the capacity interconnection rights (CIRs). The MMU recommends that PJM allow wind units to request CIRs that reflect the maximum output wind units want to inject into the transmission system at any time. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM clearly identify and classify all reasons for incurring operating reserves in the day-ahead and the real-time energy markets and the associated operating reserve charges in order to make all market participants aware of the reasons for these costs and to help ensure a long-term solution to the issue of how to allocate the costs of operating reserves. (Priority: Medium. First reported 2011. Status: Partially adopted.)
- The MMU recommends that PJM revise the current uplift (operating reserve) confidentiality rules in order to allow the disclosure of complete information about the level of uplift (operating reserve charges) by unit and the detailed reasons for the level of operating reserve credits by unit

⁷¹ As of November 1, 2018, internal bilateral transactions are no longer used for the calculation of deviations for purposes of allocating balancing operating reserve charges. See the *2018 State of the Market Report for PJM*, Volume II, Section 3: "Energy Market" at "Internal Bilateral Transactions" for an analysis of the impact of this change on virtual bidding activity.

in the PJM region. (Priority: High. First reported 2013. Status: Partially adopted.⁷²)

- The MMU recommends that PJM pay uplift based on the offer at the lower of the actual unit output or the dispatch signal MW. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM eliminate the exemption for fast start resources (CTs and diesels) from the requirement to follow dispatch. The performance of these resources should be evaluated in a manner consistent with all other resources (Priority: Medium. First reported 2018. Status: Not adopted.)

Section 4 Conclusion

Competitive market outcomes result from energy offers equal to short run marginal costs that incorporate flexible operating parameters. When PJM permits a unit to include inflexible operating parameters in its offer and pays uplift based on those inflexible parameters, there is an incentive for the unit to remain inflexible. The rules regarding operating parameters should be implemented in a way that creates incentives for flexible operations rather than inflexible operations. The standard for paying uplift should be the maximum achievable flexibility, based on OEM standards for the benchmark new entrant unit (CONE unit) in the PJM Capacity Market. Applying a weaker standard effectively subsidizes inflexible units by paying them based on inflexible parameters that result from lack of investment and that could be made more flexible. The result both inflates uplift costs and suppresses energy prices.

It is not appropriate to accept that inflexible units should be paid or set price based on short run marginal costs plus start up and no load costs. The question of why units make inflexible offers should be addressed directly. Are units inflexible because they are old and inefficient, because owners have not invested in increased flexibility or because they serve as a mechanism for the exercise of market power? The question of why the inflexible unit was built, whether it was built under cost of service regulation and whether it is

efficient to retain the unit should be answered directly. The question of how to provide market incentives for investment in flexible units and for investment in increased flexibility of existing units should be addressed directly. The question of whether inflexible units should be paid uplift at all should be addressed directly. Marginal cost pricing without paying uplift to inflexible units would create incentives for market participants to provide flexible solutions including replacing inefficient units with flexible, efficient units.

Implementing combined cycle modeling, to permit the energy market model optimization to take advantage of the versatility and flexibility of combined cycle technology in commitment and dispatch, would provide significant flexibility without requiring a distortion of the market rules.

The reduction of uplift payments should not be a goal to be achieved at the expense of the fundamental logic of the LMP system. For example, the use of closed loop interfaces to reduce uplift should be eliminated because it is not consistent with LMP fundamentals and constitutes a form of subjective price setting. The same is true of what PJM terms its CT price setting logic. The same is true of fast start pricing and of convex hull pricing. The same is true of PJM's proposal to modify the ORDC in order to increase energy prices and reduce uplift.

Accurate short run price signals, equal to the short run marginal cost of generating power, provide market incentives for cost minimizing production to all economically dispatched resources and provide market incentives to load based on the marginal cost of additional consumption. The objective of efficient short run price signals is to minimize system production costs, not to minimize uplift. Repricing the market to reflect commitment costs will create a tradeoff between minimizing production costs and reduction of uplift. The tradeoff will exist because when commitment costs are included in prices, the price signal no longer equals the short run marginal cost and therefore no longer provides the correct signal for efficient behavior for market participants making decisions on the margin, whether resources, load, interchange transactions, or virtual traders. This tradeoff will be created by PJM's fast start pricing proposal (limited convex hull pricing). Fast start

72 On September 7, 2018, PJM made a compliance filing for FERC Order No. 844 to publish unit specific uplift credits. The compliance filing was accepted by FERC on March 21, 2019. 166 FERC ¶ 61,210. PJM began posting unit specific uplift reports on May 1, 2019. 167 FERC ¶ 61,280 (2019).

pricing has been approved by FERC subject to a PJM compliance filing on the definition of fast start resources, and is expected to be implemented in 2021.⁷³ Fast start pricing will affect uplift calculations.

When units receive substantial revenues through energy uplift payments, these payments are not fully transparent to the market, in part because of the current confidentiality rules. As a result, other market participants, including generation and transmission developers, do not have the opportunity to compete to displace them. As a result, substantial energy uplift payments to a concentrated group of units and organizations have persisted. FERC Order No. 844 authorized the publication of unit specific uplift payments for credits incurred after July 1, 2019.⁷⁴ However, Order No. 844 failed to require the publication of unit specific uplift credits for the largest units receiving significant uplift payments, inflexible steam units committed for reliability in the day-ahead market.

One part of addressing the level and allocation of uplift payments is to eliminate all day-ahead operating reserve credits. It is illogical and unnecessary to pay units day-ahead operating reserve credits because units do not incur any costs to run and any revenue shortfalls are addressed by balancing operating reserve credits.

On July 16, 2020, following its investigation of the issue, the Commission ordered PJM to revise its rules so that UTCs are required to pay uplift on the withdrawal side (DEC) only.⁷⁵ The uplift payments for UTCs began on November 1, 2020.⁷⁶

PJM needs to pay substantially more attention to the details of uplift payments including accurately tracking whether units are following dispatch, identifying the actual need for units to be dispatched out of merit and determining whether

local reserve zones or better definitions of constraints would be a more market based approach. PJM pays uplift to units even when they do not operate as requested by PJM, i.e. they do not follow dispatch. PJM uses dispatcher logs as a primary screen to determine if units are eligible for uplift regardless of how they actually operate or if they followed the PJM dispatch signal. The reliance on dispatcher logs for this purpose is impractical, inefficient, and incorrect. PJM needs to define and implement rules for determining when units are following dispatch as a primary screen for eligibility for uplift payments.

The MMU notifies PJM and generators of instances in which, based on the PJM dispatch signal and the real time output of the unit, it is clear that the unit did not operate as requested by PJM. The MMU sends requests for resettlements to PJM to make these units ineligible for uplift credits. Since 2018, the MMU has identified \$12.1 million of incorrect uplift credits.

While energy uplift charges are an appropriate part of the cost of energy, market efficiency would be improved by ensuring that the level and variability of these charges are as low as possible consistent with the reliable operation of the system and consistent with pricing at short run marginal cost. The goal should be to minimize the total incurred energy uplift charges and to increase the transactions over which those charges are spread in order to reduce the impact of energy uplift charges on markets. The result would be to reduce the level of per MWh charges, to reduce the uncertainty associated with uplift charges and to reduce the impact of energy uplift charges on decisions about how and when to participate in PJM markets. The result would also be to increase incentives for flexible operation and to decrease incentives for the continued operation of inflexible and uneconomic resources.

⁷³ See 173 FERC ¶ 61,244 (2020).

⁷⁴ On March 21, 2019 FERC accepted PJM's Order No. 844 compliance filing. 166 FERC ¶ 61,210 The filing stated that PJM would begin posting unit specific uplift reports on May 1, 2019. On April 8, 2019, PJM filed for an extension on the implementation date of the zonal uplift reports and unit specific uplift reports to July 1, 2019. On June 28, 2019, FERC accepted PJM's request for extension of effective dates. 167 FERC ¶ 61,280.

⁷⁵ See 172 FERC ¶ 61,046.

⁷⁶ On October 17, 2017, PJM filed a proposed tariff change at FERC to allocate uplift to UTC transactions in the same way uplift is allocated to other virtual transactions, as a separate injection and withdrawal deviation. FERC rejected the proposed tariff change. See 162 FERC ¶ 61,019 (2018).

Overview: Section 5, Capacity Market

RPM Capacity Market

Market Design

The Reliability Pricing Model (RPM) Capacity Market is a forward-looking, annual, locational market, with a must offer requirement for Existing Generation Capacity Resources and mandatory participation by load, with performance incentives, that includes clear market power mitigation rules and that permits the direct participation of demand-side resources.⁷⁷

Under RPM, capacity obligations are annual.⁷⁸ Base Residual Auctions (BRA) are held for delivery years that are three years in the future. First, Second and Third Incremental Auctions (IA) are held for each delivery year.⁷⁹ First, Second, and Third Incremental Auctions are conducted 20, 10, and three months prior to the delivery year.⁸⁰ A Conditional Incremental Auction may be held if there is a need to procure additional capacity resulting from a delay in a planned large transmission upgrade that was modeled in the BRA for the relevant delivery year.⁸¹

The 2021/2022 RPM Third Incremental Auction was conducted in the first three months of 2021.

RPM prices are locational and may vary depending on transmission constraints and local supply and demand conditions.⁸² Existing generation capable of qualifying as a capacity resource must be offered into RPM auctions, except for resources owned by entities that elect the fixed resource requirement (FRR) option. Participation by LSEs is mandatory, except for those entities that elect the FRR option. There is an administratively determined demand curve that defines scarcity pricing levels and that, with the supply curve derived from capacity offers, determines market prices in each BRA. RPM rules provide

performance incentives for generation, including the requirement to submit generator outage data and the linking of capacity payments to the level of unforced capacity, and the performance incentives have been strengthened significantly under the Capacity Performance modifications to RPM. Under RPM there are explicit market power mitigation rules that define the must offer requirement, that define structural market power based on the marginal cost of capacity, that define offer caps, that define the minimum offer price, and that have flexible criteria for competitive offers by new entrants. Market power mitigation is effective only when these definitions are up to date and accurate. Demand resources and energy efficiency resources may be offered directly into RPM auctions and receive the clearing price without mitigation.

Market Structure

- **RPM Installed Capacity.** In the first three months of 2021, RPM installed capacity decreased 491.4 MW or 0.3 percent, from 184,270.0 MW on January 1 to 183,778.6 MW on March 31. Installed capacity includes net capacity imports and exports and can vary on a daily basis.
- **RPM Installed Capacity by Fuel Type.** Of the total installed capacity on March 31, 2021, 45.7 percent was gas; 26.8 percent was coal; 17.6 percent was nuclear; 4.8 percent was hydroelectric; 3.0 percent was oil; 1.2 percent was wind; 0.4 percent was solid waste; and 0.6 percent was solar.
- **Market Concentration.** In the 2021/2022 RPM Third Incremental Auction all participants in the total PJM market as well as the LDA RPM markets failed the three pivotal supplier (TPS) test.⁸³ Offer caps were applied to all sell offers for resources which were subject to mitigation when the capacity market seller did not pass the test, the submitted sell offer exceeded the defined offer cap, and the submitted sell offer, absent mitigation, increased the market clearing price.^{84 85 86}

⁷⁷ The terms *PJM Region*, *RTO Region* and *RTO* are synonymous in this report and include all capacity within the PJM footprint.

⁷⁸ Effective for the 2020/2021 and subsequent delivery years, the RPM market design incorporated seasonal capacity resources. Summer period and winter period capacity must be matched either with commercial aggregation or through the optimization in equal MW amounts in the LDA or the lowest common parent LDA.

⁷⁹ See 126 FERC ¶ 61,275 at P 86 (2009).

⁸⁰ See Letter Order, FERC Docket No. ER10-366-000 (January 22, 2010).

⁸¹ See 126 FERC ¶ 61,275 at P 88 (2009). There have been no Conditional Incremental Auctions.

⁸² Transmission constraints are local capacity import capability limitations (low capacity emergency transfer limit (CETL) margin over capacity emergency transfer objective (CETO)) caused by transmission facility limitations, voltage limitations or stability limitations.

⁸³ There are 27 Locational Deliverability Areas (LDAs) identified to recognize locational constraints as defined in "Reliability Assurance Agreement Among Load Serving Entities in the PJM Region," Schedule 10.1. PJM determines, in advance of each BRA, whether the defined LDAs will be modeled in the given delivery year using the rules defined in OATT Attachment DD § 5.10(a)(ii).

⁸⁴ See OATT Attachment DD § 6.5.

⁸⁵ Prior to November 1, 2009, existing DR and EE resources were subject to market power mitigation in RPM Auctions. See 129 FERC ¶ 61,081 at P 30 (2009).

⁸⁶ Effective January 31, 2011, the RPM rules related to market power mitigation were changed, including revising the definition for Planned Generation Capacity Resource and creating a new definition for Existing Generation Capacity Resource for purposes of the must offer requirement and market power mitigation, and treating a proposed increase in the capability of a generation capacity resource the same in terms of mitigation as a Planned Generation Capacity Resource. See 134 FERC ¶ 61,065 (2011).

- **Imports and Exports.** Of the 4,470.4 MW of imports in the 2021/2022 RPM Base Residual Auction, 4,051.8 MW cleared. Of the cleared imports, 1,909.9 MW (47.1 percent) were from MISO.
- **Demand-Side and Energy Efficiency Resources.** Capacity in the RPM load management programs was 10,586.0 MW for June 1, 2020, as a result of cleared capacity for demand resources and energy efficiency resources in RPM auctions for the 2020/2021 Delivery Year (13,015.2 MW) less purchases of replacement capacity (2,429.2 MW).

Market Conduct

- **2021/2022 RPM Third Incremental Auction.** Of the 481 generation resources that submitted Capacity Performance offers, the MMU calculated unit specific offer caps for zero generation resources (0.0 percent).

Market Performance

- The 2021/2022 RPM Third Incremental Auction was conducted in the first three months of 2021.⁸⁷ The weighted average capacity price for the 2019/2020 Delivery Year is \$109.82 per MW-day, including all RPM auctions for the 2019/2020 Delivery Year. The weighted average capacity price for the 2020/2021 Delivery Year is \$111.05 per MW-day, including all RPM auctions for the 2020/2021 Delivery Year.
- For the 2020/2021 Delivery Year, RPM annual charges to load are \$7.0 billion.
- In the 2021/2022 RPM Base Residual Auction, the market performance was determined to be not competitive as a result of noncompetitive offers that affected market results.

Reliability Must Run Service

- Of the seven companies (23 units) that have provided RMR service, two companies (seven units) filed to be paid for RMR service under the deactivation avoidable cost rate (DACR), the formula rate. The other five

companies (16 units) filed to be paid for RMR service under the cost of service recovery rate.

Generator Performance

- **Forced Outage Rates.** The average PJM EFORD in the first three months of 2021 was 8.1 percent, an increase from 4.5 percent in the first three months of 2020.⁸⁸
- **Generator Performance Factors.** The PJM aggregate equivalent availability factor in the first three months of 2021 was 85.8 percent, a decrease from 87.6 percent in the first three months of 2020.

Section 5 Recommendations⁸⁹

Definition of Capacity

- The MMU recommends the enforcement of a consistent definition of capacity resource. The MMU recommends that the requirement to be a physical resource be enforced and enhanced. The requirement to be a physical resource should apply at the time of auctions and should also constitute a commitment to be physical in the relevant delivery year. The requirement to be a physical resource should be applied to all resource types, including planned generation, demand resources and imports.^{90 91} (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that DR providers be required to have a signed contract with specific customers for specific facilities for specific levels of DR at least six months prior to any capacity auction in which the DR is offered. (Priority: High. First reported 2016. Status: Not adopted.)

⁸⁷ FERC granted PJM's request for waiver of its Open Access Transmission Tariff to delay the 2022/2023 RPM Base Residual Auction from May 2019 to August 2019. See 164 FERC ¶ 61,153 (2018). FERC subsequently denied PJM's motion seeking clarification of the June 29, 2018, Order (163 FERC ¶ 61,236) and directed PJM not to run the 2022/2023 BRA in August 2019. See 168 FERC ¶ 61,051 (2019).

⁸⁸ The generator performance analysis includes all PJM capacity resources for which there are data in the PJM generator availability data systems (GADS) database. Data was downloaded from the PJM GADS database on April 22, 2021. EFORD data presented in state of the market reports may be revised based on data submitted after the publication of the reports as generation owners may submit corrections at any time with permission from PJM GADS administrators.

⁸⁹ The MMU has identified serious market design issues with RPM and the MMU has made specific recommendations to address those issues. These recommendations have been made in public reports. See Table 52.

⁹⁰ See also Comments of the Independent Market Monitor for PJM, Docket No. ER14-503-000 (December 20, 2013).

⁹¹ See "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

Market Design and Parameters

- The MMU recommends that the test for determining modeled Locational Deliverability Areas (LDAs) in RPM be redefined. A detailed reliability analysis of all at risk units should be included in the redefined model. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) VRR parameter reflect the actual flexibility of units in responding to price signals rather than using assumed fixed operating blocks that are not a result of actual unit limitations.^{92 93} The result of reflecting the actual flexibility is higher net revenues, which affect the parameters of the RPM demand curve and market outcomes. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that energy efficiency resources (EE) not be included on the supply side of the capacity market, because PJM's load forecasts now account for future EE, unlike the situation when EE was first added to the capacity market. However, the MMU recommends that the PJM load forecast method should be modified so that EE impacts immediately affect the forecast without the long lag times incorporated in the current forecast method. If EE is not included on the supply side, there is no reason to have an add back mechanism. If EE remains on the supply side, the implementation of the EE add back mechanism should be modified to ensure that market clearing prices are not affected. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM reduce the number of incremental auctions to a single incremental auction held three months prior to the start of the delivery year and reevaluate the triggers for holding conditional incremental auctions. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM offer to sell back capacity in incremental auctions only at the BRA clearing price for the relevant delivery year. (Priority: Medium. First reported 2017. Status: Not adopted.)

⁹² See PJM Interconnection, LLC, Docket No. ER12-513-000 (December 1, 2011) ("Triennial Review").

⁹³ See the 2019 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue.

- The MMU recommends changing the RPM solution method to explicitly incorporate the cost of make whole payments in the objective function. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM clear the capacity market based on nodal capacity resource locations and the characteristics of the transmission system consistent with the actual electrical facts of the grid. The current nested LDA structure used in the capacity market does not adequately represent all the capacity transfers that are feasible among LDAs. Absent a fully nodal capacity market clearing process, the MMU recommends that PJM use a nonnested model for all LDAs and specify a VRR curve for each LDA separately. Each LDA requirement should be met with the capacity resources located within the LDA and exchanges from neighboring LDAs up to the transmission limit. LDAs should price separate if that is the result of the LDA supply curves and the transmission constraints. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that the maximum price on the VRR curve be defined as net CONE. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the Fixed Resource Requirement (FRR) rules, including obligations and performance requirements, be revised and updated to ensure that the rules reflect current market realities and that FRR entities do not unfairly take advantage of those customers paying for capacity in the PJM capacity market. (Priority: Medium. First reported 2019. Status: Not adopted.)

Offer Caps, Offer Floors, and Must Offer

- The MMU recommends use of the Sustainable Market Rule (SMR) in order to protect competition in the capacity market from nonmarket revenues.⁹⁴ (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that, as part of the MOPR unit specific standard of review, all projects be required to use the same basic modeling assumptions. That is the only way to ensure that projects compete on the

⁹⁴ Brief of the Independent Market Monitor for PJM, Docket No. EL16-49, ER18-1314-000-001; EL18-178 (October 2, 2018).

basis of actual costs rather than on the basis of modeling assumptions.⁹⁵ (Priority: High. First reported 2013. Status: Not adopted.)

- The MMU recommends that modifications to existing resources not be treated as new resources for purposes of market power related offer caps or MOPR offer floors. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the RPM market power mitigation rule be modified to apply offer caps in all cases when the three pivotal supplier test is failed and the sell offer is greater than the offer cap. This will ensure that market power does not result in an increase in make whole payments. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that the offer cap for capacity resources be defined as the net avoidable cost rate (ACR) of each unit so that the clearing prices are a result of such net ACR offers, consistent with the fundamental economic logic for a competitive offer of a CP resource. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM develop a process for calculating a forward looking estimate for the expected number of Performance Assessment Intervals (H) to use in calculating the Market Seller Offer Cap (MSOC). The MMU recommends that the Nonperformance Charge Rate be left at its current level. The MMU recommends that PJM develop a forward looking estimate for the Balancing Ratio (B) during Performance Assessment Intervals (PAIs) to use in calculating the MSOC. Both H and B parameters should be included in the annual review of planning parameters for the Base Residual Auction, and should incorporate the actual observed reserve margins, and other assumptions consistent with the annual IRM study. (Priority: High. First reported 2017. Status: Not adopted.)

⁹⁵ See 143 FERC ¶ 61,090 (2013) (“We encourage PJM and its stakeholders to consider, for example, whether the unit-specific review process would be more effective if PJM requires the use of common modeling assumptions for establishing unit-specific offer floors while, at the same time, allowing sellers to provide support for objective, individual cost advantages. Moreover, we encourage PJM and its stakeholders to consider these modifications to the unit-specific review process together with possible enhancements to the calculation of Net CONE.”); see also, Comments of the Independent Market Monitor for PJM, Docket No. ER13-535-001 (March 25, 2013); Complaint of the Independent Market Monitor for PJM v. Unnamed Participant, Docket No. EL12-63-000 (May 1, 2012); Motion for Clarification of the Independent Market Monitor for PJM, Docket No. ER11-2875-000, et al. (February 17, 2012); Protest of the Independent Market Monitor for PJM, Docket No. ER11-2875-002 (June 2, 2011); Comments of the Independent Market Monitor for PJM, Docket Nos. EL11-20 and ER11-2875 (March 4, 2011).

- The MMU recommends that capacity market sellers be required to request the use of minimum MW quantities greater than 0 MW (inflexible sell offer segments) and that the requests should only be permitted for defined physical reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the values in the CRF table in the tariff when the components change. (Priority: High. First reported 2020. Status: Not adopted.)

Performance Incentive Requirements of RPM

- The MMU recommends that any unit which is not capable of supplying energy consistent with its day-ahead offer which should equal its ICAP, reflect an appropriate outage. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that retroactive replacement transactions associated with a failure to perform during a PAI not be allowed and that, more generally, retroactive replacement capacity transactions not be permitted. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that there be an explicit requirement that capacity resource offers in the day-ahead energy market be competitive, where competitive is defined to be the short run marginal cost of the units. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that Capacity Performance resources be required to perform without excuses. Resources that do not perform should not be paid regardless of the reason for nonperformance. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the market data posting rules be modified to allow the disclosure of expected performance, actual performance, shortfall and bonus MW during a PAI by area without the requirement that more than three market participants’ data be aggregated for posting. (Priority: Low. First reported 2019. Status: Not adopted.)

Capacity Imports and Exports

- The MMU recommends that all capacity imports be required to be deliverable to PJM load prior to the relevant delivery year to ensure that they are full substitutes for internal, physical capacity resources. Pseudo ties alone are not adequate to ensure deliverability. (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that all costs incurred as a result of a pseudo tied unit be borne by the unit itself and included as appropriate in unit offers in the capacity market. (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends clear, explicit and detailed rules that define the conditions under which PJM will and will not recall energy from PJM capacity resources and prohibit new energy exports from PJM capacity resources. The MMU recommends that those rules define the conditions under which PJM will purchase emergency energy while at the same time not recalling energy exports from PJM capacity resources. PJM has modified these rules, but the rules need additional clarification and operational details. (Priority: Low. First reported 2010. Status: Partially adopted.)

Deactivations/Retirements

- The MMU recommends that the notification requirement for deactivations be extended from 90 days prior to the date of deactivation to 12 months prior to the date of deactivation and that PJM and the MMU be provided 60 days rather than 30 days to complete their reliability and market power analyses. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that RMR units recover all and only the incremental costs, including incremental investment costs, required by the RMR service that the unit owner would not have incurred if the unit owner had deactivated its unit as it proposed. Customers should bear no responsibility for paying previously incurred costs, including a return on or of prior investments. (Priority: Low. First reported 2010. Status: Not adopted.)

- The MMU recommends elimination of the cost of service recovery rate in OATT Section 119, and that RMR service should be provided under the deactivation avoidable cost rate in Part V. The MMU also recommends specific improvements to the DACR provisions. (Priority: Medium. First reported 2017. Status: Not adopted.)

Section 5 Conclusion

The analysis of PJM Capacity Markets begins with market structure, which provides the framework for the actual behavior or conduct of market participants. The analysis examines participant behavior within that market structure. In a competitive market structure, market participants are constrained to behave competitively. The analysis examines market performance, measured by price and the relationship between price and marginal cost, that results from the interaction of market structure and participant behavior. Market power is and will remain endemic to the structure of the PJM Capacity Market. Nonetheless a competitive outcome can be assured by appropriate market power mitigation rules.

The MMU concludes that the 2021/2022 RPM Base Residual Auction results were not competitive as a result of offers above the competitive level by some market participants. The MMU recognizes that these market participants followed the capacity market rules by offering at less than the stated offer cap of net CONE times B. But net CONE times B is not a competitive offer when the expected number of performance assessment intervals is zero or a very small number and the nonperformance charge rate is defined as net CONE/30. Under these circumstances, a competitive offer, under the logic defined in PJM's capacity performance filing, is net ACR. That is the way in which most market participants offered in this and prior capacity performance auctions.

The FERC approved PJM tariff defines the offer cap as net CONE times B, rather than including the full logic supporting the definition of the offer cap under the capacity performance paradigm. If the tariff had defined the offer cap consistent with PJM's filing in the capacity performance matter, the offer cap would have been net ACR rather than net CONE times B.

The MMU filed a complaint with the Commission asserting that the market seller offer cap is overstated.⁹⁶ The result of an overstated market seller offer cap is to permit the exercise of market power, as occurred in the 2021/2022 BRA. On March 18, 2021, the Commission issued an order determining that the current default market seller offer cap “is incorrectly calibrated such that it may unjustly and unreasonably prevent the appropriate review of offers, thereby allowing potential exercises of market power.”⁹⁷ The Commission asked the parties to file briefs to address “whether an alternative method for market power mitigation in the PJM capacity market would better address the concern that the current methodology precludes the Market Monitor from reviewing offers that raise market power concerns and mitigating offers where appropriate.” The outcome of the complaint could have a significant and standalone impact on clearing prices in the 2022/2023 BRA.

The MMU is required to identify market issues and to report them to the Commission and to market participants. The Commission decides on any action related to the MMU’s findings.

The MMU found serious market structure issues, measured by the three pivotal supplier test results in the PJM Capacity Market in the last BRA and in subsequent incremental auctions. Explicit market power mitigation rules in the RPM construct only partially offset the underlying market structure issues in the PJM Capacity Market under RPM. In the 2021/2022 RPM Base Residual Auction, the default offer cap of net CONE times B exceeded the competitive offer for a number of resources. Some seasonal resources were paid additional make whole based on a failure of the market power rules to apply offer capping.

⁹⁶ In 2019, the MMU filed a complaint seeking an order directing PJM to update the assumptions regarding the expected number of performance assessment intervals (PAI) in calculating the default capacity market seller offer cap (MSOC). Complaint of the Independent Market Monitor for PJM, Docket No. EL19-47-000 (February 21, 2019).

⁹⁷ 174 FERC ¶ 61,212.

The MMU has identified serious market design issues with RPM and the MMU has made specific recommendations to address those issues.^{98 99 100 101 102 103} In 2020 and 2021, the MMU prepared a number of RPM related reports and testimony, shown in Error! Reference source not found..

The capacity performance modifications to the RPM construct significantly improved the capacity market and addressed a number of issues that had been identified by the MMU. But significant issues remain in the PJM capacity market design.

The PJM markets have worked to provide incentives to entry and to retain capacity. PJM had excess reserves of 11,911.9 ICAP MW on June 1, 2020, and will have excess reserves of 14,228.2 ICAP MW on June 1, 2021, based on current positions.¹⁰⁴ A majority of capacity investments in PJM were financed by market sources.¹⁰⁵ Of the 41,979.4 MW of additional capacity that cleared in RPM auctions for the 2007/2008 through 2019/2020 Delivery Years, 32,348.9 MW (77.1 percent) were based on market funding. Of the 3,032.2 MW of additional capacity that cleared in RPM auctions for the 2020/2021 through 2021/2022 Delivery Years, 2,742.8 MW (90.5 percent) were based on market funding. Those investments were made based on the assumption that markets would be allowed to work and that inefficient units would exit.

The issue of external subsidies, particularly for economic nuclear power plants, continued to evolve. The subsidies are not part of the PJM market design but nonetheless threaten the foundations of the PJM Capacity Market as well as

⁹⁸ See “Analysis of the 2018/2019 RPM Base Residual Auction Revised,” <http://www.monitoringanalytics.com/reports/Reports/2016/IMM_Analysis_of_the_20182019_RPM_Base_Residual_Auction_20160706.pdf> (July 6, 2016).

⁹⁹ See “Analysis of the 2019/2020 RPM Base Residual Auction Revised,” <http://www.monitoringanalytics.com/reports/Reports/2016/IMM_Analysis_of_the_20192020_RPM_BRA_20160831-Revised.pdf> (August 31, 2016).

¹⁰⁰ See “Analysis of the 2020/2021 RPM Base Residual Auction,” <http://www.monitoringanalytics.com/reports/Reports/2017/IMM_Analysis_of_the_20202021_RPM_BRA_20171117.pdf> (November 11, 2017).

¹⁰¹ See “Analysis of the 2021/2022 RPM Base Residual Auction – Revised,” <http://www.monitoringanalytics.com/reports/Reports/2018/IMM_Analysis_of_the_20212022_RPM_BRA_Revised_20180824.pdf> (August 24, 2018).

¹⁰² See “Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2017,” <http://www.monitoringanalytics.com/reports/Reports/2017/IMM_Report_on_Capacity_Replacement_Activity_4_20171214.pdf> (December 14, 2017).

¹⁰³ See “Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019,” <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

¹⁰⁴ The calculated reserve margin for June 1, 2021, does not account for cleared buy bids that have not been used in replacement capacity transactions.

¹⁰⁵ “2020 PJM Generation Capacity and Funding Sources 2007/2008 through 2021/2022 Delivery Years,” <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf> (September 15, 2020).

the competitiveness of PJM markets overall. These subsidy programs originate from the fact that competitive markets result in the exit of uneconomic and uncompetitive generating units. Regardless of the specific rationales offered by unit owners, the proposed solution for all such generating units has been to provide out of market subsidies in order to retain such units. The proposed solution in all cases ignores the opportunity cost of subsidizing uneconomic units, which is the displacement of new resources and technologies that would otherwise be economic. Some subsidies were requested by the owners of economic resources. Some subsidies were requested by the owners of specific uneconomic generating units in order to improve the profitability of those specific units. These subsidies were not requested to accomplish broader social goals. Broader social goals can all be met with market-based mechanisms available to all market participants on a competitive basis and without discrimination.

Subsidies are contagious. Competition in the markets could be replaced and is now being replaced by competition to receive subsidies. Competition to receive subsidies is now a reality and is accelerating in PJM.

It is essential that any approach to the PJM markets incorporate a consistent view of how the preferred market design is expected to provide competitive results in a sustainable market design over the long run. A sustainable market design means a market design that results in appropriate incentives to competitive market participants to retire units and to invest in new units over time such that reliability is ensured as a result of the functioning of the market.

A sustainable competitive wholesale power market must recognize three salient structural elements: state nonmarket revenues for renewable energy; a significant level of generation resources subject to cost of service regulation; and the structure and performance of the existing market based generation fleet.

Overview: Section 6, Demand Response

- **Demand Response Activity.** Demand response activity includes economic demand response (economic resources), emergency and pre-emergency demand response (demand resources), synchronized reserves and regulation. Economic demand response participates in the energy market. Emergency and pre-emergency demand response participates in the capacity market and energy market.¹⁰⁶ Demand response resources participate in the synchronized reserve market. Demand response resources participate in the regulation market.

Total demand response revenue decreased by \$8.5 million, 9.4 percent, from \$94.0 million in the first three months of 2020 to \$85.1 million in the first three months of 2021. Emergency demand response revenue accounted for 98.4 percent of all demand response revenue, economic demand response for 0.1 percent, demand response in the synchronized reserve market for 1.1 percent and demand response in the regulation market for 0.4 percent.

Total emergency demand response revenue decreased by \$9.6 million, 10.2 percent, from \$93.3 million in the first three months of 2020 to \$83.8 million in the first three months of 2021. This decrease consisted entirely of capacity market revenue.¹⁰⁷

Economic demand response revenue increased by \$0.03 million, 96.8 percent, from \$0.03 million in the first three months of 2020 to \$0.07 million in the first three months of 2021.¹⁰⁸ Demand response revenue in the synchronized reserve market increased by \$0.6 million, 220.9 percent, from \$0.3 million in the first three months of 2020 to \$0.9 million in the first three months of 2021. Demand response revenue in the regulation market increased by \$0.05 million, 15.5 percent, from \$0.3 million in the first three months of 2020 to \$0.4 million in the first three months of 2021.

¹⁰⁶ Emergency demand response refers to both emergency and pre-emergency demand response. With the implementation of the Capacity Performance design, there is no functional difference between the emergency and pre-emergency demand response resource.

¹⁰⁷ The total credits and MWh numbers for demand resources were calculated as of January 12, 2021 and may change as a result of continued PJM billing updates.

¹⁰⁸ Economic credits are synonymous with revenue received for reductions under the economic load response program.

- **Demand Response Energy Payments are Uplift.** Energy payments to emergency and economic demand response resources are uplift. LMP does not cover energy payments although emergency and economic demand response can and does set LMP. Energy payments to emergency demand resources are paid by PJM market participants in proportion to their net purchases in the real-time market. Energy payments to economic demand resources are paid by real-time exports from PJM and real-time loads in each zone for which the load-weighted, average real-time LMP for the hour during which the reduction occurred is greater than or equal to the net benefits test price for that month.¹⁰⁹
- **Demand Response Market Concentration.** The ownership of economic load response resources was highly concentrated in 2020 and the first three months of 2021. The HHI for economic resource reductions decreased by 1048 points from 9065 in the first three months of 2020 to 8017 in the first three months of 2021. The ownership of emergency load response resources was highly concentrated in 2020. The HHI for emergency load response committed MW was 1840 for the 2019/2020 Delivery Year. In the 2019/2020 Delivery Year, the four largest CSPs owned 79.1 percent of all committed demand response UCAP MW. The HHI for emergency demand response committed MW was 2171 for the 2020/2021 Delivery Year. In the 2020/2021 Delivery Year, the four largest CSPs owned 85.6 percent of all committed demand response UCAP MW.
- **Limited Locational Dispatch of Demand Resources.** With full implementation of the Capacity Performance rules in the capacity market in the 2020/2021 Delivery Year, PJM should be able to individually dispatch any capacity performance resource, including demand resources. But PJM cannot dispatch demand resources by node with the current rules because demand resources are not registered to a node. Demand resources can be dispatched by subzone only if the subzone is defined before dispatch. Aggregation rules allow a demand resource that incorporates many small end use customers to span an entire zone, which is inconsistent with nodal dispatch.

¹⁰⁹ "PJM Manual 28: Operating Agreement Accounting," § 11.2.2, Rev. 84 (Dec. 17 2020).

Section 6 Recommendations

- The MMU recommends, as a preferred alternative to including demand resources as supply in the capacity market, that demand resources be on the demand side of the markets, that customers be able to avoid capacity and energy charges by not using capacity and energy at their discretion, that customer payments be determined only by metered load, and that PJM forecasts immediately incorporate the impacts of demand side behavior. (Priority: High. First reported 2014. Status: Not adopted.)
- The MMU recommends that the option to specify a minimum dispatch price (strike price) for demand resources be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the demand resources be treated as economic resources, responding to economic price signals like other capacity resources. The MMU recommends that demand resources not be treated as emergency resources, not trigger a PJM emergency and not trigger a Performance Assessment Interval. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Emergency Program Energy Only option be eliminated because the opportunity to receive the appropriate energy market incentive is already provided in the economic program. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends that, if demand resources remain in the capacity market, a daily energy market must offer requirement apply to demand resources, comparable to the rule applicable to generation capacity resources.¹¹⁰ (Priority: High. First reported 2013. Status: Not adopted.)

¹¹⁰ See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

- The MMU recommends that demand resources be required to provide their nodal location, comparable to generation resources. (Priority: High. First reported 2011. Status: Not adopted.)
- The MMU recommends that PJM require nodal dispatch of demand resources with no advance notice required or, if nodal location is not required, subzonal dispatch of demand resources with no advance notice required. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM eliminate the measurement of compliance across zones within a compliance aggregation area (CAA). The multiple zone approach is less locational than the zonal and subzonal approach and creates larger mismatches between the locational need for the resources and the actual response. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that measurement and verification methods for demand resources be modified to reflect compliance more accurately. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that operators have the necessary information for reliability and that market payments to demand resources be calculated based on interval meter data at the site of the demand reductions.¹¹¹ (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends limited, extended summer and annual demand response event compliance be calculated on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that shutdown cost be defined as the cost to curtail load for a given period that does not vary with the measured reduction or, for behind the meter generators, be the start cost defined in Manual 15 for generators. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Net Benefits Test be eliminated and that demand response resources be paid LMP less any generation component of the applicable retail rate. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the tariff rules for demand response clarify that a resource and its CSP, if any, must notify PJM of material changes affecting the capability of the resource to perform as registered and must terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at defined levels because load has been reduced or eliminated, as in the case of bankrupt and/or out of service facilities. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that there be only one demand response product in the capacity market, with an obligation to respond when called for any hour of the delivery year. (Priority: High. First reported 2011. Status: Partially adopted.¹¹²)
- The MMU recommends that the lead times for demand resources be shortened to 30 minutes with an hour minimum dispatch for all resources. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends setting the baseline for measuring capacity compliance under winter compliance at the customers' PLC, similar

¹¹¹ See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

¹¹² PJM's Capacity Performance design requires resources to respond when called for any hour of the delivery year, but demand resources still have a limited mandatory compliance window.

to GLD, to avoid double counting. (Priority: High. First reported 2010. Status: Partially adopted.)

- The MMU recommends the Relative Root Mean Squared Test be required for all demand resources with a CBL. (Priority: Low. First reported 2017. Status: Partially adopted.)
- The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that the limits imposed on the pre-emergency and emergency demand response share of the synchronized reserve market be eliminated. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that 30 minute pre-emergency and emergency demand response be considered to be 30 minute reserves. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that energy efficiency MW not be included in the PJM Capacity Market and that PJM should ensure that the impact of EE measures on the load forecast is incorporated immediately rather than with the existing lag. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that all demand resources register as Pre-Emergency Load Response and that the Emergency Load Response Program be eliminated. (Priority: High. First reported Q1 2020. Status: Not adopted.)

Section 6 Conclusion

A fully functional demand side of the electricity market means that end use customers or their designated intermediaries will have the ability to see real-time energy price signals in real time, will have the ability to react to real-

time prices in real time and will have the ability to receive the direct benefits or costs of changes in real-time energy use. In addition, customers or their designated intermediaries will have the ability to see current capacity prices, will have the ability to react to capacity prices and will have the ability to receive the direct benefits or costs of changes in the demand for capacity in the same year in which demand for capacity changes. A functional demand side of these markets means that customers will have the ability to make decisions about levels of power consumption based both on how customers value the power and on the actual cost of that power.

In the energy market, if there is to be a demand side program, demand resources should be paid the value of energy, which is LMP less any generation component of the applicable retail rate. There is no reason to have the net benefits test. The necessity for the net benefits test is an illustration of the illogical approach to demand side compensation embodied in paying full LMP to demand resources. The benefit of demand side resources is not that they suppress market prices, but that customers can choose not to consume at the current price of power, that individual customers benefit from their choices and that the choices of all customers are reflected in market prices. If customers face the market price, customers should have the ability to not purchase power and the market impact of that choice does not require a test for appropriateness.

If demand resources are to continue competing directly with generation capacity resources in the PJM Capacity Market, the product must be defined such that it can actually serve as a substitute for generation. This is a prerequisite to a functional market design. Demand resources do not have a must offer requirement into the day-ahead energy market, are able to offer above \$1,000 per MWh without providing a fuel cost policy, or any rationale for the offer. PJM automatically, and inappropriately, triggers a PAI when demand resources are dispatched and demand resources do not have telemetry requirements similar to other Capacity Performance resources.

In order to be a substitute for generation, demand resources should be defined in PJM rules as an economic resource, as generation is defined. Demand

resources should be required to offer in the day-ahead energy market and should be called when the resources are required and prior to the declaration of an emergency. Demand resources should be available for every hour of the year. The fact that PJM currently defines demand resources as emergency resources and the fact that calling on demand resources triggers a performance assessment interval (PAI) under the Capacity Performance design, both serve as a significant disincentive to calling on demand resources and mean that demand resources are underused. Demand resources should be treated as economic resources like any other capacity resource. Demand resources should be called when economic and paid the LMP rather than an inflated strike price up to \$1,849 per MWh that is set by the seller.

In order to be a substitute for generation, demand resources (DR) should be subject to robust measurement and verification techniques to ensure that transitional DR programs incent the desired behavior. The methods used in PJM programs today are not adequate to determine and quantify deliberate actions taken to reduce consumption.

In order to be a substitute for generation, demand resources should provide a nodal location and should be dispatched nodally to enhance the effectiveness of demand resources and to permit the efficient functioning of the energy market. Both subzonal and multi-zone compliance should be eliminated because they are inconsistent with an efficient nodal market.

In order to be a substitute for generation, compliance by demand resources with PJM dispatch instructions should include both increases and decreases in load. The current method applied by PJM simply ignores increases in load and thus artificially overstates compliance.

In order to be a substitute for generation, reductions should be calculated hourly for dispatched DR. The current rules use the average reduction for the duration of an event. The average reduction across multiple hours does not provide an accurate metric for each hour of the event and is inconsistent with the measurement of generation resources. Measuring compliance hourly would provide accurate information to the PJM system. Under the new CP

rules, the performance of demand response during Performance Assessment Interval (PAI) will be measured on a five-minute basis.

In order to be a substitute for generation, any demand resource and its Curtailment Service Provider (CSP), should be required to notify PJM of material changes affecting the capability of the resource to perform as registered and to terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at the specified level, such as in the case of bankrupt and out of service facilities. Generation resources are required to inform PJM of any change in availability status, including outages and shutdown status.

As a preferred alternative to being a substitute for generation in the capacity and energy markets, demand response resources should be on the demand side of the capacity market rather than on the supply side. Rather than detailed demand response programs with their attendant complex and difficult to administer rules, customers would be able to avoid capacity and energy charges by not using capacity and energy at their discretion and the level of usage paid for would be defined by metered usage rather than a complex and inaccurate measurement protocol.

The MMU peak shaving proposal at the Summer-Only Demand Response Senior Task Force (SODRSTF) is an example of how to create a demand side product that is on the demand side of the market and not on the supply side.¹¹³ The MMU proposal was based on the BGE load forecasting program and the Pennsylvania Act 129 Utility Program.¹¹⁴ ¹¹⁵ Under the MMU proposal, participating load would inform PJM prior to an RPM auction of the MW participating, the months and hours of participation and the temperature humidity index (THI) threshold at which load would be reduced. PJM would reduce the load forecast used in the RPM auction based on the designated reductions. Load would agree to curtail demand to at or below a defined FSL, less than the customer PLC, when the THI exceeds a defined level or load

¹¹³ See the MMU package within the *SODRSTF Matrix*, <<http://www.pjm.com/-/media/committees-groups/task-forces/sodrستف/20180802/20180802-item-04-sodrستف-matrix.ashx>>.

¹¹⁴ *Advance signals that can be used to foresee demand response days*, BGE, <<https://www.pjm.com/-/media/committees-groups/task-forces/sodrستف/20180309/20180309-item-05-bge-load-curtailment-programs.ashx>> (Accessed March 6, 2019).

¹¹⁵ *Pennsylvania ACT 129 Utility Program*, CPower, <<https://www.pjm.com/-/media/committees-groups/task-forces/sodrستف/20180413/20180413-item-03-pa-act-129-program.ashx>> (Accessed March 6, 2019).

exceeds a specified threshold. By relying on metered load and the PLC, load can reduce its demand for capacity and that reduction can be verified without complicated and inaccurate metrics to estimate load reductions. Under PJM's weakened version of the program, performance will be measured under the current economic demand response CBL rules which means relying on load estimates rather than actual metered load.¹¹⁶ PJM's proposal includes only a THI curtailment trigger and not an overall load curtailment trigger.

The long term appropriate end state for demand resources in the PJM markets should be comparable to the demand side of any market. Customers should use energy as they wish, accounting for market prices in any way they like, and that usage will determine the amount of capacity and energy for which each customer pays. There would be no counterfactual measurement and verification.

Under this approach, customers that wish to avoid capacity payments would reduce their load during expected high load hours. Capacity costs would be assigned to LSEs and by LSEs to customers, based on actual load on the system during these critical hours. Customers wishing to avoid high energy prices would reduce their load during high price hours. Customers would pay for what they actually use, as measured by meters, rather than relying on flawed measurement and verification methods. No measurement and verification estimates are required. No promises of future reductions which can only be verified by inaccurate and biased measurement and verification methods are required. To the extent that customers enter into contracts with CSPs or LSEs to manage their payments, measurement and verification can be negotiated as part of a bilateral commercial contract between a customer and its CSP or LSE. But the system would be paid for actual, metered usage, regardless of which contractual party takes that obligation.

This approach provides more flexibility to customers to limit usage at their discretion. There is no requirement to be available year round or every hour of every day. There is no 30 minute notice requirement. There is no requirement

¹¹⁶ The PJM proposal from the SODRSTF weakened the proposal but was approved at the October 25, 2018 Members Committee meeting and PJM filed Tariff changes on December 7, 2018. See "Peak Shaving Adjustment Proposal," Docket No. ER19-511-000 (December 7, 2018).

to offer energy into the day-ahead market. All decisions about interrupting are up to the customers only and they may enter into bilateral commercial arrangements with CSPs at their sole discretion. Customers would pay for capacity and energy depending solely on metered load.

A transition to this end state should be defined in order to ensure that appropriate levels of demand side response are incorporated in PJM's load forecasts and thus in the demand curve in the capacity market. That transition should be defined by the PRD rules, modified as proposed by the MMU.

This approach would work under the CP design in the capacity market. This approach is entirely consistent with the Supreme Court decision in *EPSA* as it does not depend on whether FERC has jurisdiction over the demand side.¹¹⁷ This approach will allow FERC to more fully realize its overriding policy objective to create competitive and efficient wholesale energy markets. The decision of the Supreme Court addressed jurisdictional issues and did not address the merits of FERC's approach. The Supreme Court's decision has removed the uncertainty surrounding the jurisdictional issues and created the opportunity for FERC to revisit its approach to demand side.

Overview: Section 7, Net Revenue

Net Revenue

- Energy market net revenues are significantly affected by energy prices and fuel prices. Energy prices and gas prices were higher in the first three months of 2021 than in the first three months of 2020.
- In the first three months of 2021, average energy market net revenues increased by 55 percent for a new combustion turbine (CT), 32 percent for a new combined cycle (CC), 9,549 percent for a new coal plant (CP), 53 percent for a new nuclear plant, 1,892 percent for a new diesel (DS), 38 percent for a new onshore wind installation, 67 percent for a new offshore wind installation and 27 percent for a new solar installation compared to the first three months of 2020.

¹¹⁷ 577 U.S. 260 (2016).

- The price of natural gas increased by significantly more than the price of coal in the first three months of 2021, as a result of very high gas prices in mid February. As a result, the marginal costs of a new CC and a new CT were greater than the marginal cost of a new CP in February 2021 but lower in January and March.
- Based on Western Hub prices, the spark spread in the first three months of 2021 decreased by 7 percent while the spark spread standard deviation increased by 148 percent and the dark spread increased by 134 percent while the dark spread standard deviation decreased by 189 percent.

Section 7 Recommendations

- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) and net ACR be based on a forward looking estimate of expected energy and ancillary services net revenues using forward prices for energy and fuel. (Priority: Medium. First reported 2019. Status: Adopted 2020.)

Section 7 Conclusion

Wholesale electric power markets are affected by externally imposed reliability requirements. A regulatory authority external to the market makes a determination as to the acceptable level of reliability which is enforced through a requirement to maintain a target level of installed or unforced capacity. The requirement to maintain a target level of installed capacity can be enforced via a variety of mechanisms, including government construction of generation, full-requirement contracts with developers to construct and operate generation, state utility commission mandates to construct capacity, or capacity markets of various types. Regardless of the enforcement mechanism, the exogenous requirement to construct capacity in excess of what is constructed in response to energy market signals has an impact on energy markets. The reliability requirement results in maintaining a level of capacity in excess of the level that would result from the operation of an energy market alone. The result of that additional capacity is to reduce the level and volatility of energy market prices and to reduce the duration of high

energy market prices. This, in turn, reduces net revenue to generation owners which reduces the incentive to invest. The exact level of both aggregate and locational excess capacity is a function of the calculation methods used by RTOs and ISOs.

Overview: Section 8, Environmental and Renewables Federal Environmental Regulation

- **MATS.** The U.S. Environmental Protection Agency's (EPA) Mercury and Air Toxics Standards rule (MATS) applies the Clean Air Act (CAA) maximum achievable control technology (MACT) requirement to new or modified sources of emissions of mercury and arsenic, acid gas, nickel, selenium and cyanide.¹¹⁸ On May 22, 2020, the EPA published its determination that MATS is not appropriate and necessary based on a cost-benefit analysis.¹¹⁹ The list of coal steam units subject to MATS, however, remains in place.¹²⁰ All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS. The EPA's May 22, 2020, finding is under review pursuant to Executive Order 13990.
- **Air Quality Standards (NO_x and SO₂ Emissions).** The CAA requires each state to attain and maintain compliance with fine particulate matter (PM) and ozone national ambient air quality standards (NAAQS). The CAA also requires that each state prohibit emissions that significantly interfere with the ability of another state to meet NAAQS.¹²¹ On March 15, 2021, the EPA finalized decreases to allowable emissions under the Cross-State Air Pollution Rule (CSAPR) and the 2008 ozone NAAQS for 10 PJM states.¹²²
- **NSR.** On August 1, 2019, the EPA proposed to reform the New Source Review (NSR) permitting program.¹²³ NSR requires new projects and existing projects receiving major overhauls that significantly increase

¹¹⁸ *National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil Fuel Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR-2009-0234, 77 Fed. Reg. 9304 (Feb. 16, 2012).

¹¹⁹ See *National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Reconsideration of Supplemental Finding and Residual Risk and Technology Review*, Docket No. EPA-HQ-OAR-2018-0794, 85 Fed. Reg. 31286.

¹²⁰ *Id.* at 31291.

¹²¹ CAA § 110(a)(2)(D)(i)(I).

¹²² *Revised Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*, Docket No. EPA-HQ-OAR-2020-0272; FRL-10013-42—OAR, 85 Fed. Reg. 23054 (Apr. 30, 2021).

¹²³ *Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NNSR): Project Emissions Accounting*, EPA Docket No. EPA-HQ-OAR-2018-0048; FRL-9997-95—OAR, 84 Fed. Reg. 39244 (Aug. 9, 2019).

emissions to obtain permits. Recent EPA proposals would reduce the number of projects that require permits.

- **RICE.** Stationary reciprocating internal combustion engines (RICE) are electrical generation facilities like diesel engines typically used for backup, emergency or supplemental power. RICE must be tested annually.¹²⁴ RICE do not have to meet the same emissions standards if they are emergency stationary RICE. Environmental regulations allow emergency stationary RICE participating in demand response programs to operate for up to 100 hours per calendar year when providing emergency demand response when there is a PJM declared NERC Energy Emergency Alert Level 2 or there are five percent voltage/frequency deviations.

PJM does not prevent emergency stationary RICE that cannot meet its capacity market obligations as a result of EPA emissions standards from participating in PJM markets as DR. Some emergency stationary RICE that cannot meet its capacity market obligations as a result of emissions standards are now included in DR portfolios. Emergency stationary RICE should be prohibited from participation as DR either when registered individually or as part of a portfolio if it cannot meet its capacity market obligations as a result of emissions standards.

- **Greenhouse Gas Emissions.** On January 19, 2021, the U.S. Court of Appeals for the District of Columbia Circuit vacated the EPA's Affordable Clean Energy (ACE) rule which would have permitted more CO₂ emissions than under the Clean Power Plan (CPP), which ACE had replaced.¹²⁵ Neither the ACE nor CPP is currently effective.
- **Cooling Water Intakes.** An EPA rule implementing Section 316(b) of the Clean Water Act (CWA) requires that cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts.¹²⁶
- **Waters of the United States.** The EPA finalized a rule that significantly narrows the definition of the Waters of the United States. In contrast, the Supreme Court expanded the scope of the CWA when it held that

discharge of pollutants from a point source into non jurisdictional groundwater "is the functional equivalent of a direct discharge" when pollutants are conveyed by groundwater into jurisdictional waters.¹²⁷ The EPA's definition of the Waters of the United States is among the actions under review pursuant to Executive Order 13990.

- **Coal Ash.** The EPA administers the Resource Conservation and Recovery Act (RCRA), which governs the disposal of solid and hazardous waste.¹²⁸ The EPA has proposed significant changes to the implementing regulations.

State Environmental Regulation

- **Regional Greenhouse Gas Initiative (RGGI).** The Regional Greenhouse Gas Initiative (RGGI) is a CO₂ emissions cap and trade agreement among Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia that applies to power generation facilities. New Jersey rejoined on January 1, 2020.¹²⁹ Virginia joined RGGI on January 1, 2021, and Pennsylvania is preparing to join.¹³⁰ ¹³¹ The auction price in the March 3, 2021 was \$7.60 per ton, or \$8.38 per metric tonne.
- **Carbon Price.** If the price of carbon were \$50.00 per metric tonne, short run marginal costs would increase by \$24.52 per MWh or 68.0 percent for a new combustion turbine (CT) unit, \$16.71 per MWh or 67.1 percent for a new combined cycle (CC) unit and \$43.15 per MWh or 145.0 percent for a new coal plant (CP) for January through March, 2021.

State Renewable Portfolio Standards

- **RPS.** In PJM, ten of 14 jurisdictions have enacted legislation requiring that a defined percentage of retail suppliers' load be served by renewable resources, for which definitions vary. These are typically known as renewable portfolio standards, or RPS. As of March 31, 2021, Delaware,

¹²⁴ See 40 CFR § 63.6640(f).

¹²⁵ American Lung Association et al. v. EPA, No. 19-1140.

¹²⁶ See EPA, *National Pollutant Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities*, EPA-HQ-OW-2008-0667, 79 Fed. Reg. 48300 (Aug. 15, 2014).

¹²⁷ *County of Maui v. Hawaii Wildlife Fund*, Slip. Op. No. 18-260 (April 23, 2020).

¹²⁸ 42 U.S.C. §§ 6901 et seq.

¹²⁹ "Statement on New Jersey Greenhouse Gas Rule," RGGI Inc., (June 17, 2019) <https://www.rggi.org/sites/default/files/Uploads/Press-Releases/2019_06_17_NJ_Announcement_Release.pdf>.

¹³⁰ "Statement on Virginia Greenhouse Gas Rule," RGGI, (July 8, 2020) <<https://www.rggi.org/news-releases/rggi-releases>>.

¹³¹ Executive Order—2019-07. Commonwealth Leadership in Addressing Climate Change through Electric Sector Emissions Reductions, Tom Wolf, Governor, October 3, 2019, <<https://www.governor.pa.gov/newsroom/executive-order-2019-07-commonwealth-leadership-in-addressing-climate-change-through-electric-sector-emissions-reductions/>>.

Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia and Washington, DC have renewable portfolio standards. Virginia had a voluntary RPS in 2020, but a new mandatory RPS became effective on January 1, 2021. Indiana has voluntary renewable portfolio standards. Kentucky, Tennessee and West Virginia do not have renewable portfolio standards.

- **RPS Cost.** The cost of complying with RPS, as reported by the states, is \$5.6 billion over the six year period from 2014 through 2019, an average annual RPS compliance cost of \$936.7 million. The compliance cost for 2019, the most recent year with almost complete data, was \$1.2 billion.¹³²

Emissions Controls in PJM Markets

- **Regulations.** Environmental regulations affect decisions about emission control investments in existing units, investment in new units and decisions to retire units. As a result of environmental regulations and agreements to limit emissions, many PJM units burning fossil fuels have installed emission control technology.
- **Emissions Controls.** In PJM, as of March 31, 2021, 93.6 percent of coal steam MW had some type of flue-gas desulfurization (FGD) technology to reduce SO₂ emissions, while 99.8 percent of coal steam MW had some type of particulate control, and 94.7 percent of fossil fuel fired capacity had NO_x emission control technology. All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS.

Renewable Generation

- **Renewable Generation.** Wind and solar generation was 4.6 percent of total generation in PJM in the first three months of 2021. RPS Tier I generation was 6.3 percent of total generation in PJM and RPS Tier II generation was 2.1 percent of total generation in PJM in the first three months of 2021. Only Tier I generation is defined to be renewable but Tier 1 includes some carbon emitting generation.

¹³² The 2019 compliance cost value for PJM states does not include Illinois, Michigan or North Carolina. Based on past data these states generally account for 3.0 percent of the total RPS compliance cost of PJM states.

Section 8 Recommendations

- The MMU recommends that renewable energy credit markets based on state renewable portfolio standards be brought into PJM markets as they are an increasingly important component of the wholesale energy market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the Commission reconsider its disclaimer of jurisdiction over RECs markets because, given market changes since that decision, it is clear that RECs materially affect jurisdictional rates. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to the PJM states in order to permit the states to consider a potential agreement on the development of a multistate framework for carbon pricing and the distribution of carbon revenues. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that jurisdictions with a renewable portfolio standard make the price and quantity data on supply and demand more transparent. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that load and generation located at separate nodes be treated as separate resources in order to ensure that load and generation face consistent incentives throughout the markets. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that emergency stationary RICE be prohibited from participation as DR either when registered individually or as part of a portfolio if it cannot meet the capacity market requirements to be DR as a result of emissions standards that impose environmental run hour limitations. (Priority: Medium. First reported 2019. Status: Not adopted.)

Section 8 Conclusion

Environmental requirements and renewable energy mandates at both the federal and state levels have a significant impact on the cost of energy and capacity in PJM markets. Renewable energy credit (REC) markets are markets

related to the production and purchase of wholesale power, but FERC has determined that RECs are not regulated under the Federal Power Act unless the REC is sold as part of a transaction that also includes a wholesale sale of electric energy in a bundled transaction.¹³³ The MMU recommends that the Commission reconsider its disclaimer of jurisdiction over RECs markets because, given market changes since that decision, it is clear that RECs materially affect jurisdictional rates.

RECs clearly affect prices in the PJM wholesale power market. Some resources are not economic except for the ability to purchase or sell RECs. RECs provide out of market payments to qualifying renewable resources, primarily wind and solar. The credits provide an incentive to make negative energy offers and more generally provide an incentive to enter the market, to remain in the market and to operate whenever possible. These subsidies affect the offer behavior and the operational behavior of these resources in PJM markets and in some cases the existence of these resources and thus the market prices and the mix of clearing resources. FERC's recent MOPR order addressed these impacts.

RECs markets are, as an economic fact, integrated with PJM markets including energy and capacity markets, but are not formally recognized as part of PJM markets. It would be preferable to have a single, transparent market for RECs operated by the PJM RTO on behalf of the states that would meet the standards and requirements of all states in the PJM footprint including those with no RPS. This would provide better information for market participants about supply and demand and prices and contribute to a more efficient and competitive market and to better price formation. This could also facilitate entry by qualifying renewable resources by reducing the risks associated with lack of transparent market data. The MMU recommends that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to states in order to permit states to consider the development of a multistate framework: for RECs markets; for potential

¹³³ See 139 FERC ¶ 61,061 at PP 18, 22 (2012) ("[W]e conclude that unbundled REC transactions fall outside of the Commission's jurisdiction under sections 201, 205 and 206 of the FPA. We further conclude that bundled REC transactions fall within the Commission's jurisdiction under sections 201, 205 and 206 of the FPA.... [A]lthough a transaction may not directly involve the transmission or sale of electric energy, the transaction could still fall under the Commission's jurisdiction because it is 'in connection with' or 'affects' jurisdictional rates or charges.")

agreement on carbon pricing including the distribution of carbon revenues; and for coordination with PJM wholesale markets.

REC markets are not consistently or adequately transparent. Data on REC prices, clearing quantities and markets are not publicly available for all PJM states. The provision of more complete data would facilitate competition to provide energy from renewable sources.

The economic logic of RPS programs and the associated REC and SREC prices is not always clear. The price of carbon implied by REC prices ranges from \$7.67 per tonne in Washington, DC to \$17.88 per tonne in Ohio. The price of carbon implied by SREC prices ranges from \$66.50 per tonne in Pennsylvania to \$882.33 per tonne in Washington, DC. The effective prices for carbon compare to the RGGI clearing price in March 2021 of \$8.38 per tonne and to the social cost of carbon which is estimated in the range of \$50 per tonne.¹³⁴ The impact on the cost of generation from a new combined cycle unit of a \$50 per tonne carbon price would be \$16.71 per MWh.¹³⁵ The impact of an \$800 per tonne carbon price would be \$267.30 per MWh. This wide range of implied carbon prices is not consistent with an efficient, competitive, least cost approach to the reduction of carbon emissions.

In addition, even the explicit environmental goals of RPS programs are not clear. While RPS is frequently considered to target carbon emissions, Tier 1 resources include some carbon emitting generation and Tier 2 resources include additional carbon emitting generation.

PJM markets provide a flexible mechanism for incorporating the costs of environmental controls and meeting environmental requirements in a cost effective manner. Costs for environmental controls are part of offers for capacity resources in the PJM Capacity Market. The costs of emissions credits are included in energy offers. PJM markets also provide a flexible mechanism that incorporates renewable resources and the impacts of renewable energy

¹³⁴ "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12899," Interagency Working Group on the Social Cost of Greenhouse Gases, United States Government, (Aug. 2016), <https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf>.

¹³⁵ The cost impact calculation assumes a heat rate of 6.296 MMBtu per MWh and a carbon emissions rate of 0.053070 tonne per MMBtu. The \$800 per tonne carbon price represents the approximate upper end of the carbon prices implied by the 2019 REC and SREC prices in the PJM jurisdictions with RPS. Additional cost impacts are provided in Table 818.

credit markets, and ensures that renewable resources have access to a broad market. PJM markets provide efficient price signals that permit valuation of resources with very different characteristics when they provide the same product.

PJM markets could also provide a flexible mechanism to limit carbon output, for example by incorporating a consistent carbon price in unit offers which would be reflected in PJM's economic dispatch. If there is a social decision to limit carbon output, a consistent carbon price would be the most efficient way to implement that decision. The states in PJM could agree, if they decided it was in their interests, with the appropriate information, on a carbon price and on how to allocate the revenues from a carbon price that would make all states better off. A mechanism like RGGI leaves all decision making with the states. The carbon price would not be FERC jurisdictional or subject to PJM decisions. The MMU continues to recommend that PJM provide modeling information to the states adequate to inform such a decision making process. Such modeling information would include the impact on the dispatch of every unit, the impact on energy prices and the carbon pricing revenues that would flow to each state. This would permit states to make critical decisions about carbon pricing. For example, states receiving high levels of revenue could shift revenue to states disproportionately hurt by a carbon price if they believed that all states would be better off as a result. A carbon price would also be an alternative to specific subsidies to individual nuclear power plants and to the current wide range of implied carbon prices embedded in RPS programs and instead provide a market signal to which any resource could respond. The imposition of specific and prescriptive environmental dispatch rules would, in contrast, pose a threat to economic dispatch and efficient markets and create very difficult market power monitoring and mitigation issues. The provision of subsidies to individual units creates a discriminatory regime that is not consistent with competition. The use of inconsistent implied carbon prices by state is also inconsistent with an efficient market and inconsistent with the least cost approach to meeting state environmental goals.

The annual average cost of complying with RPS over the six year period from 2014 through 2019 for the nine jurisdictions that had RPS was \$936.7 million,

or a total of \$5.2 billion over six years. The RPS compliance cost for 2019, the most recent year for which there is almost complete data, was \$1.2 billion.¹³⁶ RPS costs are payments by customers to the sellers of qualifying resources. The revenues from carbon pricing flow to the states.

If all the PJM states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances would be approximately \$2.5 billion per year if the carbon price were \$7.60 per short ton and emissions levels were five percent below 2020 emission levels. If all the PJM states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances would be approximately \$16.6 billion if the carbon price were \$50 per short ton and emission levels were five percent below 2020 levels. If only the current RPS states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances at \$7.60 per short ton would be about \$1.7 billion. The costs of a carbon price are the impact on energy market prices, net of the revenue returned to states/customers.

Overview: Section 9, Interchange Transactions

Interchange Transaction Activity

- **Aggregate Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, PJM was a monthly net exporter of energy in the real-time energy market in all months.¹³⁷ In the first three months of 2021, the real-time net interchange was -9,240.5 GWh. The real-time net interchange in the first three months of 2020 was -7,557.3 GWh.
- **Aggregate Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, PJM was a monthly net exporter of energy in the day-ahead energy market in all months. In the first three months of 2021, the total day-ahead net interchange was -7,268.0 GWh. The day-ahead net interchange in the first three months of 2020 was -1,989.6 GWh.

¹³⁶ The 2019 compliance cost value for PJM states does not include Illinois, Michigan or North Carolina. Based on past data these states generally account for 3.0 percent of the total RPS compliance cost of PJM states.

¹³⁷ Calculated values shown in Section 9, "Interchange Transactions," are based on unrounded, underlying data and may differ from calculations based on the rounded values in the tables.

- **Aggregate Imports and Exports in the Day-Ahead and the Real-Time Energy Market.** In the first three months of 2021, gross imports in the day-ahead energy market were 113.6 percent of gross imports in the real-time energy market (525.0 percent in the first three months of 2020). In the first three months of 2021, gross exports in the day-ahead energy market were 85.6 percent of the gross exports in the real-time energy market (140.1 percent in the first three months of 2020).
- **Interface Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, there were net scheduled exports at 16 of PJM's 19 interfaces in the real-time energy market.
- **Interface Pricing Point Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, there were net scheduled exports at six of PJM's nine interface pricing points eligible for real-time transactions in the real-time energy market.¹³⁸
- **Interface Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, there were net scheduled exports at 12 of PJM's 19 interfaces in the day-ahead energy market.
- **Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, there were net scheduled exports at six of PJM's nine interface pricing points eligible for day-ahead transactions in the day-ahead energy market.¹³⁹
- **Up To Congestion Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, up to congestion transactions were net exports at six of PJM's nine interface pricing points eligible for day-ahead transactions in the day-ahead energy market.¹⁴⁰
- **Inadvertent Interchange.** In the first three months of 2021, net scheduled interchange was 9,240.5 GWh and net actual interchange was -9,240.8 GWh, a difference of 0.3 GWh. In the first three months of 2020, the difference was 38.1 GWh. This difference is inadvertent interchange.

¹³⁸ The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the real-time energy market and the day-ahead energy market and has been removed from the figures and tables. The removal of this pricing point reduces the number of real-time and day-ahead interface pricing points to nine.

¹³⁹ *ibid.*

¹⁴⁰ *ibid.*

- **Loop Flows.** In the first three months of 2021, the Northern Indiana Public Service (NIPS) Interface had the largest loop flows of any interface with -339 GWh of net scheduled interchange and -3,097 GWh of net actual interchange, a difference of 2,758 GWh. In the first three months of 2021, the SouthIMP interface pricing point had the largest loop flows of any interface pricing point with 1,121 GWh of net scheduled interchange and 6,200 GWh of net actual interchange, a difference of 5,079 GWh.

Interactions with Bordering Areas

PJM Interface Pricing with Organized Markets

- **PJM and MISO Interface Prices.** In the first three months of 2021, the direction of the hourly flow was consistent with the real-time hourly price differences between the PJM/MISO Interface and the MISO/PJM Interface in 60.2 percent of the hours.
- **PJM and New York ISO Interface Prices.** In the first three months of 2021, the direction of the hourly flow was consistent with the real-time hourly price differences between the PJM/NYIS Interface and the NYISO/PJM proxy bus in 52.4 percent of the hours.
- **Neptune Underwater Transmission Line to Long Island, New York.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Neptune Interface and the NYISO Neptune bus in 53.8 percent of the hours.
- **Linden Variable Frequency Transformer (VFT) Facility.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Linden Interface and the NYISO Linden bus in 75.8 percent of the hours.
- **Hudson DC Line.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Hudson Interface and the NYISO Hudson bus in 62.3 percent of the hours.

Interchange Transaction Issues

- **PJM Transmission Loading Relief Procedures (TLRs).** PJM issued two TLRs of level 3a or higher in the first three months of 2021, compared to zero such TLRs issued in the first three months of 2020.
- **Up To Congestion.** The average number of up to congestion bids submitted in the day-ahead energy market decreased by 45.6 percent, from 49,461 bids per day in the first three months of 2020 to 26,918 bids per day in the first three months of 2021. The average cleared volume of up to congestion bids submitted in the day-ahead energy market decreased by 54.8 percent, from 464,019 MWh per day in the first three months of 2020, to 209,921 MWh per day in the first three months of 2021.

Section 9 Recommendations

- The MMU recommends that PJM implement rules to prevent sham scheduling. The MMU recommends that PJM apply after the fact market settlement adjustments to identified sham scheduling segments to ensure that market participants cannot benefit from sham scheduling. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would prohibit market participants from breaking transactions into smaller segments to defeat the interface pricing rule by concealing the true source or sink of the transaction. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would require market participants to submit transactions on paths that reflect the expected actual power flow in order to reduce unscheduled loop flows. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM end the practice of maintaining outdated definitions of interface pricing points, eliminate the NIPSCO, Southeast and Southwest interface pricing points from the day-ahead and real-time energy markets and, with VACAR, assign the transactions created

under the reserve sharing agreement to the SouthIMP/EXP pricing point. (Priority: High. First reported 2013. Status: Partially adopted, Q2 2020.)¹⁴¹

- The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the locational price impact of flows between the DC tie line point of connection with the Eastern Interconnection and PJM. (Priority: High. First reported Q1, 2020. Status: Not adopted.)
- The MMU recommends changing the assignment of the Saskatchewan Power Company and Manitoba Hydro balancing authorities from the Northwest interface pricing point to the MISO interface pricing point and eliminating the Northwest interface pricing point from the day-ahead and real-time energy markets. (Priority: High. First reported Q1, 2020. Status: Adopted Q4, 2020.)
- The MMU recommends that PJM eliminate the IMO interface pricing point, and assign the transactions that originate or sink in the IESO balancing authority to the MISO interface pricing point. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM eliminate the NCMPAIMP and NCMPAEXP interface pricing points. It is not appropriate to have special pricing agreements between PJM and any external entity. The same market pricing should apply to all transactions. (Priority: High. First reported Q2, 2020. Status: Adopted Q4, 2020.)
- The MMU recommends that PJM monitor, and adjust as necessary, the weights applied to the components of the interfaces to ensure that the interface prices reflect ongoing changes in system conditions. The MMU also recommends that PJM review the mappings of external balancing authorities to individual interface pricing points to reflect changes to the impact of the external power source on PJM tie lines as a result of system topology changes. The MMU recommends that this review occur at least annually. (Priority: Low. First reported 2009. Status: Not adopted.)

¹⁴¹ The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the day-ahead or real-time energy markets. Effective June 1, 2020, PJM retired the NIPSCO interface pricing point.

- The MMU recommends that, in order to permit a complete analysis of loop flow, FERC and NERC ensure that the identified data are made available to market monitors as well as other industry entities determined appropriate by FERC. (Priority: Medium. First reported 2003. Status: Not adopted.)
- The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that would remove the need for market participants to schedule physical transactions across seams. Such a solution would include an optimized, but limited, joint dispatch approach that uses supply curves and treats seams between balancing authorities as constraints, similar to other constraints within an LMP market. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM permit unlimited spot market imports as well as unlimited nonfirm point to point willing to pay congestion imports and exports at all PJM interfaces in order to improve the efficiency of the market. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that the emergency interchange cap be replaced with a market based solution. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the submission deadline for real-time dispatchable transactions be modified from 1800 on the day prior, to three hours prior to the requested start time, and that the minimum duration be modified from one hour to 15 minutes. These changes would give PJM a more flexible product that could be used to meet load in the most economic manner. (Priority: Medium. First reported 2014. Status: Partially adopted, 2015.)
- The MMU recommends modifications to the FFE calculation to ensure that FFE calculations reflect the current capability of the transmission system as it evolves. The MMU recommends that the Commission set a deadline for PJM and MISO to resolve the FFE freeze date and related issues. (Priority: Medium. First reported 2019. Status: Not adopted.)

Section 9 Conclusion

Transactions between PJM and multiple balancing authorities in the Eastern Interconnection are part of a single energy market. While some of these balancing authorities are termed market areas and some are termed nonmarket areas, all electricity transactions are part of a single energy market. Nonetheless, there are significant differences between market and nonmarket areas. Market areas, like PJM, include essential features of an energy market including locational marginal pricing, financial congestion offsets (FTRs and ARRs in PJM) and transparent, least cost, security constrained economic dispatch for all available generation. Nonmarket areas do not include these features. Pricing in the market areas is transparent and pricing in the nonmarket areas is not transparent.

The MMU's recommendations related to transactions with external balancing authorities all share the goal of improving the economic efficiency of interchange transactions. The standard of comparison is an LMP market. In an LMP market, redispatch based on LMP and competitive generator offers results in an efficient dispatch and efficient prices. The goal of designing interface transaction rules should be to match the outcomes that would exist in an LMP market across the interfaces.

It is not appropriate to have special pricing agreements between PJM and any external entity. The same market pricing should apply to all transactions. External entities wishing to receive the benefits of the PJM LMP market should join PJM.

In 2020, PJM terminated a number of interface pricing points, consistent with longstanding MMU recommendations. Following the termination of the Northwest pricing point on October 1, 2020, PJM failed to correctly map the pricing points to transactions that had been mapped to the Northwest pricing point to pricing points that are consistent with electrical impacts on the PJM system. The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the electrical impact of flows between the DC tie line point of connection with the Eastern Interconnection

and PJM. The MMU continues to recommend the termination of the Southeast interface pricing point and the Ontario interface pricing point. The Southeast pricing point is inappropriately used to support a special agreement and the Ontario interface pricing point is noncontiguous to the PJM footprint that creates opportunities for market participants to engage in sham scheduling activities.

Overview: Section 10, Ancillary Services

Primary Reserve

PJM's primary reserves are made up of resources, both synchronized and nonsynchronized, that can provide energy within 10 minutes. Primary reserve is PJM's implementation of the NERC 15-minute contingency reserve requirement.¹⁴²

PJM determines the primary reserve requirement based on the most severe single contingency plus 190 MW in every approved RT SCED case. Every real-time market solution calculates the available tier 1 synchronized reserve. The required synchronized reserve and nonsynchronized reserve are calculated and dispatched in every real-time market solution, and there are associated clearing prices (SRMCP and NSRMCP) assigned every five minutes. Scheduled resources are credited based on a dispatched assignment and a five minute clearing price.

Market Structure

- **Supply.** Primary reserve is satisfied by both synchronized reserve (generation or demand response currently synchronized to the grid and available within 10 minutes), and nonsynchronized reserve (generation currently off line but available to start and provide energy within 10 minutes).
- **Demand.** The PJM primary reserve requirement is 150 percent of the most severe single contingency plus 190 MW. In the first three months of 2021, the average primary reserve requirement was 2,458.0 MW in both the RTO Zone and the MAD Subzone.

¹⁴² See PJM. "Manual 10: Pre-Scheduling Operations," § 3.1.1 Day-ahead Scheduling (Operating Reserve, Rev. 39 (Nov. 19, 2019)).

Tier 1 Synchronized Reserve

Synchronized reserve is provided by generators and demand response resources synchronized to the grid and capable of increasing output or decreasing load within 10 minutes in response to a PJM declared synchronized reserve event. Synchronized reserve consists of tier 1 and tier 2 synchronized reserves.

Tier 1 synchronized reserve is the capability of online resources following economic dispatch to ramp up in 10 minutes from their current output in response to a synchronized reserve event. There is no formal market for tier 1 synchronized reserve.

- **Supply.** No offers are made for tier 1 synchronized reserves. The market solution estimates tier 1 synchronized reserve as available 10 minute ramp from the energy dispatch. In the first three months of 2021, there was an average hourly supply of 1,769.8 MW of tier 1 available in the RTO Zone and an average hourly supply of 897.4 MW of tier 1 synchronized reserve available within the MAD Subzone.
- **Demand.** The synchronized reserve requirement is calculated for each real-time dispatch solution as the most severe single contingency plus 190 MW within both the RTO Zone and the MAD Subzone.
- **Tier 1 Synchronized Reserve Event Response.** Tier 1 synchronized reserve is paid when a synchronized reserve event occurs and it responds. When a synchronized reserve event is called, all tier 1 response is paid for increasing its output (or reducing load for demand response) at the rate of \$50 per MWh in addition to LMP.¹⁴³ This is the Synchronized Energy Premium Price.
- **Issues.** The competitive offer for tier 1 synchronized reserves is zero, as there is no incremental cost associated with the ability to ramp up from the current economic dispatch point and the appropriate payment for responding to an event is the synchronized energy premium price of \$50 per MWh. The tariff requires payment of the tier 2 synchronized reserve market clearing price to tier 1 resources whenever the nonsynchronized reserve market clearing price rises above zero. This requirement is unnecessary and inconsistent with efficient markets. This change had a

¹⁴³ See PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.10 Settlements, Rev. 113 (March 29, 2021).

significant impact on the cost of tier 1 synchronized reserves, resulting in a windfall payment of \$89,719,045 to tier 1 resources in 2014, \$34,397,441 in 2015, \$4,948,084 in 2016, \$2,197,514 in 2017, \$4,732,025 in 2018, and \$3,217,178 in 2019. The nonsynchronized reserve market clearing price was above \$0 in 2,015 intervals (1.9 percent of intervals) in 2020 resulting in a payment to tier 1 resources of \$3,319,263. In the first three months of 2021, the nonsynchronized reserve market clearing price was above \$0 in 48 intervals resulting in a net payment of \$1,125,792.

Tier 2 Synchronized Reserve Market

Tier 2 synchronized reserve is part of primary reserve and is comprised of resources that are synchronized to the grid, that may incur costs to be synchronized, and that have an obligation to respond to PJM declared synchronized reserve events. Tier 2 synchronized reserve is penalized for failure to respond to a PJM declared synchronized reserve event. In PJM the required amount of synchronized reserve is defined to be no less than the largest single contingency, and 10 minute primary reserve as no less than 150 percent of the largest single contingency, plus 190 MW. This is stricter than the NERC standard of the greater of 80 percent of the largest single contingency or 900 MW.¹⁴⁴

When the synchronized reserve requirement cannot be met with tier 1 synchronized reserve, PJM uses the tier 2 synchronized reserve market to satisfy the balance of the requirement. The tier 2 synchronized reserve market includes the PJM RTO Reserve Zone and a subzone, the Mid-Atlantic Dominion Reserve Subzone (MAD).

Market Structure

- **Supply.** In the first three months of 2021, the supply of daily offered and eligible tier 2 synchronized reserve was 33,842.6 MW in the RTO Zone of which 4,665.5 MW was located in the MAD Subzone.
- **Demand.** The average hourly synchronized reserve requirement was 1,684.6 MW in both the RTO Reserve Zone and the Mid-Atlantic Dominion

Reserve Subzone. The hourly average cleared tier 2 synchronized reserve was 243.8 MW in the MAD Subzone and 595.8 MW in the RTO.

- **Market Concentration.** Both the Mid-Atlantic Dominion Subzone Tier 2 Synchronized Reserve Market and the RTO Synchronized Reserve Zone Market were characterized by structural market power in the first three months of 2021.

The average HHI for tier 2 synchronized reserve in the RTO Zone was 5376 which is classified as highly concentrated.

Market Conduct

- **Offers.** There is a must offer requirement for tier 2 synchronized reserve. All nonemergency generation capacity resources are required to submit a daily offer for tier 2 synchronized reserve, unless the unit type is exempt. Tier 2 synchronized reserve offers from generating units are subject to an offer cap of marginal cost plus \$7.50 per MW, plus opportunity cost which is calculated by PJM. PJM automatically enters an offer of \$0 for tier 2 synchronized reserve when an offer is not entered by the owner.

Market Performance

- **Price.** The weighted average price for tier 2 synchronized reserve for all cleared hours in the MAD subzone was \$5.66 per MW in the first three months of 2021. The weighted average price for tier 2 synchronized reserve for all cleared intervals in the RTO Synchronized Reserve Zone was \$5.95 per MW in the first three months of 2021.

Nonsynchronized Reserve Market

Nonsynchronized reserve is part of primary reserve and includes the RTO Reserve Zone and the Mid-Atlantic Dominion Reserve Subzone (MAD). Nonsynchronized reserve is comprised of nonemergency energy resources not currently synchronized to the grid that can provide energy within 10 minutes. Nonsynchronized reserve is available to fill the primary reserve requirement above the synchronized reserve requirement. Generation owners do not submit supply offers for nonsynchronized reserve. PJM defines the demand

¹⁴⁴ NERC (June 2, 2020) <NERC Reliability Standard BAL-002-2 Glossary_of_Terms.pdf>.

curve for nonsynchronized reserve and PJM defines the supply curve based on nonemergency generation resources that are available to provide energy and can start in 10 minutes or less (based on offer parameters), and on the resource opportunity costs calculated by PJM.

Market Structure

- **Supply.** In the first three months of 2021, the average supply of eligible and available nonsynchronized reserve was 1,419.2 MW in the RTO Zone.
- **Demand.** Demand for nonsynchronized reserve equals the primary reserve requirement minus the tier 1 synchronized reserve estimate and minus the scheduled tier 2 synchronized reserve.¹⁴⁵
- **Market Concentration.** The MMU calculates that the three pivotal supplier test would have been failed in 91.2 percent of intervals where the price was above \$0.01 in 2020.

Market Conduct

- **Offers.** Generation owners do not submit supply offers. Nonemergency generation resources that are available to provide energy and can start in 10 minutes or less are considered available for nonsynchronized reserves by the market solution software. PJM calculates the associated offer prices based on PJM calculations of resource specific opportunity costs.

Market Performance

- **Price.** The nonsynchronized reserve price is determined by the opportunity cost of the marginal nonsynchronized reserve unit. The nonsynchronized reserve weighted average price for all intervals in the RTO Reserve Zone was \$0.22 in the first three months of 2021.

Secondary Reserve (DASR)

There is no NERC standard for secondary reserve. PJM defines secondary reserve in the day-ahead market as reserves (online or offline available for dispatch) that can be converted to energy in 30 minutes. PJM defines a

¹⁴⁵ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 5b.2.2 Non-Synchronized Reserve Zones and Levels, Rev. 113 (March 29, 2021). "Because Synchronized Reserve may be utilized to meet the Primary Reserve requirement, there is no explicit requirement for non-synchronized reserves."

secondary reserve requirement but is not required to maintain this level of secondary reserve in real time.

PJM maintains a day-ahead, offer-based market for 30 minute day-ahead secondary reserve. The PJM Day-Ahead Scheduling Reserve Market (DASR) has no performance obligations except that a unit which clears the DASR market may not be on an outage in real time.¹⁴⁶ If DASR units are on an outage in real time or cleared DASR MW are not available, the DASR payment is not made.

Market Structure

- **Supply.** The DASR market is a must offer market. Any resources that do not make an offer have their offer set to \$0.00 per MW. DASR is calculated by the day-ahead market solution as the lesser of the 30 minute energy ramp rate or the economic maximum MW minus the day-ahead dispatch point for all resources that can provide energy within 30 minutes of a request from PJM Dispatch. In the first three months of 2021, the average available hourly DASR was 46,303.2 MW.
- **Demand.** The DASR requirement is the sum of the PJM requirement and the Dominion requirement based on the VACAR reserve sharing agreement. For November 2020 through October 2021, the DASR requirement is 4.78 percent of peak load forecast. The average hourly DASR MW purchased in the first three months of 2021 was 4,597.9 MW, a reduction from the 4,911.5 hourly MW in 2020.
- **Concentration.** The three pivotal supplier test would have failed in 11 hours in the first three months of 2021.

Market Conduct

- **Withholding.** Economic withholding remains an issue in the DASR Market. The direct marginal cost of providing DASR is zero. PJM calculates the opportunity cost for each resource. All offers by resource owners greater than zero constitute economic withholding. In the first three months of

¹⁴⁶ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 11.2.7 Day-Ahead Scheduling Reserve Performance, Rev. 113 (March 29, 2021).

2021, 39.4 percent of daily unit offers were above \$0.00 and 16.2 percent of daily unit offers were above \$5.

- **DR.** Demand resources are eligible to participate in the DASR Market. Some demand resources have entered offers for DASR. No demand resources cleared the DASR market in the first three months of 2021.

Market Performance

- **Price.** In the first three months of 2021, the weighted average DASR price for all hours when the DASRMCP was above \$0.00 was \$0.14.

Regulation Market

The PJM Regulation Market is a real-time market. Regulation is provided by generation resources and demand response resources that qualify to follow one of two regulation signals, RegA or RegD. PJM jointly optimizes regulation with synchronized reserve and energy to provide all three products at least cost. The PJM regulation market design includes three clearing price components: capability; performance; and opportunity cost. The RegA signal is designed for energy unlimited resources with physically constrained ramp rates. The RegD signal is designed for energy limited resources with fast ramp rates. In the regulation market RegD MW are converted to effective MW using a marginal rate of technical substitution (MRTS), called a marginal benefit factor (MBF). Correctly implemented, the MBF would be the marginal rate of technical substitution (MRTS) between RegA and RegD, holding the level of regulation service constant. The current market design is critically flawed as it has not properly implemented the MBF as an MRTS between RegA and RegD resource MW and the MBF has not been consistently applied in the optimization, clearing and settlement of the regulation market.

Market Structure

- **Supply.** In the first three months of 2021, the average hourly offered supply of regulation for nonramp hours was 778.5 performance adjusted MW (762.2 effective MW). This was a decrease of 88.0 performance adjusted MW (a decrease of 64.8 effective MW) from the first three months of 2020. In the first three months of 2021, the average hourly offered supply of

regulation for ramp hours was 1,106.5 performance adjusted MW (1,115.1 effective MW). This was a decrease of 173.5 performance adjusted MW (a decrease of 125.5 effective MW) from the first three months of 2020, when the average hourly offered supply of regulation was 933.0 performance adjusted MW (effective MW).

- **Demand.** The hourly regulation demand is 525.0 effective MW for nonramp hours and 800.0 effective MW for ramp hours.
- **Supply and Demand.** The nonramp regulation requirement of 525.0 effective MW was provided by a combination of RegA and RegD resources equal to 497.1 hourly average performance adjusted actual MW in the first three months of 2021. This is an increase of 5.1 performance adjusted actual MW from the first three months of 2020, when the average hourly total regulation cleared performance adjusted actual MW for nonramp hours were 492.0 performance adjusted actual MW. The ramp regulation requirement of 800.0 effective MW was provided by a combination of RegA and RegD resources equal to 712.2 hourly average performance adjusted actual MW in the first three months of 2021. This is a decrease of 9.8 performance adjusted actual MW from the first three months of 2020, where the average hourly regulation cleared MW for ramp hours were 702.5 performance adjusted actual MW.

The ratio of the average hourly offered supply of regulation to average hourly regulation demand (performance adjusted cleared MW) for ramp hours was 1.55 in the first three months of 2021 (1.33 in the first three months of 2020). The ratio of the average hourly offered supply of regulation to average hourly regulation demand (performance adjusted cleared MW) for nonramp hours was 1.57 in the first three months of 2021 (1.41 in the first three months of 2020).

- **Market Concentration.** In the first three months of 2021, the three pivotal supplier test was failed in 89.1 percent of hours. In the first three months of 2021, the actual MW weighted average HHI of RegA resources was 2528 which is highly concentrated and the weighted average HHI of RegD resources was 1786 which is moderately concentrated. The weighted average HHI of all resources was 1334, which is moderately concentrated.

Market Conduct

- **Offers.** Daily regulation offer prices are submitted for each unit by the unit owner. Owners are required to submit a cost-based offer and may submit a price-based offer. Offers include both a capability offer and a performance offer. Owners must specify which signal type the unit will be following, RegA or RegD.¹⁴⁷ In the first three months of 2021, there were 164 resources following the RegA signal and 46 resources following the RegD signal.

Market Performance

- **Price and Cost.** The weighted average clearing price for regulation was \$17.18 per MW of regulation in the first three months of 2021, an increase of \$6.19 per MW, or 56.3 percent, from the weighted average clearing price of \$10.00 per MW in the first three months of 2020. The weighted average cost of regulation in the the first three months of 2021 was \$21.01 per MW of regulation, an increase of 51.1 percent, from the weighted average cost of \$13.91 per MW in the first three months of 2020.
- **Prices.** RegD resources continue to be incorrectly compensated relative to RegA resources due to an inconsistent application of the marginal benefit factor in the optimization, assignment and settlement processes. If the regulation market were functioning efficiently and competitively, RegD and RegA resources would be paid the same price per effective MW.
- **Marginal Benefit Factor.** The marginal benefit factor (MBF) is intended to measure the operational substitutability of RegD resources for RegA resources. The marginal benefit factor is incorrectly defined and applied in the PJM market clearing. The current incorrect and inconsistent implementation of the MBF has resulted in the PJM Regulation Market over procuring RegD relative to RegA in most hours and in an inefficient market signal about the value of RegD in every hour.

¹⁴⁷ See the 2019 State of the Market Report for PJM, Vol. II, Appendix F "Ancillary Services Markets."

Black Start Service

Black start service is required for the reliable restoration of the grid following a blackout. Black start service is the ability of a generating unit to start without an outside electrical supply, or is the demonstrated ability of a generating unit to automatically remain operating at reduced levels when disconnected from the grid (automatic load rejection or ALR).¹⁴⁸

In the first three months of 2021, total black start charges were \$16.553 million, including \$ 16.5 million in revenue requirement charges and \$0.069 million in uplift charges. Black start revenue requirements consist of fixed black start service costs, variable black start service costs, training costs, fuel storage costs, and an incentive payment. Black start uplift charges are paid to units scheduled in the day-ahead energy market or committed in real time to provide black start service under the ALR option or for black start testing. Black start zonal charges in the first three months of 2021 ranged from \$0.02 per MW-day in the BGE Zone (total charges were \$11,441) to \$4.10 per MW-day in the PE Zone (total charges were \$1,074,321).

The PJM tariff tables including CRF values should have been changed for both black start and the capacity market when the tax laws changed in 2017. As a result, CRF values have overcompensated black start units since the changes to the tax code.

Reactive

Reactive service, reactive supply and voltage control are provided by generation and other sources of reactive power (measured in MVar). Reactive power helps maintain appropriate voltage levels on the transmission system and is essential to the flow of real power (measured in MW). The same equipment provides both MVar and MW. The current rules permit double recovery of some fixed costs.

Reactive capability charges are based on FERC approved filings that permit recovery based on a cost of service approach.¹⁴⁹ Reactive service charges are

¹⁴⁸ OATT Schedule 1 § 1.3BB. There are no ALR units currently providing black start service.

¹⁴⁹ OATT Schedule 2.

paid to units that operate in real time outside of their normal range at the direction of PJM for the purpose of providing reactive service. Total reactive charges increased 5.99 percent from \$87.5 million in the first three months of 2020 to \$92.7 million in 2021. Reactive capability charges increased 5.24 percent from \$87.5 million in the first three months of 2020 to \$92.0 million in 2021. Total reactive service charges in the first three months of 2021 ranged from \$0 in the REC and OVEC Zones, to \$12.5 million in the AEP Zone.

Frequency Response

On February 15, 2018, the Commission issued Order No. 842, which modified the pro forma large and small generator interconnection agreements and procedures to require newly interconnecting generating facilities, both synchronous and nonsynchronous, to include equipment for primary frequency response capability as a condition to receive interconnection service.^{150 151}

The PJM Tariff requires that all new generator interconnection customers (Nuclear Regulatory Commission regulated facilities are exempt from this provision) have hardware and/or software that provides frequency responsive real power control with the ability to sense changes in system frequency and autonomously adjust real power output in a direction to correct for frequency deviations. This includes a governor or equivalent controls capable of operating with a maximum five percent droop and a +/- 0.036 deadband.¹⁵² In addition to resource capability, resource owners must comply by setting control systems to autonomously adjust real power output in a direction to correct for frequency deviations.

The response of generators within PJM to NERC identified frequency events remains under evaluation. A frequency event is declared when the frequency goes outside +/-40 mHz for 60 continuous seconds. The NERC BAL-003-2 requirement for balancing authorities (PJM is a balancing authority) uses a threshold value (L_{10}) equal to -261.1 MW/0.1 Hz and has selected four events between June 1, 2020 and December 31, 2020 as well as two events in January of 2021 to evaluate.

¹⁵⁰ See 157 FERC ¶ 61,122 (2016).

¹⁵¹ See 164 FERC ¶ 61,224 (2018).

¹⁵² OATT Attachment O § 4.7.2 (Primary Frequency Response).

Market Procurement of Real Time Ancillary Services

PJM uses market mechanisms to varying degrees in the procurement of ancillary services, including primary reserves and regulation. Ideally, all ancillary services would be procured taking full account of the interactions with the energy market. When a resource is used for an ancillary service instead of providing energy in real time, the cost of removing the resource, either fully or partially, from the energy market should be weighed against the benefit the ancillary service provides. The degree to which PJM markets account for these interactions depends on the timing of the product clearing and software limitations and the accuracy of unit parameters and offers.

The synchronized reserve market clearing is more integrated with the energy market clearing than the other ancillary services. Resources categorized as flexible tier 2 reserve, those that can provide reserves by backing down according to their ramp rate, are jointly cleared along with energy in every real-time market solution. Given the joint clearing of energy and flexible tier 2, the synchronized reserve market clearing price should always cover the opportunity cost of providing flexible tier 2. PJM should never need to pay uplift to flexible tier 2. The uplift paid to flexible tier 2 results from issues with the dispatch and pricing software timing. Inflexible tier 2 reserves, provided by resources that require longer notice to take actions to prepare for reserve deployment, are not cleared along with energy in the real-time market solution. Inflexible tier 2 reserves are cleared hourly by the Ancillary Service Optimizer (ASO). The ASO uses forward looking information about the energy market, flexible tier 2, tier 1, and regulation to estimate the costs and benefits of using a resource for inflexible tier 2 synchronized reserves.

Nonsynchronized reserves are cleared with every real-time energy market solution, but its costs are not fully known by the real-time energy market software (RT SCED) because the resources are offline. PJM uses an estimate of the cost of using a resource for nonsynchronized reserve instead of energy from a previously solved IT SCED solution. IT SCED runs every 15 minutes looking ahead at target dispatch times up to two hours in the future. The energy commitment decisions for the offline resources have already been made when the RT SCED clears the nonsynchronized reserve market. RT SCED

compares the IT SCED estimated cost of nonsynchronized reserve clearing to the RT SCED determined cost of synchronized reserve clearing in satisfying the primary reserve requirement. Nonsynchronized reserve clearing indirectly interacts with energy clearing through both products' substitutability with synchronized reserves.

Prices for the regulation and reserve markets are set by the pricing calculator (LPC), which is based on the RT SCED solution. The software determining the prices (RT SCED) is partially, but not fully clearing the reserve market. The software determining the prices is not clearing the regulation market.

Section 10 Recommendations

- The MMU recommends that all data necessary to perform the regulation market three pivotal supplier test be saved by PJM so that the test can be replicated. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that the total regulation (TReg) signal sent on a fleet wide basis be eliminated and replaced with individual regulation signals for each unit. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the ability to make dual offers (to make offers as both a RegA and a RegD resource in the same market hour) be removed from the regulation market. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the regulation market be modified to incorporate a consistent application of the marginal benefit factor (MBF) throughout the optimization, assignment and settlement process. The MBF should be defined as the Marginal Rate of Technical Substitution (MRTS) between RegA and RegD. (Priority: High. First reported 2012. Status: Not adopted. FERC rejected.¹⁵³)
- The MMU recommends that the lost opportunity cost in the ancillary services markets be calculated using the schedule on which the unit was

scheduled to run in the energy market. (Priority: High. First reported 2010. Status: Not adopted.¹⁵⁴ FERC rejected.¹⁵⁵)

- The MMU recommends that the lost opportunity cost calculation used in the regulation market be based on the resource's dispatched energy offer schedule, not the lower of its price or cost offer schedule. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.¹⁵⁶)
- The MMU recommends that, to prevent gaming, there be a penalty enforced in the regulation market as a reduction in performance score and/or a forfeiture of revenues when resource owners elect to deassign assigned regulation resources within the hour. (Priority: Medium. First reported 2016. Status: Not adopted. FERC rejected.¹⁵⁷)
- The MMU recommends enhanced documentation of the implementation of the regulation market design. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.¹⁵⁸)
- The MMU recommends that PJM be required to save data elements necessary for verifying the performance of the regulation market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the \$12.00 margin adder be eliminated from the definition of the cost based regulation offer because it is a markup and not a cost. (Priority: Medium. New recommendation. Status: Not adopted.)
- The MMU recommends that PJM replace the static MidAtlantic/Dominion Reserve Subzone with a reserve zone structure consistent with the actual deliverability of reserves based on current transmission constraints. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the \$7.50 margin be eliminated from the definition of the cost of tier 2 synchronized reserve because it is a markup and not a cost. (Priority: Medium. First reported 2018. Status: Not adopted.)

¹⁵⁴ This recommendation was adopted by PJM for the energy market. Lost opportunity costs in the energy market are calculated using the schedule on which the unit was scheduled to run. In the regulation market, this recommendation has not been adopted, as the LOC continues to be calculated based on the lower of price or cost in the energy market offer.

¹⁵⁵ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

¹⁵⁶ *Id.*

¹⁵⁷ *Id.*

¹⁵⁸ *Id.*

¹⁵³ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

- The MMU recommends that the variable operating and maintenance cost be eliminated from the definition of the cost of tier 2 synchronized reserve and that the calculation of synchronized reserve variable operations and maintenance costs be removed from Manual 15. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the components of the cost-based offers for providing regulation and synchronous condensing be defined in Schedule 2 of the Operating Agreement. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the rule requiring that tier 1 synchronized reserve resources are paid the tier 2 price when the nonsynchronized reserve price is above zero be eliminated immediately and that, under the current rule, tier 1 synchronized reserve resources not be paid the tier 2 price when they do not respond. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that the tier 2 synchronized reserve must offer requirement be enforced on a daily and hourly basis. The MMU recommends that PJM define a set of acceptable reasons why a unit can be made unavailable daily or hourly and require unit owners to select a reason in Markets Gateway whenever making a unit unavailable either daily or hourly or setting the offer MW to 0 MW. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that, for calculating the penalty for a tier 2 resource failing to meet its scheduled obligation during a spinning event, the definition of the IPI be changed from the average number of days between events to the actual number of days since the last event greater than 10 minutes. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that aggregation not be permitted to offset unit specific penalties for failure to respond to a synchronized reserve event. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM eliminate the use of Degree of Generator Performance (DGP) in the synchronized reserve market solution and improve the actual tier 1 estimate. If PJM continues to use DGP, DGP should be documented in PJM's manuals. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that the details of VACAR Reserve Sharing Agreement (VRSA) be made public, including any responsibilities assigned to PJM and including the amount of reserves that Dominion commits to meet its obligations under the VRSA. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that the VRSA be terminated and, if necessary, replaced by a reserve sharing agreement between PJM and VACAR South, similar to agreements between PJM and other bordering areas. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that a reason code be attached to every hour in which PJM market operations adds additional DASR MW. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM modify the DASR market to ensure that all resources cleared incur a real-time performance obligation. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that offers in the DASR market be based on opportunity cost only in order to mitigate market power. (Priority: Low. First reported 2009. Modified, 2018. Status: Not adopted.)
- The MMU recommends that all resources, new and existing, have a requirement to include and maintain equipment for primary frequency response capability as a condition of interconnection service. The PJM capacity and energy markets already compensate resources for frequency response capability and any marginal costs. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that new CRF rates for black start units, incorporating current tax code changes, be implemented immediately. The new CRF rates should apply to all black start units. The black start units should be required to commit to providing black start service for the life of the unit. (Priority: High. First reported 2020. Status: Not adopted.)

- The MMU recommends for oil tanks shared with other resources that only a proportionate share of the minimum tank suction level (MTSL) be allocated to black start service. The MMU further recommends that the PJM tariff be updated to clearly state how the MTSL will be calculated for black start units sharing oil tanks. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that separate cost of service payments for reactive capability be eliminated and the cost of reactive capability be recovered in the capacity market. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that payments for reactive capability, if continued, be based on the 0.90 power factor that PJM has determined is necessary. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that, if payments for reactive are continued, fleet wide cost of service rates used to compensate resources for reactive capability be eliminated and replaced with compensation based on unit specific costs. (Priority: Low. First reported 2019.¹⁵⁹ Status: Partially adopted.)
- The MMU recommends that Schedule 2 to OATT be revised to state explicitly that only generators that provide reactive capability to the transmission system that PJM operates and has responsibility for are eligible for reactive capability compensation. Specifically, such eligibility should be determined based on whether a generation facility's point of interconnection is on a transmission line that is a Monitored Transmission Facility as defined by PJM and is on a Reportable Transmission Facility as defined by PJM.¹⁶⁰ (Priority: Medium. First reported 2020. Status: Not adopted.)

¹⁵⁹ The MMU has discussed this recommendation in state of the market reports since 2016 but Q3, 2019 was the first time it was reported as a formal MMU recommendation.

¹⁶⁰ See PJM Transmission Facilities (note that this requires you first log into a PJM Tools account. If you do not, then the link sends you to an Access Request page, <<https://pjm.com/markets-and-operations/ops-analysis/transmission-facilities>>.

Section 10 Conclusion

The design of the PJM Regulation Market is significantly flawed.¹⁶¹ The market design does not correctly incorporate the marginal rate of technical substitution (MRTS) in market clearing and settlement. The market design uses the marginal benefit factor (MBF) to incorrectly represent the MRTS and uses a mileage ratio instead of the MBF in settlement. This failure to correctly and consistently incorporate the MRTS into the regulation market design has resulted in both underpayment and overpayment of RegD resources and in the over procurement of RegD resources in all hours. The market results continue to include the incorrect definition of opportunity cost. These issues are the basis for the MMU's conclusion that the regulation market design is flawed.

To address these flaws, the MMU and PJM developed a joint proposal which was approved by the PJM Members Committee on July 27, 2017, and filed with FERC on October 17, 2017.¹⁶² The PJM/MMU joint proposal addresses issues with the inconsistent application of the marginal benefit factor throughout the optimization and settlement process in the PJM Regulation Market. FERC rejected the joint proposal on March 30, 2018, as being noncompliant with Order No. 755.¹⁶³ The MMU and PJM separately filed requests for rehearing, which were denied by order issued March 26, 2020.¹⁶⁴

The structure of the tier 2 synchronized reserve market has been evaluated and the MMU has concluded that these markets are not structurally competitive as they are characterized by high levels of supplier concentration and inelastic demand. As a result, these markets are operated with market clearing prices and with offers based on the marginal cost of producing the product plus a margin. As a result of these requirements, the conduct of market participants within these market structures has been consistent with competition, and the market performance results have been competitive. However, the \$7.50 margin is not a cost. The margin is effectively a rule-based form of economic withholding and is therefore not consistent with a competitive outcome. **The \$7.50 margin should be eliminated. The variable operating and maintenance**

¹⁶¹ The current PJM regulation market design that incorporates two signals using two resource types was a result of FERC Order No. 755 and subsequent orders. Order No. 755, 137 FERC ¶ 61,064 at PP 197–200 (2011).

¹⁶² 18 CFR § 385.211 (2017)

¹⁶³ 162 FERC ¶ 61,295.

¹⁶⁴ 170 FERC ¶ 61,259.

component of the synchronized reserve offer should also be eliminated. All variable operating and maintenance costs are incurred to provide energy and to make units available to provide energy. There are no variable operating and maintenance costs associated with providing synchronized reserve.

Participant performance has not been adequate for tier 2 synchronized reserve. Compliance with calls to respond to actual synchronized reserve events remains significantly less than 100 percent. Actual participant performance means that the penalty structure is not an adequate incentive for performance.

The rule that requires payment of the tier 2 synchronized reserve price to tier 1 synchronized reserve resources when the nonsynchronized reserve price is greater than zero, is inefficient and results in a substantial windfall payment to the holders of tier 1 synchronized reserve resources. Tier 1 resources have no obligation to perform and pay no penalties if they do not perform, and tier 1 resources do not incur any costs when they are part of the tier 1 estimate in the market solution. Tier 1 resources are already paid for their response if they do respond to a synchronized reserve event. Tier 1 resources require no additional payment. If tier 1 resources wish to be paid as tier 2 resources, the rules provide the opportunity to make competitive offers in the tier 2 market and take on the associated obligations. Overpayment of tier 1 resources based on this rule has added more than \$100 million to the cost of primary reserve since 2014.

The benefits of markets are realized under these approaches to ancillary service markets. Even in the presence of structurally noncompetitive markets, there can be transparent, market clearing prices based on competitive offers that account explicitly and accurately for opportunity cost. This is consistent with the market design goal of ensuring competitive outcomes that provide appropriate incentives without reliance on the exercise of market power and with explicit mechanisms to prevent the exercise of market power.

The MMU concludes that the regulation market results were not competitive, and the market design is significantly flawed. The MMU concludes that the synchronized reserve market results were competitive, although the \$7.50

margin should be removed. The MMU concludes that the DASR market results were competitive, although offers above the competitive level continue to affect prices.

Overview: Section 11, Congestion and Marginal Losses

Congestion Cost

- **Total Congestion.** Total congestion costs increased by \$35.9 million or 42.2 percent, from \$85.1 million in the first three months of 2020 to \$121.0 million in the first three months of 2021.
- **Day-Ahead Congestion.** Day-ahead congestion costs increased by \$121.1 million or 117.2 percent, from \$103.3 million in the first three months of 2020 to \$224.5 million in the first three months of 2021.
- **Balancing Congestion.** Negative balancing congestion costs increased by \$85.2 million, from -\$18.2 million in the first three months of 2020 to -\$103.4 million in the first three months of 2021. Negative balancing explicit charges increased by \$22.7 million, from -\$14.2 million in the first three months of 2020 to -\$36.9 million in the first three months of 2021.
- **Real-Time Congestion.** Real-time congestion costs increased by \$220.2 million, from \$87.7 million in the first three months of 2020 to \$308.0 million in the first three months of 2021.
- **Monthly Congestion.** Monthly total congestion costs in the first three months of 2021 ranged from \$29.1 million in January to \$55.2 million in March.
- **Geographic Differences in CLMP.** Differences in CLMP among eastern, southern and western control zones in PJM were primarily a result of congestion on the Vienna Transformer, the Bagley - Raphael Road Line, the Bagley - Graceton Line, the Conastone Transformer, and the Harwood - Susquehanna Line.
- **Congestion Frequency.** Congestion frequency continued to be significantly higher in the day-ahead energy market than in the real-time energy

market in the first three months of 2021. The number of congestion event hours in the day-ahead energy market was about three times the number of congestion event hours in the real-time energy market.

Day-ahead congestion frequency decreased by 14.4 percent from 17,087 congestion event hours in the first three months of 2020 to 14,618 congestion event hours in the first three months of 2021.

Real-time congestion frequency decreased by 0.6 percent from 5,515 congestion event hours in the first three months of 2020 to 5,484 congestion event hours in the first three months of 2021.

- **Congested Facilities.** The monthly average of daily day-ahead congestion event hours decreased in November 2020 as a result of decreased UTC activity due to a FERC order issued effective November 1, 2020, directing PJM to charge uplift to up to congestion transactions.¹⁶⁵ Day-ahead, congestion event hours decreased on all types of facilities except lines. The congestion event hours on the PA Central Interface decreased from 1,340 hours in the first three months of 2020 to 0 hours in the first three months of 2021.

The Vienna Transformer was the largest contributor to congestion costs in the first three months of 2021. With \$14.4 million in total congestion costs, it accounted for 11.9 percent of the total PJM congestion costs in the first three months of 2021.

- **CT Price Setting Logic and Closed Loop Interface Related Congestion.** CT Price Setting Logic caused -\$0.0 million of day-ahead congestion in the first three months of 2021 and -\$5.2 million of balancing congestion in the first three months of 2021. None of the closed loop interfaces was binding in the first three months of 2021 or 2020.
- **Zonal Congestion.** AEP had the highest zonal congestion costs among all control zones in the first three months of 2021. AEP had \$16.3 million in zonal congestion costs, comprised of \$31.8 million in day-ahead congestion costs and -\$15.6 million in balancing congestion costs.

Marginal Loss Cost

- **Total Marginal Loss Costs.** Total marginal loss costs increased by \$101.2 million or 93.2 percent, from \$108.5 million in the first three months of 2020 to \$209.7 million in the first three months of 2021. The loss MWh in PJM increased by 395.4 GWh or 10.9 percent, from 3,613.6 GWh in the first three months of 2020 to 4,009.0 GWh in the first three months of 2021. The loss component of real-time LMP in the first three months of 2021 was \$0.02, compared to \$0.01 in the first three months of 2020.
- **Day-Ahead Marginal Loss Costs.** Day-ahead marginal loss costs increased by \$98.6 million or 80.8 percent, from \$122.0 million in the first three months of 2020 to \$220.5 million in the first three months of 2021.
- **Balancing Marginal Loss Costs.** Negative balancing marginal loss costs decreased by \$2.6 million or 19.5 percent, from -\$13.4 million in the first three months of 2020 to -\$10.8 million in the first three months of 2021.
- **Total Marginal Loss Surplus.** The total marginal loss surplus increased by \$43.8 million or 131.9 percent, from \$33.2 million in the first three months of 2020, to \$77.1 million in the first three months of 2021.
- **Monthly Total Marginal Loss Costs.** Monthly total marginal loss costs in the first three months of 2021 ranged from \$47.2 million in March to \$102.7 million in February.

System Energy Cost

- **Total System Energy Costs.** Total system energy costs decreased by \$56.4 million or 74.8 percent, from -\$75.3 million in the first three months of 2020 to -\$131.7 million in the first three months of 2021.
- **Day-Ahead System Energy Costs.** Day-ahead system energy costs decreased by \$55.7 million or 57.8 percent, from -\$96.3 million in the first three months of 2020 to -\$152.0 million in the first three months of 2021.
- **Balancing System Energy Costs.** Balancing system energy costs decreased by \$1.7 million or 8.1 percent, from \$21.4 million in the first three months of 2020 to \$19.7 million in the first three months of 2021.

¹⁶⁵ 172 FERC ¶ 61,046 (2020).

- **Monthly Total System Energy Costs.** Monthly total system energy costs in the first three months of 2021 ranged from -\$63.1 million in February to -\$30.8 million in March.

Section 11 Conclusion

Congestion is defined as the total payments by load in excess of the total payments to generation, excluding marginal losses. The level and distribution of congestion reflects the underlying characteristics of the power system, including the nature and capability of transmission facilities, the offers and geographic distribution of generation facilities, the level and geographic distribution of incremental bids and offers and the geographic and temporal distribution of load.

Total congestion costs increased by \$35.9 million or 42.2 percent, from \$85.1 million in the first three months of 2020 to \$121.0 million in the first three months of 2021. The total day-ahead congestion costs and negative balancing congestion costs increased significantly compared to the first three months of 2020. This was the combined result of higher demand and higher prices, cold weather in February of 2021, CT pricing logic, and transmission facility outages in March.

The monthly total congestion costs ranged from \$29.1 million in January to \$55.2 million in March in the first three months of 2021.

The current ARR/FTR design does not serve as an efficient way to ensure that load receives the rights to all congestion revenues. The congestion offset for the first ten months of the 2020/2021 planning period was 45.8 percent. The cumulative offset of congestion by ARRs for the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period, using the rules effective for each planning period, was 74.1 percent. Load has been underpaid by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period.

Overview: Section 12, Planning

Generation Interconnection Planning

Existing Generation Mix

- As of March 31, 2021, PJM had a total installed capacity of 197,274.9 MW, of which 49,877.4 MW (25.3 percent) are coal fired steam units, 50,194.0 MW (25.4 percent) are combined cycle units and 33,452.6 MW (17.0 percent) are nuclear units. This measure of installed capacity differs from capacity market installed capacity because it includes energy only units, excludes all external units, and uses nameplate values for solar and wind resources.
- Of the 197,274.9 MW of installed capacity, 71,985.4 MW (36.5 percent) are from units older than 40 years, of which 38,446.4 MW (53.4 percent) are coal fired steam units, 191.0 MW (0.3 percent) are combined cycle units and 16,184.6 MW (22.5 percent) are nuclear units.

Generation Retirements¹⁶⁶

- There are 45,070.3 MW of generation that have been, or are planned to be, retired between 2011 and 2024, of which 32,084.1 MW (71.2 percent) are coal fired steam units. Coal unit retirements are primarily a result of the inability of coal units to compete with efficient combined cycle units burning low cost natural gas.
- In the first three months of 2021, 430.4 MW of generation retired. The largest generator that retired in the first three months of 2021 was the 237.9 MW Birchwood coal fired steam unit located in the Dominion Zone. Of the 430.4 MW of generation that retired, 353.4 MW (82.1 percent) were located in the Dominion Zone.
- As of March 31, 2021, there are 4,622.5 MW of generation that have requested retirement after March 31, 2021, of which 1,786.5 MW (38.7 percent) are located in the COMED Zone. Of the generation requesting retirement in the COMED Zone, all 1,786.5 MW (100.0 percent) are nuclear units.

¹⁶⁶ See PJM, Planning, "Generator Deactivations," (Accessed on March 31, 2021) <<http://www.pjm.com/planning/services-requests/gen-deactivations.aspx>>.

Generation Queue¹⁶⁷

- There were 173,182.4 MW in generation queues, in the status of active, under construction or suspended, at the end of 2020. In the first three months of 2021, the AG2 queue window closed. As projects move through the queue process, projects can be removed from the queue due to incomplete or invalid data, withdrawn by the market participant or placed in service. On March 31, 2021, there were 177,645.3 MW in generation queues, in the status of active, under construction or suspended, an increase of 4,462.9 MW (2.6 percent) from the end of 2020.¹⁶⁸
- As of March 31, 2021, 5,982 projects, representing 668,740.7 MW, have entered the queue process since its inception in 1998. Of those, 967 projects, representing 73,369.0 MW, went into service. Of the projects that entered the queue process, 3,088 projects, representing 417,726.4 MW (62.5 percent of the MW) withdrew prior to completion. Such projects may create barriers to entry for projects that would otherwise be completed by taking up queue positions, increasing interconnection costs and creating uncertainty.
- As of March 31, 2021, 177,645.3 MW were in generation request queues in the status of active, under construction or suspended. Based on historical completion rates, 37,491.5 MW of new generation in the queue are expected to go into service.
- The number of queue entries has increased during the past several years, primarily renewable projects. Of the 3,330 projects entered from January 2015 through March 2021, 2,515 projects (75.5 percent) were renewable. Of the 140 projects entered in the first three months of 2021, 117 projects (83.6 percent) were renewable. Renewable projects make up 79.1 percent of all projects in the queue and those projects account for 76.0 percent of the nameplate MW currently active, suspended or under construction in the queue as of March 31, 2021.

But of the 134,968.2 MW of renewable projects in the queue, only 7,506.5 MW (5.6 percent) of capacity resources are expected to go into service,

¹⁶⁷ See PJM. Planning. "New Services Queue," [Accessed on March 31, 2021] <<https://www.pjm.com/planning/services-requests/interconnection-queues.aspx>>.

¹⁶⁸ The queue totals in this report are the winter net MW energy for the interconnection requests ("MW Energy") as shown in the queue.

based on both historical completion rates and average derate factors for wind and solar.

Regional Transmission Expansion Plan (RTEP)

Market Efficiency Process

- There are significant issues with PJM's benefit/cost analysis that should be addressed prior to approval of additional projects. PJM's benefit/cost analysis does not correctly account for the costs of increased congestion associated with market efficiency projects.
- Through March 31, 2021, PJM has completed four market efficiency cycles under Order No. 1000.¹⁶⁹

PJM MISO Interregional Market Efficiency Process (IMEP)

- PJM and MISO developed a process to facilitate the construction of interregional projects in response to the Commission's concerns about interregional coordination along the PJM-MISO seam. This process, called the Interregional Market Efficiency Process (IMEP), operates on a two year study schedule and is designed to address forward looking congestion.

But the use of an inaccurate cost-benefit method by PJM and the correct method by MISO results in an over allocation of the costs associated with joint PJM/MISO projects to PJM participants and in some cases approval of projects that do not pass an accurate cost-benefit test.

PJM MISO Targeted Market Efficiency Process (TMEP)

- PJM and MISO developed the Targeted Market Efficiency Process (TMEP) to facilitate the resolution of historic congestion issues that could be addressed through small, quick implementation projects.

Supplemental Transmission Projects

- Supplemental projects are defined to be "transmission expansions or enhancements that are not required for compliance with PJM criteria

¹⁶⁹ See *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Order No. 1000, FERC Stats. & Regs. ¶ 31,323 (2011) (Order No. 1000), *order on reh'g*, Order No. 1000-A, 139 FERC ¶ 61,132 (2012).

and are not state public policy projects according to the PJM Operating Agreement. These projects are used as inputs to RTEP models, but are not required for reliability, economic efficiency or operational performance criteria, as determined by PJM.¹⁷⁰ Supplemental projects are exempt from the competitive planning process.

- The average number of supplemental projects in each expected in service year increased by 795.0 percent, from 20 for years 1998 through 2007 (pre Order No. 890¹⁷¹) to 179 for years 2008 through 2021 (post Order 890).
- The process for designating projects as supplemental projects should be reviewed and modified to ensure that the supplemental project designation is not used to exempt transmission projects from a transparent, robust and clearly defined mechanism to permit competition to build the project, or used to effectively replace the RTEP process.¹⁷²

End of Life Transmission Projects

- An end of life transmission project is a project submitted for the purpose of replacing existing infrastructure that is at, or is approaching, the end of its useful life. End of life transmission projects should be included in the RTEP process and should be subject to a transparent, robust and clearly defined mechanism to permit competition to build the project. Under the current approach, end of life projects are excluded from competition.¹⁷³

Board Authorized Transmission Upgrades

- The Transmission Expansion Advisory Committee (TEAC) reviews internal and external proposals to improve transmission reliability throughout PJM. These proposals, which include reliability baseline, network, market efficiency and targeted market efficiency projects, as well as scope

¹⁷⁰ See PJM, "Transmission Construction Status," (Accessed on March 31, 2021) <<http://www.pjm.com/planning/rtep-upgrades-status/construct-status.aspx>>.

¹⁷¹ See *Preventing Undue Discrimination and Preference in Transmission Service*, Order No. 890, 118 FERC ¶ 61,119, *order on reh'g*, Order No. 890-A, 121 FERC ¶ 61,297 (2007), *order on reh'g*, Order No. 890-B, 123 FERC ¶ 61,299 (2008), *order on reh'g*, Order No. 890-C, 126 FERC ¶ 61,228, *order on clarification*, Order No. 890-D, 129 FERC ¶ 61,126 (2009).

¹⁷² The FERC accepted tariff provisions that exclude supplemental projects from competition in the RTEP. 162 FERC ¶ 61,129 (2018), *reh'g denied*, 164 FERC ¶ 61,217 (2018).

¹⁷³ In recent decisions addressing competing proposals on end of life projects, the Commission accepted a transmission owner proposal excluding end of life projects from competition in the RTEP process, 172 FERC ¶ 61,136 (2020), *reh'g denied*, 173 FERC ¶ 61,225 (2020), and rejected a proposal from PJM stakeholders that would have included end of life projects in competition in the RTEP process, 173 FERC ¶ 61,242 (2020).

changes and project cancellations, but exclude supplemental and end of life projects, are periodically presented to the PJM Board of Managers for authorization.¹⁷⁴ In the first three months of 2021, the PJM Board approved \$349.8 million in upgrades. As of March 31, 2021, the PJM Board has approved \$38.2 billion in system enhancements since 1999.

Transmission Competition

- The MMU makes several recommendations related to the competitive transmission planning process. The recommendations include improved process transparency, incorporation of competition between transmission and generation alternatives and the removal of barriers to competition from nonincumbent transmission. These recommendations would help ensure that the process is an open and transparent process that results in the most competitive solutions.
- On May 24, 2018, the PJM Markets and Reliability Committee (MRC) approved a motion that required PJM, with input from the MMU, to develop a comparative framework to evaluate the quality and effectiveness of competitive transmission proposals with binding cost containment proposals compared to proposals from incumbent and nonincumbent transmission companies without cost containment provisions.

Qualifying Transmission Upgrades (QTU)

- A Qualifying Transmission Upgrade (QTU) is an upgrade to the transmission system that increases the Capacity Emergency Transfer Limit (CETL) into an LDA and can be offered into capacity auctions as capacity. Once a QTU is in service, the upgrade is eligible to continue to offer the approved incremental import capability into future RPM Auctions. As of March 31, 2021, no QTUs have cleared a Base Residual Auction or an Incremental Auction.

¹⁷⁴ Supplemental Projects, including the end of life subset of supplemental projects, do not require PJM Board of Managers authorization.

Transmission Facility Outages

- PJM maintains a list of reportable transmission facilities. When the reportable transmission facilities need to be taken out of service, PJM transmission owners are required to report planned transmission facility outages as early as possible. PJM processes the transmission facility outage requests according to rules in PJM's Manual 3 to decide if the outage is on time or late and whether or not they will allow the outage.¹⁷⁵
- There were 16,542 transmission outage requests submitted in the first ten months of the 2020/2021 planning period. Of the requested outages, 77.2 percent of the requested outages were planned for less than or equal to five days and 8.4 percent of requested outages were planned for greater than 30 days. Of the requested outages, 42.7 percent were late according to the rules in PJM's Manual 3.

Section 12 Recommendations

Generation Retirements

- The MMU recommends that the question of whether Capacity Interconnection Rights (CIRs) should persist after the retirement of a unit be addressed. The rules need to ensure that incumbents cannot exploit control of CIRs to block or postpone entry of competitors.¹⁷⁶ (Priority: Low. First reported 2013. Status: Partially adopted, 2012.)

Generation Queue

- The MMU recommends that barriers to entry be addressed in a timely manner in order to help ensure that the capacity market will result in the entry of new capacity to meet the needs of PJM market participants and reflect the uncertainty and resultant risks in the cost of new entry used to establish the capacity market demand curve in RPM. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends improvements in queue management including that PJM establish a review process to ensure that projects are removed

from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress, subject to rules to prevent gaming. (Priority: Medium. First reported 2013. Status: Partially adopted.)

- The MMU recommends continuing analysis of the study phase of PJM's transmission planning to reduce the need for postponements of study results, to decrease study completion times, and to improve the likelihood that a project at a given phase in the study process will successfully go into service. (Priority: Medium. First reported 2014. Status: Partially adopted.)
- The MMU recommends outsourcing interconnection studies to an independent party to avoid potential conflicts of interest. Currently, these studies are performed by incumbent transmission owners under PJM's direction. This creates potential conflicts of interest, particularly when transmission owners are vertically integrated and the owner of transmission also owns generation. (Priority: Low. First reported 2013. Status: Not adopted.)

Market Efficiency Process

- The MMU recommends that the market efficiency process be eliminated because it is not consistent with a competitive market design. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that, if the market efficiency process is retained, PJM modify the rules governing benefit/cost analysis, the evaluation process for selecting among competing market efficiency projects and cost allocation for economic projects in order to ensure that all costs, including increased congestion costs and the risk of project cost increases, in all zones are included in order to ensure that the correct metrics are used for defining benefits. (Priority: Medium. First reported 2018. Status: Not adopted.)

Comparative Cost Framework

- The MMU recommends that PJM modify the project proposal templates to include data necessary to perform a detailed project lifetime financial

¹⁷⁵ See PJM, "PJM Manual 03: Transmission Operations," Rev. 58 (November 19, 2020).

¹⁷⁶ See "Comments of the Independent Market Monitor for PJM," Docket No. ER12-1177-000 (March 12, 2012) <http://www.monitoringanalytics.com/filings/2012/IMM_Comments_ER12-1177-000_20120312.PDF>.

analysis. The required data includes, but is not limited to: capital expenditure; capital structure; return on equity; cost of debt; tax assumptions; ongoing capital expenditures; ongoing maintenance; and expected life. (Priority: Medium. First reported 2020. Status: Not adopted.)

Transmission Competition

- The MMU recommends, to increase the role of competition, that the exemption of supplemental projects from the Order No. 1000 competitive process be terminated and that the basis for all such exemptions be reviewed and modified to ensure that the supplemental project designation is not used to exempt transmission projects from a transparent, robust and clearly defined mechanism to permit competition to build such projects or to effectively replace the RTEP process. (Priority: Medium. First reported 2017. Status: Not adopted. Rejected by FERC.)
- The MMU recommends, to increase the role of competition, that the exemption of end of life projects from the Order No. 1000 competitive process be terminated and that end of life transmission projects be included in the RTEP process and should be subject to a transparent, robust and clearly defined mechanism to permit competition to build such projects. (Priority: Medium. First reported 2019. Status: Not adopted. Rejected by FERC.)
- The MMU recommends that PJM enhance the transparency and queue management process for nonincumbent transmission investment. Issues related to data access and complete explanations of cost impacts should be addressed. The goal should be to remove barriers to competition from nonincumbent transmission providers. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM continue to incorporate the principle that the goal of transmission planning should be the incorporation of transmission investment decisions into market driven processes as much as possible. (Priority: Low. First reported 2001. Status: Not adopted.)
- The MMU recommends the creation of a mechanism to permit a direct comparison, or competition, between transmission and generation

alternatives, including which alternative is less costly and who bears the risks associated with each alternative. (Priority: Low. First reported 2013. Status: Not adopted.)

- The MMU recommends that PJM establish fair terms of access to rights of way and property, such as at substations, in order to remove any barriers to entry and permit competition between incumbent transmission providers and nonincumbent transmission providers in the RTEP. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that rules be implemented to permit competition to provide financing for transmission projects. This competition could reduce the cost of capital for transmission projects and significantly reduce total costs to customers. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that rules be implemented to require that project cost caps on new transmission projects be part of the evaluation of competing projects. (Priority: Medium. First reported 2015. Status: Adopted 2020.)
- The MMU recommends that storage resources not be includable as transmission assets for any reason. (Priority: High. First reported 2020. Status: Not adopted.)

Cost Allocation

- The MMU recommends a comprehensive review of the ways in which the solution based dfax is implemented. The goal for such a process would be to ensure that the most rational and efficient approach to implementing the solution based dfax method is used in PJM. Such an approach should allocate costs consistent with benefits and appropriately calibrate the incentives for investment in new transmission capability. No replacement approach should be approved until all potential alternatives, including the status quo, are thoroughly reviewed. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends consideration of changing the minimum distribution factor in the allocation from 0.01 to 0.00 and adding a

threshold minimum usage impact on the line.¹⁷⁷ (Priority: Medium. First reported 2015. Status: Not adopted.)

Transmission Line Ratings

- The MMU recommends that all PJM transmission owners use the same methods to define line ratings, subject to NERC standards and guidelines, subject to review by NERC and approval by FERC. (Priority: Medium. First reported 2019. Status: Not adopted.)

Transmission Facility Outages

- The MMU recommends that PJM reevaluate all transmission outage tickets as on time or late as if they were new requests when an outage is rescheduled, and apply the standard rules for late submissions to any such outages. (Priority: Low. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM draft a clear definition of the congestion analysis required for transmission outage requests to include in Manual 3 after appropriate review. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM modify the rules to reduce or eliminate the approval of late outage requests submitted or rescheduled after the FTR auction bidding opening date. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not permit transmission owners to divide long duration outages into smaller segments to avoid complying with the requirements for long duration outages. (Priority: Low. First reported 2015. Status: Not adopted.)

Section 12 Conclusion

The goal of PJM market design should be to enhance competition and to ensure that competition is the driver for all the key elements of PJM markets. But transmission investments have not been fully incorporated into competitive markets. The construction of new transmission facilities has significant

¹⁷⁷ See the 2015 State of the Market Report for PJM, Volume II, Section 12: Generation and Transmission Planning, at p. 463, Cost Allocation Issues.

impacts on the energy and capacity markets. But when generating units retire or load increases, there is no market mechanism in place that would require direct competition between transmission and generation to meet loads in the affected area. In addition, despite FERC Order No. 1000, there is not yet a transparent, robust and clearly defined mechanism to permit competition to build transmission projects, to ensure that competitors provide a total project cost cap, or to obtain least cost financing through the capital markets.

The MMU recognizes that the Commission has recently issued orders that are inconsistent with the recommendations of the MMU and that PJM cannot unilaterally modify those directives. It remains the recommendation of the MMU that the PJM rules for competitive transmission development through the RTEP should build upon FERC Order No. 1000 to create real competition between incumbent transmission providers and nonincumbent transmission providers. The ability of transmission owners to block competition for supplemental projects and end of life projects and reasons for that policy should be reevaluated. PJM should enhance the transparency and queue management process for nonincumbent transmission investment. Issues related to data access and complete explanations of cost impacts should be addressed. The goal should be to remove barriers to competition from nonincumbent transmission. Another element of opening competition would be to consider transmission owners' ownership of property and rights of way at or around transmission substations. In many cases, the land acquired included property intended to support future expansion of the grid. Incumbents have included the costs of the property in their rate base, paid for by customers. Because PJM now has the responsibility for planning the development of the grid under its RTEP process, property bought to facilitate future expansion should be a part of the RTEP process and be made available to all providers on equal terms.

The process for determining the reasonableness or purpose of supplemental transmission projects that are asserted to be not needed for reliability, economic efficiency or operational performance as defined under the RTEP process needs additional oversight and transparency. If there is a need for a supplemental project, that need should be clearly defined and there should be a transparent, robust and clearly defined mechanism to permit competition to

build the project. If there is no defined need for of a supplemental project for reliability, economic efficiency or operational performance then the project should not be included in rates.

Managing the generation queues is a highly complex process. The PJM queue evaluation process has been substantially improved in recent years and it is more efficient and effective as a result. The PJM queue evaluation process should continue to be improved to help ensure that barriers to competition for new generation investments are not created. Issues that need to be addressed include the ownership rights to CIRs, whether transmission owners should perform interconnection studies, and improvements in queue management to ensure that projects are removed from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress.

The addition of a planned transmission project changes the parameters of the capacity auction for the area, changes the amount of capacity needed in the area, changes the capacity market supply and demand fundamentals in the area and may effectively forestall the ability of generation to compete. But there is no mechanism to permit a direct comparison, let alone competition, between transmission and generation alternatives. There is no mechanism to evaluate whether the generation or transmission alternative is less costly, whether there is more risk associated with the generation or transmission alternatives, or who bears the risks associated with each alternative. Creating such a mechanism should be an explicit goal of PJM market design.

The current market efficiency process does exactly the opposite by permitting transmission projects to be approved without competition from generation. The broader issue is that the market efficiency project approach explicitly allows transmission projects to compete against future generation projects, but without allowing the generation projects to compete. Projecting speculative transmission related benefits for 15 years based on the existing generation fleet and existing patterns of congestion eliminates the potential for new generation to respond to market signals. The market efficiency process allows assets built under the cost of service regulatory paradigm to displace generation

assets built under the competitive market paradigm. In addition, there are significant issues with PJM's current benefit/cost analysis which cause it to consistently overstate the potential benefits of market efficiency projects. The MMU recommends that the market efficiency process be eliminated.

In addition, the use of an inaccurate cost-benefit method by PJM and the correct method by MISO results in an over allocation of the costs associated with joint PJM/MISO projects to PJM participants and in some cases approval of projects that do not pass an accurate cost-benefit test.

If it is retained, there are significant issues with PJM's benefit/cost analysis that should be addressed prior to approval of additional projects. The current benefit/cost analysis for a regional project, for example, explicitly and incorrectly ignores the increased congestion in zones that results from an RTEP project when calculating the energy market benefits. All costs should be included in all zones and LDAs. The definition of benefits should also be reevaluated.

The benefit/cost analysis should also account for the fact that the transmission project costs are not subject to cost caps and may exceed the estimated costs by a wide margin. When actual costs exceed estimated costs, the cost benefit analysis is effectively meaningless and low estimated costs may result in inappropriately favoring transmission projects over market generation projects. The risk of cost increases for transmission projects should be incorporated in the cost benefit analysis.

There are currently no market incentives for transmission owners to submit and complete transmission outages in a timely and efficient manner. Requiring transmission owners to pay does not create an effective incentive when those payments are passed through to transmission customers. The process for the submission of planned transmission outages needs to be carefully reviewed and redesigned to limit the ability of transmission owners to submit transmission outages that are late for FTR auction bid submission dates and are late for the day-ahead energy market. The submission of late transmission

outages can inappropriately affect market outcomes when market participants do not have the ability to modify market bids and offers.

Overview: Section 13, FTRs and ARR

Auction Revenue Rights

Market Structure

- **ARR Ownership.** In the 2020/2021 planning period ARRs were allocated to 1,392 individual participants, held by 131 parent companies. ARR ownership for the 2020/2021 planning period was unconcentrated with an HHI of 851.

Market Behavior

- **Self Scheduled FTRs.** For the 2020/2021 planning period, 25.4 percent of eligible ARRs were self scheduled as FTRs.

Market Performance

- **ARRs as an Offset to Congestion.** ARRs have not served as an effective mechanism to return all congestion revenues to load. For the first 10 months of the 2020/2021 planning period, ARRs offset only 45.8 percent of total congestion. Congestion payments by load in some zones were more than offset and congestion payments in some zones were less than offset. Load has been underpaid congestion revenues by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period. The cumulative offset for that period was 74.1 percent of total congestion.
- **Revenue Adequacy.** For the first 10 months of the 2020/2021 planning period, the ARR target allocations, which are based on the nodal price differences from the Annual FTR Auction, were \$514.8 million, while PJM collected \$688.7 million from the combined Long Term, Annual and Monthly Balance of Planning Period FTR Auctions, making ARRs revenue adequate. For the 2019/2020 planning period, the ARR target allocations were \$752.2 million while PJM collected \$982.0 million from the combined Annual and Monthly Balance of Planning Period FTR Auctions.

- **Residual ARRs.** Residual ARRs are only available on contract paths prorated in Stage 1 of the annual ARR allocation, are only effective for single, whole months and cannot be self scheduled. Residual ARR clearing prices are based on monthly FTR auction clearing prices. Residual ARRs with negative target allocations are not allocated to participants. Instead they are removed and the model is rerun.

In the first 10 months of the 2020/2021 planning period, PJM allocated a total of 20,616.0 MW of residual ARRs with a total target allocation of \$9.4 million, down from 22,090.7 MW, with a total target allocation of \$11.1 million, in the first 10 months of the 2019/2020 planning period.

- **ARR Reassignment for Retail Load Switching.** There were 27,387 MW of ARRs associated with \$373,700 of revenue that were reassigned in the first 10 months of the 2020/2021 planning period. There were 29,509 MW of ARRs associated with \$583.6 of revenue that were reassigned for the same time frame of the 2019/2020 planning period.

Financial Transmission Rights

Market Design

- **Monthly Balance of Planning Period FTR Auctions.** The design of the Monthly Balance of Planning Period FTR Auctions was changed effective with the 2020/2021 planning period. The new design includes auctions for each remaining month in the planning period. The prior design included auctions for the next three individual months plus remaining quarters.

Market Structure

- **Patterns of Ownership.** For the Monthly Balance of Planning Period Auctions, financial entities purchased 88.6 percent of prevailing flow and 92.2 percent of counter flow FTRs for January through March, 2021. Financial entities owned 78.4 percent of all prevailing and counter flow FTRs, including 71.5 percent of all prevailing flow FTRs and 85.9 percent of all counter flow FTRs during the period from January through March 2021. Self scheduled FTRs account for 1.9 percent of all FTRs held.

- **Market Concentration.** For prevailing flow obligation FTRs in the Monthly Balance of Planning Period Auctions for the first 10 months of the 2020/2021 planning period, all market periods were unconcentrated. For counter flow obligation FTRs for the first 10 months of the 2020/2021 planning period, two periods were moderately concentrated and all others were unconcentrated. All periods were highly concentrated for FTR options. FTR options in the Annual FTR Auction were moderately concentrated.

Market Behavior

- **Sell Offers.** In a given auction, market participants can sell FTRs acquired in preceding auctions or preceding rounds of auctions. In the Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning period, total participant FTR sell offers were 15,507,661 MW.
- **Buy Bids.** The total FTR buy bids from the Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning were 33,157,407 MW.
- **FTR Forfeitures.** Total FTR forfeitures were \$4.0 million for the first 10 months of the 2020/2021 planning period.
- **Credit.** There were five collateral defaults in 2021. There were 5 payment defaults in 2021 not involving GreenHat Energy, LLC for a total of \$1.8 million. GreenHat Energy accrued payment defaults of \$1.1 million in 2021 for a total of \$163.0 million in defaults to date, which will continue to accrue through May 2021, including the auction liquidation costs.¹⁷⁸ In addition, PJM added the settlement fee and claimant payee funds to the default allocation, resulting in allocations of \$12.5 million and \$5.0 million for a total of \$180.5 million.

Market Performance

- **Quantity.** In the first 10 months of the 2020/2021 planning period, Monthly Balance of Planning Period FTR Auctions cleared 5,271,196 (15.9 percent) of FTR buy bids and 2,579,029 MW (16.6 percent) of FTR sell offers. For

¹⁷⁸ See the 2019 Quarterly State of the Market Report for PJM: January through June for a more complete explanation of credit issues that occurred in 2019.

the first 10 months of the 2019/2020 planning period, Monthly Balance of Planning Period FTR Auctions cleared 3,548,585 (19.2 percent) of FTR buy bids and 1,457,284 MW (20.5 percent) of FTR sell offers.

- **Price.** The weighted average buy bid cleared FTR price in the Monthly Balance of Planning Period FTR Auctions for all periods of the first 10 months of the 2020/2021 planning period was \$0.14 per MWh.
- **Revenue.** The Monthly Balance of Planning Period FTR Auctions resulted in net revenue of \$39.0 million in the first 10 months of the 2020/2021 planning period, down from \$51.2 million for the same time period in the 2019/2020 planning period.
- **Revenue Adequacy.** FTRs were paid at 98.8 percent of the target allocation level for the first 10 months of the 2020/2021 planning period, including distribution of the current surplus revenue.
- **Profitability.** FTR profitability is the difference between the revenue received directly from holding an FTR plus any revenue from the sale of an FTR, and the cost of the FTR. In the first 10 months of 2020/2021 planning period, physical entities made \$70.8 million in profits on FTRs purchased directly (not self scheduled), up from \$56.8 million in losses for the same time period in the 2019/2020 planning period and financial entities made \$211.0 million in profits, up from \$9.5 million in losses for the same time period in the 2019/2020 planning period.

Section 13 Recommendations

Market Design

ARR

- The MMU recommends that the ARR/FTR design be modified to ensure that the rights to all congestion revenues are assigned to load. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that all historical generation to load paths be eliminated as a basis for assigning ARRs. The MMU recommends that the current design be replaced with a network design in which the rights to

actual congestion are assigned directly to load by node. (Priority: High. First reported 2015. Status: Partially adopted.)

- The MMU recommends that, under the current FTR design, the rights to all congestion revenue be allocated as ARR rights prior to sale as FTRs. Reductions for outages and increased system capability should be reserved for ARR rights rather than sold in the Long Term FTR Auction. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that IARRs be eliminated from PJM's tariff, but that if IARRs are not eliminated, IARRs should be subject to the same proration rules that apply to all other ARR rights. (Priority: Low. First reported 2018. Status: Not adopted.)

FTR

- The MMU recommends that FTR funding be based on total congestion, including day-ahead and balancing congestion. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM enforce the FTR auction bid limits at the parent company level starting immediately. (Priority: High. First reported 2020. Status: Adopted 2021.)
- The MMU recommends a requirement that the details of all bilateral FTR transactions be reported to PJM. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM continue to evaluate the bilateral indemnification rules and any asymmetries they may create. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM reduce FTR sales on paths with persistent overallocation of FTRs, including a clear definition of persistent overallocation and how the reduction will be applied. (Priority: High. First reported 2013. Status: Partially adopted, 2014/2015 planning period.)
- MMU recommends that PJM eliminate generation to generation paths and all other paths that do not represent the delivery of power to load. (Priority: High. First reported 2018. Status: Not adopted.)

- The MMU recommends that the Long Term FTR product be eliminated. If the Long Term FTR product is not eliminated, the Long Term FTR Market should be modified so that the supply of prevailing flow FTRs in the Long Term FTR Market is based solely on counter flow offers in the Long Term FTR Market. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM improve transmission outage modeling in the FTR auction models, including the use of probabilistic outage modeling. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that the forfeiture amount from the FTR forfeiture rule be based on the correct hourly cost of an FTR, rather than a simple daily price divided by 24. (Priority: High. First reported 2018. Status: Adopted 2019.)

Surplus

- The MMU recommends that all FTR auction revenue be distributed to ARR holders monthly, regardless of FTR funding levels. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that, under the current FTR design, all congestion revenue in excess of FTR target allocations be distributed to ARR holders on a monthly basis. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that FTR auction revenues not be used by PJM to buy counter flow FTRs for the purpose of improving FTR payout ratios.¹⁷⁹ (Priority: High. First reported 2015. Status: Not adopted.)

FTR Subsidies

- The MMU recommends that PJM eliminate portfolio netting to eliminate cross subsidies among FTR market participants. (Priority: High. First reported 2012. Status: Not adopted. Rejected by FERC.)
- The MMU recommends that PJM eliminate subsidies to counter flow FTRs by applying the payout ratio to counter flow FTRs in the same way the payout ratio is applied to prevailing flow FTRs. (Priority: High. First reported 2012. Status: Not adopted.)

¹⁷⁹ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

- The MMU recommends that PJM eliminate geographic cross subsidies. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM examine the mechanism by which self scheduled FTRs are allocated when load switching among LSEs occurs throughout the planning period. (Priority: Low. First reported 2011. Status: Not adopted.)

FTR Liquidation

- The MMU recommends that the FTR portfolio of a defaulted member be canceled rather than liquidated or allowed to settle as a default cost on the membership. (Priority: High. First reported 2018. Status: Not adopted.)

Section 13 Conclusion

Solutions

The annual ARR allocation should be designed to ensure that the rights to all congestion revenues are assigned to load, without requiring contract path physical transmission rights that are inconsistent with the network based delivery of power and the actual way congestion is generated in security constrained LMP markets. When there are binding transmission constraints and locational price differences, load pays more for energy than generation is paid to produce that energy. The difference is congestion. As a result, congestion belongs to load and should be returned to load.

The current contract path based design should be replaced with a network design in which the rights to actual congestion are assigned directly to load by node. The assigned right is to the actual difference between load payments, both day-ahead and balancing, and revenues paid to the generation used to serve that load. The load can retain the right to the network congestion or sell the right through auctions. The correct assignment of congestion revenues to load is fully consistent with retaining FTR auctions for the sale by ARR holders of their congestion revenue rights.

Issues

If the original PJM FTR approach had been designed to return congestion revenues to load without use of the generation to load contract paths, and if the distortions subsequently introduced into the FTR design not been added, many of the subsequent issues with the FTR design and complex redesigns would have been avoided. PJM would not have had to repeatedly intervene in the functioning of the FTR system in an effort to meet the artificial and incorrectly defined goal of revenue adequacy.

PJM has persistently and subjectively intervened in the FTR market in order to affect the payments to FTR holders. These interventions are not appropriate. For example, in the 2014/2015, 2015/2016 and 2016/2017 planning periods, PJM significantly reduced the allocation of ARR capacity, and FTRs, in order to guarantee full FTR funding. PJM reduced system capability in the FTR auction model by including more outages, reducing line limits and including additional constraints. PJM's modeling changes resulted in significant reductions in Stage 1B and Stage 2 ARR allocations, a corresponding reduction in the available quantity of FTRs, a reduction in congestion revenues assigned to ARRs, and an associated surplus of congestion revenue relative to FTR target allocations. This also resulted in a significant redistribution of ARRs among ARR holders based on differences in allocations between Stage 1A and Stage 1B ARRs. Starting in the 2017/2018 planning period, with the allocation of balancing congestion and M2M payments to load rather than FTRs, PJM increased system capability allocated to Stage 1B and Stage 2 ARRs, but continued to conservatively select outages to manage FTR funding levels.

PJM has intervened aggressively in the FTR market since its inception in order to meet various subjective objectives including so called revenue adequacy. PJM should not intervene in the FTR market to subjectively manage FTR funding. PJM should fix the FTR/ARR design and then should let the market work to return congestion to load and to let FTR values reflect actual congestion.

Load should never be required to subsidize payments to FTR holders, regardless of the reason.¹⁸⁰ The FERC order of September 15, 2016, introduced a subsidy to FTR holders at the expense of ARR holders.¹⁸¹ The order requires PJM to ignore balancing congestion when calculating total congestion dollars available to fund FTRs. As a result, balancing congestion and M2M payments are assigned to load, rather than to FTR holders, as of the 2017/2018 planning period. When combined with the direct assignment of both surplus day-ahead congestion and surplus FTR auction revenues to FTR holders, the Commission's order shifted substantial revenue from load to the holders of FTRs and further reduced the offset to congestion payments by load. This approach ignores the fact that load pays both day-ahead and balancing congestion, and that congestion is defined, in an accounting sense, to equal the sum of day-ahead and balancing congestion. Eliminating balancing congestion from the FTR revenue calculation requires load to pay twice for congestion. Load pays total congestion and pays negative balancing congestion again. The fundamental reasons that there has been a significant and persistent difference between day-ahead and balancing congestion include inadequate transmission modeling in the FTR auction and the role of UTCs in taking advantage of these modeling differences and creating negative balancing congestion. There is no reason to impose these costs on load.

These changes were made in order to increase the payout to holders of FTRs who are not loads. Increasing the payout to FTR holders at the expense of the load is not a supportable market objective. PJM should implement an FTR design that calculates and assigns congestion rights to load rather than continuing to modify the current, fundamentally flawed, design.

Load was made significantly worse off as a result of the changes made to the FTR/ARR process by PJM based on the FERC order of September 15, 2016. ARR revenues were significantly reduced for the 2017/2018 FTR Auction, the first auction under the new rules. ARRs and self scheduled FTRs offset only 49.5 percent of total congestion costs for the 2017/2018 planning period rather than the 58.0 percent offset that would have occurred under the prior rules, a difference of \$101.4 million.

¹⁸⁰ Such subsidies have been suggested repeatedly. See FERC Dockets Nos. EL13-47-000 and EL12-19-000.

¹⁸¹ See 156 FERC ¶ 61,180 (2016), *reh'g denied*, 156 FERC ¶ 61,093 (2017).

A subsequent rule change was implemented that modified the allocation of surplus auction revenue to load. Beginning with the 2018/2019 planning period, surplus day-ahead congestion and surplus FTR auction revenue are assigned to FTR holders only up total target allocations, and then distributed to ARR holders.¹⁸² ARR holders will only be allocated this surplus after full funding of FTRs is accomplished. While this rule change increased the level of congestion revenues returned to load, the rules do not fully recognize ARR holders' rights to congestion revenue. With this rule in effect for the first 10 months of the 2020/2021 planning period, ARRs and FTRs offset 45.8 percent of total congestion.

The complex process related to what is termed the overallocation of Stage 1A ARRs are entirely an artificial result of reliance on the contract path model in the assignment of FTRs. For example, there is a reason that transmission is not built to address the Stage 1A overallocation issue. The Stage 1A overallocation issue is a fiction based on the use of outdated and irrelevant generation to load contract paths to assign Stage 1A rights that have nothing to do with actual power flows.

¹⁸² 163 FERC ¶61,165 (2018).

Recommendations

In order to perform its role in PJM market design, the MMU evaluates existing and proposed PJM Market Rules and the design of the PJM Markets.¹ The MMU initiates and proposes changes to the design of the markets and the PJM Market Rules in stakeholder and regulatory proceedings.² In support of this function, the MMU engages in discussions with stakeholders, State Commissions, PJM management, and the PJM Board; participates in PJM stakeholder meetings and working groups regarding market design matters; publishes proposals, reports and studies on market design issues; and makes filings with the Commission on market design issues.³ The MMU also recommends changes to the PJM Market Rules to the staff of the Commission's Office of Energy Market Regulation, State Commissions, and the PJM Board.⁴ The MMU may provide in its annual, quarterly and other reports "recommendations regarding any matter within its purview."⁵

Priority rankings are relative. The creation of rankings recognizes that there are limited resources available to address market issues and that problems must be ranked in order to determine the order in which to address them. It does not mean that all the problems should not be addressed. Priority rankings are dynamic and as new issues are identified, priority rankings will change. The rankings reflect a number of factors including the significance of the issue for efficient markets, the difficulty of completion and the degree to which items are already in progress. A low ranking does not necessarily mean that an issue is not important, but could mean that the issue would be easy to resolve.

There are three priority rankings: High, Medium and Low. High priority indicates that the recommendation requires action because it addresses a market design issue that creates significant market inefficiencies and/or long lasting negative market effects. Medium priority indicates that the recommendation addresses a market design issue that creates intermediate market inefficiencies and/or near term negative market effects. Low priority

¹ OATT Attachment M § IV.D.

² *Id.*

³ *Id.*

⁴ *Id.*

⁵ OATT Attachment M § VI.A.

indicates that the recommendation addresses a market design issue that creates smaller market inefficiencies and/or more limited market effects or that it could be easily resolved.

The MMU is also tracking PJM's progress in addressing these recommendations. The MMU recognizes that part of the process of addressing recommendations may include discussions in the stakeholder process, FERC decisions and court decisions and those elements are included in the tracking. The MMU recognizes that PJM does not have the unilateral authority to implement changes to the tariff but PJM has a significant role in the issues PJM focuses on, in proposed changes to the PJM manuals, and in the recommendations PJM makes to the stakeholders and to FERC. Each recommendation includes a status. The status categories are:

- **Adopted:** PJM has implemented the recommendation made by the MMU.
- **Partially adopted:** PJM has implemented part of the recommendation made by the MMU.
- **Not adopted:** PJM does not plan to implement the recommendation made by the MMU, or has not yet implemented any part of the recommendation made by the MMU. Where the subject of the recommendation is pending stakeholder, FERC, or court action, that status is noted.

New Recommendations

Consistent with its core function to "[e]valuate existing and proposed market rules, tariff provisions and market design elements and recommend proposed rule and tariff changes," the MMU recommends specific enhancements to existing market rules and implementation of new rules that are required for competitive results in PJM markets and for continued improvements in the functioning of PJM markets.⁶

In this *2021 Quarterly State of the Market Report for PJM: January through March*, the MMU includes two new recommendations.

⁶ 18 CFR § 35.28(g)(3)(ii)(A); see also OATT Attachment M § IV.D.

New Recommendation from Section 3, Energy Market

- The MMU recommends that PJM stop capping the system marginal price in RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh. (Priority: Medium. New recommendation. Status: Not adopted.)

New Recommendation from Section 10, Ancillary Services

- The MMU recommends that the \$12.00 margin adder be eliminated from the definition of the cost based regulation offer because it is a markup and not a cost. (Priority: Medium. New recommendation. Status: Not adopted.)

Complete List of Current MMU Recommendations

The recommendations are explained in each section of the report.

Section 3, Energy Market

Market Power

- The MMU recommends that the market rules explicitly require that offers in the energy market be competitive, where competitive is defined to be the short run marginal cost of the units. The short run marginal cost should reflect opportunity cost when and where appropriate. The MMU recommends that the level of incremental costs includable in cost-based offers not exceed the short run marginal cost of the unit. (Priority: Medium. First reported 2009. Status: Not adopted.)

Fuel Cost Policies

- The MMU recommends that PJM require that all fuel cost policies be algorithmic, verifiable, and systematic, and accurately reflect short run marginal costs. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends that the tariff be changed to allow units to have fuel cost policies that do not include fuel procurement practices, including fuel contracts. Fuel procurement practices, including fuel contracts, may be used as the basis for fuel cost policies but should not be required. (Priority: Low. First reported 2018. Status: Adopted 2020.)
- The MMU recommends that PJM change the fuel cost policy requirement to apply only to units that will be offered with non-zero cost-based offers. The PJM market rules should require that the cost-based offers of units without an approved fuel cost policy be set to zero. (Priority: Low. First reported 2018. Status: Adopted 2020.)
- The MMU recommends that the temporary cost method be removed and that all units that submit nonzero cost-based offers be required to have an approved fuel cost policy. (Priority: Low. First reported 2020. Status: Not adopted.)
- The MMU recommends that the penalty exemption provision be removed and that all units that submit nonzero cost-based offers be required to follow their approved fuel cost policy. (Priority: Medium. First reported 2020. Status: Not adopted.)

Cost-Based Offers

- The MMU recommends that Manual 15 (Cost Development Guidelines) be replaced with a straightforward description of the components of cost-based offers based on short run marginal costs and the correct calculation of cost-based offers. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends removal of all use of FERC System of Accounts in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all use of cyclic starting and peaking factors from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends the removal of all labor costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all maintenance costs from the Cost Development Guidelines. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that market participants be required to document the amount and cost of consumables used when operating in order to verify that the total operating cost is consistent with the total quantity used and the unit characteristics. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends, given that maintenance costs are currently allowed in cost-based offers, that market participants be permitted to include only variable maintenance costs, linked to verifiable operational events and that can be supported by clear and unambiguous documentation of the operational data (e.g. run hours, MWh, MMBtu) that support the maintenance cycle of the equipment being serviced/replaced. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends explicitly accounting for soak costs and changing the definition of the start heat input for combined cycles to include only the amount of fuel used from first fire to the first breaker close in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of nuclear fuel and nonfuel operations and maintenance costs that are not short run marginal costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends revising the pumped hydro fuel cost calculation to include day-ahead and real-time power purchases. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends revisions to the calculation of energy market opportunity costs to incorporate all time based offer parameters and all

limitations that impact the opportunity cost of generating unit output. (Priority: Medium. First reported 2016. Status: Adopted 2020.)

- The MMU recommends removing the catastrophic designation for force majeure fuel supply limitations in Schedule 2. (Priority: Medium. First reported 2016. Status: Not adopted.)

Market Power: TPS Test and Offer Capping

- The MMU recommends that the rules governing the application of the TPS test be clarified and documented. The TPS test application in the day-ahead energy market is not documented. (Priority: High. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM require every market participant to make available at least one cost schedule based on the same hourly fuel type(s) and parameters at least as flexible as their offered price schedule. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that markup be constant across the full MWh range of price and cost-based offers. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that offer capping be applied to units that fail the TPS test in the real-time market that were not offer capped at the time of commitment in the day-ahead market or at a prior time in the real-time market. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, and during high load conditions such as cold and hot weather alerts or more severe emergencies, that the operating parameters in the cost-based offer and the price-based parameter limited schedule (PLS) offer be at least as flexible as the operating parameters in the available price-based non-PLS offer, and that the price-MW pairs in the price-based PLS offer be exactly equal to the

price-based non-PLS offer. (Priority: High. First reported 2015. Status: Not adopted.)

- The MMU recommends, in order to ensure effective market power mitigation, that PJM always enforce parameter limited values by committing units only on parameter limited schedules, when the TPS test is failed or during high load conditions such as cold and hot weather alerts or more severe emergencies. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM retain the \$1,000 per MWh offer cap in the PJM energy market except when cost-based offers exceed \$1,000 per MWh, and retain other existing rules that limit incentives to exercise market power. (Priority: High. First reported 1999. Status: Partially adopted, 1999, 2017.)
- The MMU recommends the elimination of FMU and AU adders. FMU and AU adders no longer serve the purpose for which they were created and interfere with the efficient operation of PJM markets. (Priority: Medium. First reported 2012. Status: Partially adopted, 2014.)

Offer Behavior

- The MMU recommends that resources not be allowed to violate the ICAP must offer requirement. The MMU recommends that PJM enforce the ICAP must offer requirement by assigning a forced outage to any unit that is derated in the energy market below its committed ICAP without an outage that reflects the derate. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that storage and intermittent resources be subject to an enforceable ICAP must offer rule that reflects the limitations of these resources. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that capacity resources not be allowed to offer any portion of their capacity market obligation as maximum emergency energy. (Priority: Medium. First reported 2012. Status: Not adopted.)

Capacity Performance Resources

- The MMU recommends that capacity performance resources be held to the OEM operating parameters of the capacity market CONE reference resource for performance assessment and energy uplift payments and that this standard be applied to all technologies on a uniform basis. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that the parameters which determine nonperformance charges and the amounts of uplift payments should reflect the flexibility goals of the capacity performance construct. The operational parameters used by generation owners to indicate to PJM operators what a unit is capable of during the operating day should not determine capacity performance assessment or uplift payments. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM not include the balancing ratios calculated for localized Performance Assessment Intervals (PAIs) in the capacity market default offer cap, and only include those events that trigger emergencies at a defined zonal or higher level. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM clearly define the business rules that apply to the unit specific parameter adjustment process, including PJM's implementation of the tariff rules in the PJM manuals to ensure market sellers know the requirements for their resources. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the tariff to clarify that all generation resources are subject to unit specific parameter limits on their cost-based offers using the same standard and process as capacity performance capacity resources. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM institute rules to assess a penalty for resources that choose to submit real-time values that are less flexible than their unit specific parameter limits or approved parameter limit exceptions based on tariff defined reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)

- The MMU recommends that PJM not approve temporary exceptions that are based on pipeline tariff terms that are not routinely enforced, and based on inferior transportation service procured by the generator. (Priority: Medium. First reported 2019. Status: Not adopted.)

Accurate System Modeling

- The MMU recommends that PJM approve one RT SCED case for each five minute interval to dispatch resources during that interval using a five minute ramp time, and that PJM calculate prices using LPC for that five minute interval using the same approved RT SCED case. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM explicitly state its policy on the use of transmission penalty factors including: the level of the penalty factors; the triggers for the use of the penalty factors; the appropriate line ratings to trigger the use of penalty factors; the allowed duration of the violation; the use of constraint relaxation logic; and when the transmission penalty factors will be used to set the shadow price. (Priority: Medium. First reported 2015. Status: Partially adopted 2020.)
- The MMU recommends that PJM routinely review all transmission facility ratings and any changes to those ratings to ensure that the normal, emergency and load dump ratings used in modeling the transmission system are accurate and reflect standard ratings practice. (Priority: Low. First reported 2013. Status: Partially adopted.)
- The MMU recommends that PJM not use closed loop interface or surrogate constraints to artificially override nodal prices based on fundamental LMP logic in order to: accommodate rather than resolve the inadequacies of the demand side resource capacity product; address the inability of the power flow model to incorporate the need for reactive power; accommodate rather than resolve the flaws in PJM's approach to scarcity pricing; or for any other reason. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM not use CT price setting logic to modify transmission line limits to artificially override the nodal prices that are based on fundamental LMP logic in order to reduce uplift. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that if PJM believes it appropriate to implement CT price setting logic, PJM first initiate a stakeholder process to determine whether such modification is appropriate. PJM should file any proposed changes with FERC to ensure review. Any such changes should be incorporated in the PJM tariff. (Priority: Medium. First reported 2016. Status: Partially adopted.)
- The MMU recommends that PJM update the outage impact studies, the reliability analyses used in RPM for capacity deliverability, and the reliability analyses used in RTEP for transmission upgrades to be consistent with the more conservative emergency operations (post contingency load dump limit exceedance analysis) in the energy market that were implemented in June 2013. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM include in the tariff or appropriate manual an explanation of the initial creation of hubs, the process for modifying hub definitions and a description of how hub definitions have changed.^{7,8} (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that all buses with a net withdrawal be treated as load for purposes of calculating load and load-weighted LMP, even if the MW are settled to the generator. The MMU recommends that during hours when a load bus shows a net injection, the energy injection be treated as generation, not negative load, for purposes of calculating generation and load-weighted LMP, even if the injection MW are settled to the load serving entity. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM identify and collect data on available behind the meter generation resources, including nodal location information and relevant operating parameters. (Priority: Low. First reported 2013. Status: Partially adopted.)

⁷ According to minutes from the first meeting of the Energy Market Committee (EMC) on January 28, 1998, the EMC unanimously agreed to be responsible for approving additions, deletions and changes to the hub definitions to be published and modeled by PJM. Since the EMC has become the Market Implementation Committee (MIC), the MIC now appears to be responsible for such changes.

⁸ There is currently no PJM documentation in the tariff or manuals explaining how hubs are created and how their definitions are changed. The general definition of a hub can be found in the PJM.com Glossary <<http://www.pjm.com/Glossary.aspx>>.

- The MMU recommends that PJM document how LMPs are calculated when demand response is marginal. (Priority: Low. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM not allow nuclear generators which do not respond to prices or which only respond to manual instructions from the operator to set the LMPs in the real-time market. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM increase the coordination of outage and operational restrictions data submitted by market participants via eDART/eGADs and offer data submitted via Markets Gateway. (Priority: Low. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM model generators' operating transitions, including soak time for units with a steam turbine, configuration transitions for combined cycles, and peak operating modes. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM clarify, modify and document its process for dispatching reserves and energy when SCED indicates that supply is less than total demand including forecasted load and reserve requirements. The modifications should define: a SCED process to economically convert reserves to energy; a process for the recall of energy from capacity resources; and the minimum level of synchronized reserves that would trigger load shedding. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM stop capping the system marginal price in RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh. (Priority: Medium. New recommendation. Status: Not adopted.)

Transparency

- The MMU recommends that PJM market rules require the fuel type be identified for every price and cost schedule and PJM market rules remove nonspecific fuel types such as other or co-fire other from the list of fuel types available for market participants to identify the fuel type associated

with their price and cost schedules. (Priority: Medium. First reported 2015. Status: Adopted 2019.)

- The MMU recommends that PJM allow generators to report fuel type on an hourly basis in their offer schedules and to designate schedule availability on an hourly basis. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM clearly define the criteria for operator approval of RT SCED cases used to send dispatch signals to resources and for pricing, to minimize operator discretion and implement a rule based, scheduled approach. (Priority: High. First reported 2018. Status: Partially adopted.)

Virtual Bids and Offers

- The MMU recommends eliminating up to congestion (UTC) bidding at pricing nodes that aggregate only small sections of transmission zones with few physical assets. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating INC, DEC, and UTC bidding at pricing nodes that allow market participants to profit from modeling issues. (Priority: Medium. First reported 2020. Status: Not adopted.)

Section 4, Energy Uplift

- The MMU recommends that uplift be paid only based on operating parameters that reflect the flexibility of the benchmark new entrant unit (CONE unit) in the PJM Capacity Market. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM initiate an analysis of the reasons why a significant number of combustion turbines and diesels scheduled in the day-ahead energy market are not called in real time when they are economic. (Priority: Medium. First Reported 2012. Status: Partially adopted, 2019.)

- The MMU recommends that PJM develop and implement an accurate metric to define when a unit is following dispatch to determine eligibility to receive balancing operating reserve credits and for assessing generator deviations. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM designate units whose offers are flagged for fixed generation in Markets Gateway as not eligible for uplift. Units that are flagged for fixed generation are not dispatchable. Following dispatch is an eligibility requirement for uplift compensation. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating intraday segments from the calculation of uplift payments and returning to calculating the need for uplift based on the entire 24 hour operating day. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends the elimination of day-ahead uplift to ensure that units receive an energy uplift payment based on their real-time output and not their day-ahead scheduled output. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends enhancing the current energy uplift allocation rules to reflect the recommended elimination of day-ahead uplift, the timing of commitment decisions and the commitment reasons. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends reincorporating the use of net regulation revenues as an offset in the calculation of balancing operating reserve credits. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that self scheduled units not be paid energy uplift for their startup cost when the units are scheduled by PJM to start before the self scheduled hours. (Priority: Low. First reported 2013. Status: Not adopted. Stakeholder process.)
- The MMU recommends three modifications to the energy lost opportunity cost calculations:
 - The MMU recommends calculating LOC based on 24 hour daily periods for combustion turbines and diesels scheduled in the day-ahead energy market, but not committed in real time. (Priority: Medium. First reported 2014. Status: Not adopted.)
 - The MMU recommends that units scheduled in the day-ahead energy market and not committed in real time should be compensated for LOC based on their real-time desired and achievable output, not their scheduled day-ahead output. (Priority: Medium. First reported 2015. Status: Not adopted.)
 - The MMU recommends that only flexible fast start units (startup plus notification times of 10 minutes or less) and units with short minimum run times (one hour or less) be eligible by default for the LOC compensation to units scheduled in the day-ahead energy market and not committed in real time. Other units should be eligible for LOC compensation only if PJM explicitly cancels their day-ahead commitment. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that up to congestion transactions be required to pay energy uplift charges for both the injection and the withdrawal sides of the UTC. (Priority: High. First reported 2011. Status: Partially adopted.)
- The MMU recommends eliminating the use of internal bilateral transactions (IBTs) in the calculation of deviations used to allocate balancing operating reserve charges. (Priority: High. First reported 2013. Status: Adopted 2018.⁹)
- The MMU recommends allocating the energy uplift payments to units scheduled as must run in the day-ahead energy market for reasons other than voltage/reactive or black start services as a reliability charge to real-time load, real-time exports and real-time wheels. (Priority: Medium. First reported 2014. Status: Not adopted. Stakeholder process.)
- The MMU recommends that the total cost of providing reactive support be categorized and allocated as reactive services. Reactive services credits should be calculated consistent with the balancing operating reserve

⁹ As of November 1, 2018, internal bilateral transactions are no longer used for the calculation of deviations for purposes of allocating balancing operating reserve charges. See the *2018 State of the Market Report for PJM*, Volume II, Section 3: "Energy Market" at "Internal Bilateral Transactions" for an analysis of the impact of this change on virtual bidding activity.

credit calculation. (Priority: Medium. First reported 2012. Status: Not adopted. Stakeholder process.)

- The MMU recommends including real-time exports and real-time wheels in the allocation of the cost of providing reactive support to the 500 kV system or above, in addition to real-time load. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends modifications to the calculation of lost opportunity costs credits paid to wind units. The lost opportunity costs credits paid to wind units should be based on the lesser of the desired output, the estimated output based on actual wind conditions and the capacity interconnection rights (CIRs). The MMU recommends that PJM allow wind units to request CIRs that reflect the maximum output wind units want to inject into the transmission system at any time. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM clearly identify and classify all reasons for incurring operating reserves in the day-ahead and the real-time energy markets and the associated operating reserve charges in order to make all market participants aware of the reasons for these costs and to help ensure a long term solution to the issue of how to allocate the costs of operating reserves. (Priority: Medium. First reported 2011. Status: Partially adopted.)
- The MMU recommends that PJM revise the current uplift (operating reserve) confidentiality rules in order to allow the disclosure of complete information about the level of uplift (operating reserve charges) by unit and the detailed reasons for the level of operating reserve credits by unit in the PJM region. (Priority: High. First reported 2013. Status: Partially adopted.¹⁰)
- The MMU recommends that PJM pay uplift based on the offer at the lower of the actual unit output or the dispatch signal MW. (Priority: Medium. First reported 2018. Status: Not adopted.)

¹⁰ On September 7, 2018, PJM made a compliance filing for FERC Order No. 844 to publish unit specific uplift credits. The compliance filing was accepted by FERC on March 21, 2019. 166 FERC ¶ 61,210. PJM began posting unit specific uplift reports on May 1, 2019. 167 FERC ¶ 61,280 (2019).

- The MMU recommends that PJM eliminate the exemption for fast start resources (CTs and diesels) from the requirement to follow dispatch. The performance of these resources should be evaluated in a manner consistent with all other resources (Priority: Medium. First reported 2018. Status: Not adopted.)

Section 5, Capacity Market

Definition of Capacity

- The MMU recommends the enforcement of a consistent definition of capacity resource. The MMU recommends that the requirement to be a physical resource be enforced and enhanced. The requirement to be a physical resource should apply at the time of auctions and should also constitute a commitment to be physical in the relevant delivery year. The requirement to be a physical resource should be applied to all resource types, including planned generation, demand resources and imports.^{11 12} (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that DR providers be required to have a signed contract with specific customers for specific facilities for specific levels of DR at least six months prior to any capacity auction in which the DR is offered. (Priority: High. First reported 2016. Status: Not adopted.)

Market Design and Parameters

- The MMU recommends that the test for determining modeled Locational Deliverability Areas (LDAs) in RPM be redefined. A detailed reliability analysis of all at risk units should be included in the redefined model. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) VRR parameter reflect the actual flexibility of units in responding to price signals rather than using assumed fixed operating blocks that are not a result of actual unit

¹¹ See also Comments of the Independent Market Monitor for PJM, Docket No. ER14-503-000 (December 20, 2013).

¹² See "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

limitations.^{13 14} The result of reflecting the actual flexibility is higher net revenues, which affect the parameters of the RPM demand curve and market outcomes. (Priority: High. First reported 2013. Status: Not adopted.)

- The MMU recommends that energy efficiency resources (EE) not be included on the supply side of the capacity market, because PJM's load forecasts now account for future EE, unlike the situation when EE was first added to the capacity market. However, the MMU recommends that the PJM load forecast method should be modified so that EE impacts immediately affect the forecast without the long lag times incorporated in the current forecast method. If EE is not included on the supply side, there is no reason to have an add back mechanism. If EE remains on the supply side, the implementation of the EE add back mechanism should be modified to ensure that market clearing prices are not affected. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM reduce the number of incremental auctions to a single incremental auction held three months prior to the start of the delivery year and reevaluate the triggers for holding conditional incremental auctions. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM offer to sell back capacity in incremental auctions only at the BRA clearing price for the relevant delivery year. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends changing the RPM solution method to explicitly incorporate the cost of make whole payments in the objective function. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM clear the capacity market based on nodal capacity resource locations and the characteristics of the transmission system consistent with the actual electrical facts of the grid. The current nested LDA structure used in the capacity market does not adequately represent all the capacity transfers that are feasible among LDAs. Absent a fully nodal capacity market clearing process, the MMU recommends that

PJM use a nonnested model for all LDAs and specify a VRR curve for each LDA separately. Each LDA requirement should be met with the capacity resources located within the LDA and exchanges from neighboring LDAs up to the transmission limit. LDAs should price separate if that is the result of the LDA supply curves and the transmission constraints. (Priority: Medium. First reported 2017. Status: Not adopted.)

- The MMU recommends that the maximum price on the VRR curve be defined as net CONE. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the Fixed Resource Requirement (FRR) rules, including obligations and performance requirements, be revised and updated to ensure that the rules reflect current market realities and that FRR entities do not unfairly take advantage of those customers paying for capacity in the PJM capacity market. (Priority: Medium. First reported 2019. Status: Not adopted.)

Offer Caps, Offer Floors, and Must Offer

- The MMU recommends use of the Sustainable Market Rule (SMR) in order to protect competition in the capacity market from nonmarket revenues.¹⁵ (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that, as part of the MOPR unit specific standard of review, all projects be required to use the same basic modeling assumptions. That is the only way to ensure that projects compete on the basis of actual costs rather than on the basis of modeling assumptions.¹⁶ (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that modifications to existing resources not be treated as new resources for purposes of market power related offer caps

¹⁵ Brief of the Independent Market Monitor for PJM, Docket No. EL16-49, ER18-1314-000-001; EL18-178 (October 2, 2018).

¹⁶ See 143 FERC ¶ 61,090 (2013) ("We encourage PJM and its stakeholders to consider, for example, whether the unit-specific review process would be more effective if PJM requires the use of common modeling assumptions for establishing unit-specific offer floors while, at the same time, allowing sellers to provide support for objective, individual cost advantages. Moreover, we encourage PJM and its stakeholders to consider these modifications to the unit-specific review process together with possible enhancements to the calculation of Net CONE."); see also, Comments of the Independent Market Monitor for PJM, Docket No. ER13-535-001 (March 25, 2013); Complaint of the Independent Market Monitor for PJM v. Unnamed Participant, Docket No. EL12-63-000 (May 1, 2012); Motion for Clarification of the Independent Market Monitor for PJM, Docket No. ER11-2875-000, et al. (February 17, 2012); Protest of the Independent Market Monitor for PJM, Docket No. ER11-2875-002 (June 2, 2011); Comments of the Independent Market Monitor for PJM, Docket Nos. EL11-20 and ER11-2875 (March 4, 2011).

¹³ See PJM Interconnection, LLC, Docket No. ER12-513-000 (December 1, 2011) ("Triennial Review").

¹⁴ See the 2019 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue.

or MOPR offer floors. (Priority: Low. First reported 2012. Status: Not adopted.)

- The MMU recommends that the RPM market power mitigation rule be modified to apply offer caps in all cases when the three pivotal supplier test is failed and the sell offer is greater than the offer cap. This will ensure that market power does not result in an increase in make whole payments. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that the offer cap for capacity resources be defined as the net avoidable cost rate (ACR) of each unit so that the clearing prices are a result of such net ACR offers, consistent with the fundamental economic logic for a competitive offer of a CP resource. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM develop a process for calculating a forward looking estimate for the expected number of Performance Assessment Intervals (H) to use in calculating the Market Seller Offer Cap (MSOC). The MMU recommends that the Nonperformance Charge Rate be left at its current level. The MMU recommends that PJM develop a forward looking estimate for the Balancing Ratio (B) during Performance Assessment Intervals (PAIs) to use in calculating the MSOC. Both H and B parameters should be included in the annual review of planning parameters for the Base Residual Auction, and should incorporate the actual observed reserve margins, and other assumptions consistent with the annual IRM study. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that capacity market sellers be required to request the use of minimum MW quantities greater than 0 MW (inflexible sell offer segments) and that the requests should only be permitted for defined physical reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the values in the CRF table in the tariff when the components change. (Priority: High. First reported 2020. Status: Not adopted.)

Performance Incentive Requirements of RPM

- The MMU recommends that any unit which is not capable of supplying energy consistent with its day-ahead offer which should equal its ICAP, reflect an appropriate outage. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that retroactive replacement transactions associated with a failure to perform during a PAI not be allowed and that, more generally, retroactive replacement capacity transactions not be permitted. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that there be an explicit requirement that capacity resource offers in the day-ahead energy market be competitive, where competitive is defined to be the short run marginal cost of the units. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that Capacity Performance resources be required to perform without excuses. Resources that do not perform should not be paid regardless of the reason for nonperformance. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the market data posting rules be modified to allow the disclosure of expected performance, actual performance, shortfall and bonus MW during a PAI by area without the requirement that more than three market participants' data be aggregated for posting. (Priority: Low. First reported 2019. Status: Not adopted.)

Capacity Imports and Exports

- The MMU recommends that all capacity imports be required to be deliverable to PJM load prior to the relevant delivery year to ensure that they are full substitutes for internal, physical capacity resources. Pseudo ties alone are not adequate to ensure deliverability. (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that all costs incurred as a result of a pseudo tied unit be borne by the unit itself and included as appropriate in unit offers

in the capacity market. (Priority: High. First reported 2016. Status: Not adopted.)

- The MMU recommends clear, explicit and detailed rules that define the conditions under which PJM will and will not recall energy from PJM capacity resources and prohibit new energy exports from PJM capacity resources. The MMU recommends that those rules define the conditions under which PJM will purchase emergency energy while at the same time not recalling energy exports from PJM capacity resources. PJM has modified these rules, but the rules need additional clarification and operational details. (Priority: Low. First reported 2010. Status: Partially adopted.)

Deactivations/Retirements

- The MMU recommends that the notification requirement for deactivations be extended from 90 days prior to the date of deactivation to 12 months prior to the date of deactivation and that PJM and the MMU be provided 60 days rather than 30 days to complete their reliability and market power analyses. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that RMR units recover all and only the incremental costs, including incremental investment costs, required by the RMR service that the unit owner would not have incurred if the unit owner had deactivated its unit as it proposed. Customers should bear no responsibility for paying previously incurred costs, including a return on or of prior investments. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends elimination of the cost of service recovery rate in OATT Section 119, and that RMR service should be provided under the deactivation avoidable cost rate in Part V. The MMU also recommends specific improvements to the DACR provisions. (Priority: Medium. First reported 2017. Status: Not adopted.)

Section 6, Demand Response

- The MMU recommends, as a preferred alternative to including demand resources as supply in the capacity market, that demand resources be on the demand side of the markets, that customers be able to avoid capacity and energy charges by not using capacity and energy at their discretion, that customer payments be determined only by metered load, and that PJM forecasts immediately incorporate the impacts of demand side behavior. (Priority: High. First reported 2014. Status: Not adopted.)
- The MMU recommends that the option to specify a minimum dispatch price (strike price) for demand resources be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the demand resources be treated as economic resources, responding to economic price signals like other capacity resources. The MMU recommends that demand resources not be treated as emergency resources, not trigger a PJM emergency and not trigger a Performance Assessment Interval. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Emergency Program Energy Only option be eliminated because the opportunity to receive the appropriate energy market incentive is already provided in the economic program. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends that, if demand resources remain in the capacity market, a daily energy market must offer requirement apply to demand resources, comparable to the rule applicable to generation capacity resources.¹⁷ (Priority: High. First reported 2013. Status: Not adopted.)

¹⁷ See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

- The MMU recommends that demand resources be required to provide their nodal location, comparable to generation resources. (Priority: High. First reported 2011. Status: Not adopted.)
- The MMU recommends that PJM require nodal dispatch of demand resources with no advance notice required or, if nodal location is not required, subzonal dispatch of demand resources with no advance notice required. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM eliminate the measurement of compliance across zones within a compliance aggregation area (CAA). The multiple zone approach is less locational than the zonal and subzonal approach and creates larger mismatches between the locational need for the resources and the actual response. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that measurement and verification methods for demand resources be modified to reflect compliance more accurately. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that operators have the necessary information for reliability and that market payments to demand resources be calculated based on interval meter data at the site of the demand reductions.¹⁸ (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends limited, extended summer and annual demand response event compliance be calculated on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that shutdown cost be defined as the cost to curtail load for a given period that does not vary with the measured reduction or, for behind the meter generators, be the start cost defined in Manual 15 for generators. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Net Benefits Test be eliminated and that demand response resources be paid LMP less any generation component of the applicable retail rate. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the tariff rules for demand response clarify that a resource and its CSP, if any, must notify PJM of material changes affecting the capability of the resource to perform as registered and must terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at defined levels because load has been reduced or eliminated, as in the case of bankrupt and/or out of service facilities. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that there be only one demand response product in the capacity market, with an obligation to respond when called for any hour of the delivery year. (Priority: High. First reported 2011. Status: Partially adopted.¹⁹)
- The MMU recommends that the lead times for demand resources be shortened to 30 minutes with an hour minimum dispatch for all resources. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends setting the baseline for measuring capacity compliance under winter compliance at the customers' PLC, similar

¹⁸ See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

¹⁹ PJM's Capacity Performance design requires resources to respond when called for any hour of the delivery year, but demand resources still have a limited mandatory compliance window.

to GLD, to avoid double counting. (Priority: High. First reported 2010. Status: Partially adopted.)

- The MMU recommends the Relative Root Mean Squared Test be required for all demand resources with a CBL. (Priority: Low. First reported 2017. Status: Partially adopted.)
- The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that the limits imposed on the pre-emergency and emergency demand response share of the synchronized reserve market be eliminated. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that 30 minute pre-emergency and emergency demand response be considered to be 30 minute reserves. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that energy efficiency MW not be included in the PJM Capacity Market and that PJM should ensure that the impact of EE measures on the load forecast is incorporated immediately rather than with the existing lag. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that all demand resources register as Pre-Emergency Load Response and that the Emergency Load Response Program be eliminated. (Priority: High. First reported Q1 2020. Status: Not adopted.)

Section 7, Net Revenue

- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) and net ACR be based on a forward looking estimate of expected energy and ancillary services net

revenues using forward prices for energy and fuel. (Priority: Medium. First reported 2019. Status: Adopted 2020.)

Section 8, Environmental and Renewables

- The MMU recommends that renewable energy credit markets based on state renewable portfolio standards be brought into PJM markets as they are an increasingly important component of the wholesale energy market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the Commission reconsider its disclaimer of jurisdiction over RECs markets because, given market changes since that decision, it is clear that RECs materially affect jurisdictional rates. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to the PJM states in order to permit the states to consider a potential agreement on the development of a multistate framework for carbon pricing and the distribution of carbon revenues. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that jurisdictions with a renewable portfolio standard make the price and quantity data on supply and demand more transparent. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that load and generation located at separate nodes be treated as separate resources in order to ensure that load and generation face consistent incentives throughout the markets. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that emergency stationary RICE be prohibited from participation as DR either when registered individually or as part of a portfolio if it cannot meet the capacity market requirements to be DR as a result of emissions standards that impose environmental run hour limitations. (Priority: Medium. First reported 2019. Status: Not adopted.)

Section 9, Interchange Transactions

- The MMU recommends that PJM implement rules to prevent sham scheduling. The MMU recommends that PJM apply after the fact market settlement adjustments to identified sham scheduling segments to ensure that market participants cannot benefit from sham scheduling. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would prohibit market participants from breaking transactions into smaller segments to defeat the interface pricing rule by concealing the true source or sink of the transaction. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would require market participants to submit transactions on paths that reflect the expected actual power flow in order to reduce unscheduled loop flows. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM end the practice of maintaining outdated definitions of interface pricing points, eliminate the NIPSCO, Southeast and Southwest interface pricing points from the day-ahead and real-time energy markets and, with VACAR, assign the transactions created under the reserve sharing agreement to the SouthIMP/EXP pricing point. (Priority: High. First reported 2013. Status: Partially adopted, Q2 2020.)²⁰
- The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the locational price impact of flows between the DC tie line point of connection with the Eastern Interconnection and PJM. (Priority: High. First reported Q1, 2020. Status: Not adopted.)
- The MMU recommends changing the assignment of the Saskatchewan Power Company and Manitoba Hydro balancing authorities from the Northwest interface pricing point to the MISO interface pricing point and

eliminating the Northwest interface pricing point from the day-ahead and real-time energy markets. (Priority: High. First reported Q1, 2020. Status: Adopted Q4, 2020.)

- The MMU recommends that PJM eliminate the IMO interface pricing point, and assign the transactions that originate or sink in the IESO balancing authority to the MISO interface pricing point. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM eliminate the NCMPAIMP and NCMPAEXP interface pricing points. It is not appropriate to have special pricing agreements between PJM and any external entity. The same market pricing should apply to all transactions. (Priority: High. First reported Q2, 2020. Status: Adopted Q4, 2020.)
- The MMU recommends that PJM monitor, and adjust as necessary, the weights applied to the components of the interfaces to ensure that the interface prices reflect ongoing changes in system conditions. The MMU also recommends that PJM review the mappings of external balancing authorities to individual interface pricing points to reflect changes to the impact of the external power source on PJM tie lines as a result of system topology changes. The MMU recommends that this review occur at least annually. (Priority: Low. First reported 2009. Status: Not adopted.)
- The MMU recommends that, in order to permit a complete analysis of loop flow, FERC and NERC ensure that the identified data are made available to market monitors as well as other industry entities determined appropriate by FERC. (Priority: Medium. First reported 2003. Status: Not adopted.)
- The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that would remove the need for market participants to schedule physical transactions across seams. Such a solution would include an optimized, but limited, joint dispatch approach that uses supply curves and treats seams between balancing authorities as constraints, similar to other constraints within an LMP market. (Priority: Medium. First reported 2014. Status: Not adopted.)

²⁰ The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the day-ahead or real-time energy markets. Effective June 1, 2020, PJM retired the NIPSCO interface pricing point.

- The MMU recommends that PJM permit unlimited spot market imports as well as unlimited nonfirm point to point willing to pay congestion imports and exports at all PJM interfaces in order to improve the efficiency of the market. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that the emergency interchange cap be replaced with a market based solution. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the submission deadline for real-time dispatchable transactions be modified from 1800 on the day prior, to three hours prior to the requested start time, and that the minimum duration be modified from one hour to 15 minutes. These changes would give PJM a more flexible product that could be used to meet load in the most economic manner. (Priority: Medium. First reported 2014. Status: Partially adopted, 2015.)
- The MMU recommends modifications to the FFE calculation to ensure that FFE calculations reflect the current capability of the transmission system as it evolves. The MMU recommends that the Commission set a deadline for PJM and MISO to resolve the FFE freeze date and related issues. (Priority: Medium. First reported 2019. Status: Not adopted.)

Section 10, Ancillary Services

- The MMU recommends that all data necessary to perform the regulation market three pivotal supplier test be saved by PJM so that the test can be replicated. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that the total regulation (TReg) signal sent on a fleet wide basis be eliminated and replaced with individual regulation signals for each unit. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the ability to make dual offers (to make offers as both a RegA and a RegD resource in the same market hour) be removed from the regulation market. (Priority: High. First reported 2019. Status: Not adopted.)

- The MMU recommends that the regulation market be modified to incorporate a consistent application of the marginal benefit factor (MBF) throughout the optimization, assignment and settlement process. The MBF should be defined as the Marginal Rate of Technical Substitution (MRTS) between RegA and RegD. (Priority: High. First reported 2012. Status: Not adopted. FERC rejected.²¹)
- The MMU recommends that the lost opportunity cost in the ancillary services markets be calculated using the schedule on which the unit was scheduled to run in the energy market. (Priority: High. First reported 2010. Status: Not adopted.²² FERC rejected.²³)
- The MMU recommends that the lost opportunity cost calculation used in the regulation market be based on the resource's dispatched energy offer schedule, not the lower of its price or cost offer schedule. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.²⁴)
- The MMU recommends that, to prevent gaming, there be a penalty enforced in the regulation market as a reduction in performance score and/or a forfeiture of revenues when resource owners elect to deassign assigned regulation resources within the hour. (Priority: Medium. First reported 2016. Status: Not adopted. FERC rejected.²⁵)
- The MMU recommends enhanced documentation of the implementation of the regulation market design. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.²⁶)
- The MMU recommends that PJM be required to save data elements necessary for verifying the performance of the regulation market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the \$12.00 margin adder be eliminated from the definition of the cost based regulation offer because it is a markup and not a cost. (Priority: Medium. New recommendation. Status: Not adopted.)

²¹ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

²² This recommendation was adopted by PJM for the energy market. Lost opportunity costs in the energy market are calculated using the schedule on which the unit was scheduled to run. In the regulation market, this recommendation has not been adopted, as the LOC continues to be calculated based on the lower of price or cost in the energy market offer.

²³ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

²⁴ *Id.*

²⁵ *Id.*

²⁶ *Id.*

- The MMU recommends that PJM replace the static MidAtlantic/Dominion Reserve Subzone with a reserve zone structure consistent with the actual deliverability of reserves based on current transmission constraints. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the \$7.50 margin be eliminated from the definition of the cost of tier 2 synchronized reserve because it is a markup and not a cost. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that the variable operating and maintenance cost be eliminated from the definition of the cost of tier 2 synchronized reserve and that the calculation of synchronized reserve variable operations and maintenance costs be removed from Manual 15. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the components of the cost-based offers for providing regulation and synchronous condensing be defined in Schedule 2 of the Operating Agreement. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the rule requiring that tier 1 synchronized reserve resources are paid the tier 2 price when the nonsynchronized reserve price is above zero be eliminated immediately and that, under the current rule, tier 1 synchronized reserve resources not be paid the tier 2 price when they do not respond. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that the tier 2 synchronized reserve must offer requirement be enforced on a daily and hourly basis. The MMU recommends that PJM define a set of acceptable reasons why a unit can be made unavailable daily or hourly and require unit owners to select a reason in Markets Gateway whenever making a unit unavailable either daily or hourly or setting the offer MW to 0 MW. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that, for calculating the penalty for a tier 2 resource failing to meet its scheduled obligation during a spinning event, the definition of the IPI be changed from the average number of days between events to the actual number of days since the last event greater than 10 minutes. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that aggregation not be permitted to offset unit specific penalties for failure to respond to a synchronized reserve event. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM eliminate the use of Degree of Generator Performance (DGP) in the synchronized reserve market solution and improve the actual tier 1 estimate. If PJM continues to use DGP, DGP should be documented in PJM's manuals. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that the details of VACAR Reserve Sharing Agreement (VRSA) be made public, including any responsibilities assigned to PJM and including the amount of reserves that Dominion commits to meet its obligations under the VRSA. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that the VRSA be terminated and, if necessary, replaced by a reserve sharing agreement between PJM and VACAR South, similar to agreements between PJM and other bordering areas. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that a reason code be attached to every hour in which PJM market operations adds additional DASR MW. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM modify the DASR market to ensure that all resources cleared incur a real-time performance obligation. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that offers in the DASR market be based on opportunity cost only in order to mitigate market power. (Priority: Low. First reported 2009. Modified, 2018. Status: Not adopted.)
- The MMU recommends that all resources, new and existing, have a requirement to include and maintain equipment for primary frequency response capability as a condition of interconnection service. The PJM

capacity and energy markets already compensate resources for frequency response capability and any marginal costs. (Priority: Medium. First reported 2018. Status: Not adopted.)

- The MMU recommends that new CRF rates for black start units, incorporating current tax code changes, be implemented immediately. The new CRF rates should apply to all black start units. The black start units should be required to commit to providing black start service for the life of the unit. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends for oil tanks shared with other resources that only a proportionate share of the minimum tank suction level (MTSL) be allocated to black start service. The MMU further recommends that the PJM tariff be updated to clearly state how the MTSL will be calculated for black start units sharing oil tanks. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that separate cost of service payments for reactive capability be eliminated and the cost of reactive capability be recovered in the capacity market. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that payments for reactive capability, if continued, be based on the 0.90 power factor that PJM has determined is necessary. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that, if payments for reactive are continued, fleet wide cost of service rates used to compensate resources for reactive capability be eliminated and replaced with compensation based on unit specific costs. (Priority: Low. First reported 2019.²⁷ Status: Partially adopted.)
- The MMU recommends that Schedule 2 to OATT be revised to state explicitly that only generators that provide reactive capability to the transmission system that PJM operates and has responsibility for are eligible for reactive capability compensation. Specifically, such eligibility should be determined based on whether a generation facility's point of interconnection is on a transmission line that is a Monitored Transmission

²⁷ The MMU has discussed this recommendation in state of the market reports since 2016 but Q3, 2019 was the first time it was reported as a formal MMU recommendation.

Facility as defined by PJM and is on a Reportable Transmission Facility as defined by PJM.²⁸ (Priority: Medium. First reported 2020. Status: Not adopted.)

Section 11, Congestion and Marginal Losses

There are no recommendations in this section.

Section 12, Planning

Generation Retirements

- The MMU recommends that the question of whether Capacity Interconnection Rights (CIRs) should persist after the retirement of a unit be addressed. The rules need to ensure that incumbents cannot exploit control of CIRs to block or postpone entry of competitors.²⁹ (Priority: Low. First reported 2013. Status: Partially adopted, 2012.)

Generation Queue

- The MMU recommends that barriers to entry be addressed in a timely manner in order to help ensure that the capacity market will result in the entry of new capacity to meet the needs of PJM market participants and reflect the uncertainty and resultant risks in the cost of new entry used to establish the capacity market demand curve in RPM. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends improvements in queue management including that PJM establish a review process to ensure that projects are removed from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress, subject to rules to prevent gaming. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends continuing analysis of the study phase of PJM's transmission planning to reduce the need for postponements of study

²⁸ See PJM Transmission Facilities (note that this requires you first log into a PJM Tools account. If you do not, then the link sends you to an Access Request page, <<https://pjm.com/markets-and-operations/ops-analysis/transmission-facilities>>.

²⁹ See "Comments of the Independent Market Monitor for PJM," Docket No. ER12-1177-000 (March 12, 2012) <http://www.monitoringanalytics.com/Filings/2012/IMM_Comments_ER12-1177-000_20120312.PDF>.

results, to decrease study completion times, and to improve the likelihood that a project at a given phase in the study process will successfully go into service. (Priority: Medium. First reported 2014. Status: Partially adopted.)

- The MMU recommends outsourcing interconnection studies to an independent party to avoid potential conflicts of interest. Currently, these studies are performed by incumbent transmission owners under PJM's direction. This creates potential conflicts of interest, particularly when transmission owners are vertically integrated and the owner of transmission also owns generation. (Priority: Low. First reported 2013. Status: Not adopted.)

Market Efficiency Process

- The MMU recommends that the market efficiency process be eliminated because it is not consistent with a competitive market design. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that, if the market efficiency process is retained, PJM modify the rules governing benefit/cost analysis, the evaluation process for selecting among competing market efficiency projects and cost allocation for economic projects in order to ensure that all costs, including increased congestion costs and the risk of project cost increases, in all zones are included in order to ensure that the correct metrics are used for defining benefits. (Priority: Medium. First reported 2018. Status: Not adopted.)

Comparative Cost Framework

- The MMU recommends that PJM modify the project proposal templates to include data necessary to perform a detailed project lifetime financial analysis. The required data includes, but is not limited to: capital expenditure; capital structure; return on equity; cost of debt; tax assumptions; ongoing capital expenditures; ongoing maintenance; and expected life. (Priority: Medium. First reported 2020. Status: Not adopted.)

Transmission Competition

- The MMU recommends, to increase the role of competition, that the exemption of supplemental projects from the Order No. 1000 competitive process be terminated and that the basis for all such exemptions be reviewed and modified to ensure that the supplemental project designation is not used to exempt transmission projects from a transparent, robust and clearly defined mechanism to permit competition to build such projects or to effectively replace the RTEP process. (Priority: Medium. First reported 2017. Status: Not adopted. Rejected by FERC.)
- The MMU recommends, to increase the role of competition, that the exemption of end of life projects from the Order No. 1000 competitive process be terminated and that end of life transmission projects be included in the RTEP process and should be subject to a transparent, robust and clearly defined mechanism to permit competition to build such projects. (Priority: Medium. First reported 2019. Status: Not adopted. Rejected by FERC.)
- The MMU recommends that PJM enhance the transparency and queue management process for nonincumbent transmission investment. Issues related to data access and complete explanations of cost impacts should be addressed. The goal should be to remove barriers to competition from nonincumbent transmission providers. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM continue to incorporate the principle that the goal of transmission planning should be the incorporation of transmission investment decisions into market driven processes as much as possible. (Priority: Low. First reported 2001. Status: Not adopted.)
- The MMU recommends the creation of a mechanism to permit a direct comparison, or competition, between transmission and generation alternatives, including which alternative is less costly and who bears the risks associated with each alternative. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM establish fair terms of access to rights of way and property, such as at substations, in order to remove any barriers to

entry and permit competition between incumbent transmission providers and nonincumbent transmission providers in the RTEP. (Priority: Medium. First reported 2014. Status: Not adopted.)

- The MMU recommends that rules be implemented to permit competition to provide financing for transmission projects. This competition could reduce the cost of capital for transmission projects and significantly reduce total costs to customers. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that rules be implemented to require that project cost caps on new transmission projects be part of the evaluation of competing projects. (Priority: Medium. First reported 2015. Status: Adopted 2020.)
- The MMU recommends that storage resources not be includable as transmission assets for any reason. (Priority: High. First reported 2020. Status: Not adopted.)

Cost Allocation

- The MMU recommends a comprehensive review of the ways in which the solution based dfax is implemented. The goal for such a process would be to ensure that the most rational and efficient approach to implementing the solution based dfax method is used in PJM. Such an approach should allocate costs consistent with benefits and appropriately calibrate the incentives for investment in new transmission capability. No replacement approach should be approved until all potential alternatives, including the status quo, are thoroughly reviewed. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends consideration of changing the minimum distribution factor in the allocation from 0.01 to 0.00 and adding a threshold minimum usage impact on the line.³⁰ (Priority: Medium. First reported 2015. Status: Not adopted.)

³⁰ See the *2015 State of the Market Report for PJM*, Volume II, Section 12: Generation and Transmission Planning, at p. 463, Cost Allocation Issues.

Transmission Line Ratings

- The MMU recommends that all PJM transmission owners use the same methods to define line ratings, subject to NERC standards and guidelines, subject to review by NERC and approval by FERC. (Priority: Medium. First reported 2019. Status: Not adopted.)

Transmission Facility Outages

- The MMU recommends that PJM reevaluate all transmission outage tickets as on time or late as if they were new requests when an outage is rescheduled, and apply the standard rules for late submissions to any such outages. (Priority: Low. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM draft a clear definition of the congestion analysis required for transmission outage requests to include in Manual 3 after appropriate review. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM modify the rules to reduce or eliminate the approval of late outage requests submitted or rescheduled after the FTR auction bidding opening date. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not permit transmission owners to divide long duration outages into smaller segments to avoid complying with the requirements for long duration outages. (Priority: Low. First reported 2015. Status: Not adopted.)

Section 13, FTRs and ARRs

Market Design

ARR

- The MMU recommends that the ARR/FTR design be modified to ensure that the rights to all congestion revenues are assigned to load. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that all historical generation to load paths be eliminated as a basis for assigning ARRs. The MMU recommends that the

current design be replaced with a network design in which the rights to actual congestion are assigned directly to load by node. (Priority: High. First reported 2015. Status: Partially adopted.)

- The MMU recommends that, under the current FTR design, the rights to all congestion revenue be allocated as ARRs prior to sale as FTRs. Reductions for outages and increased system capability should be reserved for ARRs rather than sold in the Long Term FTR Auction. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that IARRs be eliminated from PJM's tariff, but that if IARRs are not eliminated, IARRs should be subject to the same proration rules that apply to all other ARR rights. (Priority: Low. First reported 2018. Status: Not adopted.)

FTR

- The MMU recommends that FTR funding be based on total congestion, including day-ahead and balancing congestion. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM enforce the FTR auction bid limits at the parent company level starting immediately. (Priority: High. First reported 2020. Status: Adopted 2021.)
- The MMU recommends a requirement that the details of all bilateral FTR transactions be reported to PJM. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM continue to evaluate the bilateral indemnification rules and any asymmetries they may create. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM reduce FTR sales on paths with persistent overallocation of FTRs, including a clear definition of persistent overallocation and how the reduction will be applied. (Priority: High. First reported 2013. Status: Partially adopted, 2014/2015 planning period.)
- MMU recommends that PJM eliminate generation to generation paths and all other paths that do not represent the delivery of power to load. (Priority: High. First reported 2018. Status: Not adopted.)

- The MMU recommends that the Long Term FTR product be eliminated. If the Long Term FTR product is not eliminated, the Long Term FTR Market should be modified so that the supply of prevailing flow FTRs in the Long Term FTR Market is based solely on counter flow offers in the Long Term FTR Market. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM improve transmission outage modeling in the FTR auction models, including the use of probabilistic outage modeling. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that the forfeiture amount from the FTR forfeiture rule be based on the correct hourly cost of an FTR, rather than a simple daily price divided by 24. (Priority: High. First reported 2018. Status: Adopted 2019.)

Surplus

- The MMU recommends that all FTR auction revenue be distributed to ARR holders monthly, regardless of FTR funding levels. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that, under the current FTR design, all congestion revenue in excess of FTR target allocations be distributed to ARR holders on a monthly basis. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that FTR auction revenues not be used by PJM to buy counter flow FTRs for the purpose of improving FTR payout ratios.³¹ (Priority: High. First reported 2015. Status: Not adopted.)

³¹ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

FTR Subsidies

- The MMU recommends that PJM eliminate portfolio netting to eliminate cross subsidies among FTR market participants. (Priority: High. First reported 2012. Status: Not adopted. Rejected by FERC.)
- The MMU recommends that PJM eliminate subsidies to counter flow FTRs by applying the payout ratio to counter flow FTRs in the same way the payout ratio is applied to prevailing flow FTRs. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM eliminate geographic cross subsidies. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM examine the mechanism by which self scheduled FTRs are allocated when load switching among LSEs occurs throughout the planning period. (Priority: Low. First reported 2011. Status: Not adopted.)

FTR Liquidation

- The MMU recommends that the FTR portfolio of a defaulted member be canceled rather than liquidated or allowed to settle as a default cost on the membership. (Priority: High. First reported 2018. Status: Not adopted.)

Energy Market

The PJM energy market comprises all types of energy transactions, including the sale or purchase of energy in PJM's Day-Ahead and Real-Time Energy Markets, bilateral and forward markets and self supply. Energy transactions analyzed in this report include those in the PJM Day-Ahead and Real-Time Energy Markets. These markets provide key benchmarks against which market participants may measure results of transactions in other markets.

The Market Monitoring Unit (MMU) analyzed measures of market structure, participant conduct and market performance, including market size, concentration, pivotal suppliers, offer behavior, markup, and price. The MMU concludes that the PJM energy market results were competitive in the first three months of 2021.

Table 3-1 The energy market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Partially Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Effective

- The aggregate market structure was evaluated as partially competitive because the aggregate market power test based on pivotal suppliers indicates that the aggregate day-ahead market structure was not competitive on every day. The hourly HHI (Herfindahl-Hirschman Index) results indicate that the PJM aggregate energy market in the first three months of 2021 was unconcentrated by FERC HHI standards. Average HHI was 738 with a minimum of 607 and a maximum of 919 in the first three months of 2021. The peaking segment of supply was highly concentrated. The fact that the average HHI and the maximum hourly HHI are in the unconcentrated range does not mean that the aggregate market was competitive in all hours. As demonstrated for the day-ahead market, it is possible to have pivotal suppliers in the aggregate market even when the HHI level is not in the highly concentrated range. It is possible to have an exercise of market power even when the HHI level is

not in the highly concentrated range. The number of pivotal suppliers in the energy market is a more precise measure of structural market power than the HHI. The HHI is not a definitive measure of structural market power.

- The local market structure was evaluated as not competitive due to the highly concentrated ownership of supply in local markets created by transmission constraints and local reliability issues. The results of the three pivotal supplier (TPS) test, used to test local market structure, indicate the existence of market power in local markets created by transmission constraints. The local market performance is competitive as a result of the application of the TPS test. While transmission constraints create the potential for the exercise of local market power, PJM's application of the three pivotal supplier test identified local market power and resulted in offer capping to force competitive offers, correcting for structural issues created by local transmission constraints. There are, however, identified issues with the definition of cost-based offers and the application of market power mitigation to resources whose owners fail the TPS test that need to be addressed because unit owners can exercise market power even when they fail the TPS test.
- Participant behavior was evaluated as competitive because the analysis of markup shows that marginal units generally make offers at, or close to, their marginal costs in both the day-ahead and real-time energy markets, although the behavior of some participants both routinely and during periods of high demand represents economic withholding. The ownership of marginal units is concentrated. The markups of pivotal suppliers in the aggregate market and of many pivotal suppliers in local markets remain unmitigated due to the lack of aggregate market power mitigation and the flawed implementation of offer caps for resources that fail the TPS test. The markups of those participants affected LMP.
- Market performance was evaluated as competitive because market results in the energy market reflect the outcome of a competitive market, as PJM prices are set, on average, by marginal units operating at, or close to, their marginal costs in both day-ahead and real-time energy markets, although high markups for some marginal units did affect prices.

- Market design was evaluated as effective because the analysis shows that the PJM energy market resulted in competitive market outcomes. In general, PJM's energy market design provides incentives for competitive behavior and results in competitive outcomes. In local markets, where market power is an issue, the market design identifies market power and causes the market to provide competitive market outcomes in most cases although issues with the implementation of market power mitigation and development of cost-based offers remain. The role of UTCs in the day-ahead energy market continues to cause concerns. Market design implementation issues, including inaccuracies in modeling of the transmission system and of generator capabilities as well as inefficiencies in real-time dispatch and price formation, undermine market efficiency in the energy market.
- PJM markets are designed to promote competitive outcomes derived from the interaction of supply and demand in each of the PJM markets. Market design itself is the primary means of achieving and promoting competitive outcomes in PJM markets. One of the MMU's core functions is to identify actual or potential market design flaws.¹ The approach to market power mitigation in PJM has focused on market designs that promote competition (a structural basis for competitive outcomes) and on mitigating market power in instances where the market structure is not competitive and thus where market design alone cannot mitigate market power. FERC relies on effective market power mitigation when it approves market sellers to participate in the PJM market at market based rates.² In the PJM energy market, market power mitigation occurs primarily in the case of local market power. When a transmission constraint creates the potential for local market power, PJM applies a structural test to determine if the local market is competitive, applies a behavioral test to determine if generator offers exceed competitive levels and applies a market performance test to determine if such generator offers would affect the market price.³ There are, however, identified issues with the application of market power mitigation to resources whose owners fail

¹ OATT Attachment M (PJM Market Monitoring Plan).

² See *Refinements to Horizontal Market Power Analysis for Sellers in Certain Regional Transmission Organization and Independent System Operator Markets*, Order No. 861, 168 FERC ¶ 61,040 (July 18, 2019); *order on reh'g*, Order No. 861-A; 170 FERC ¶ 61,106 (2020).

³ The market performance test means that offer capping is not applied if the offer does not exceed the competitive level and therefore market power would not affect market performance.

the TPS test that can result in the exercise of local market power even when market power mitigation rules are applied. These issues need to be addressed. Some units with market power have positive markups and some have inflexible parameters, which means that the cost-based offer was not used and that the process for offer capping units that fail the TPS test does not consistently result in competitive market outcomes in the presence of market power. There are issues related to the definition of gas costs includable in energy offers that need to be addressed. There are issues related to the level of maintenance expense includable in energy offers that need to be addressed. There are currently no market power mitigation rules in place that limit the ability to exercise market power when aggregate market conditions are tight and there are pivotal suppliers in the aggregate market. Aggregate market power needs to be addressed. Market design must reflect appropriate incentives for competitive behavior, the application of local market power mitigation needs to be fixed, the definition of a competitive offer needs to be fixed, and aggregate market power mitigation rules need to be developed. The importance of these issues is amplified by the rules permitting cost-based offers in excess of \$1,000 per MWh.

Overview

Supply and Demand

Market Structure

- **Supply.** The average hourly day-ahead supply was 170,016 MW for the 2019/2020 winter, and 167,982 MW for the 2020/2021 winter. The average on-peak hourly offered real-time supply was 140,120 MW for the 2019/2020 winter, and 144,457 MW for the 2020-2021 winter. In the first three months of 2021, 703.2 MW of new resources were added in the energy market, and 430.4 MW of resources were retired.
- PJM average hourly real-time cleared generation in the first three months of 2021 increased by 5.9 percent from the first three months of 2020, from 90,675 MWh to 96,005 MWh.

- PJM average hourly day-ahead demand in the first three months of 2021, including DECs and up to congestion transactions, decreased by 5.3 percent from the first three months of 2020, from 108,144 MWh to 102,372 MWh.
- **Demand.** The PJM system real-time hourly peak load in the first three months of 2021 was 114,457 MWh in the HE 0900 on January 29, 2021, which was 2,303 MWh, 2.0 percent, lower than the PJM peak load in the first three months of 2020, which was 116,761 MWh in the HE 0800 on January 22, 2020.
- The PJM system real-time hourly peak load plus exports in the first three months of 2021 was 126,546 MWh in the HE 0900 on February 17, 2021. There were 113,294 MWh load in PJM and 13,252 MWh of exports.
- PJM average hourly real-time load in the first three months of 2021 increased by 5.0 percent from the first three months of 2020, from 85,608 MWh to 89,887 MWh.
- PJM average hourly day-ahead demand in the first three months of 2021, including load, DECs and up to congestion transactions, decreased by 5.3 percent from the first three months of 2020, from 108,144 MWh to 102,372 MWh.

Market Behavior

- **Generator Offers.** In the day-ahead market in the first three months of 2021, 22.4 percent of offered MW were must run, 31.1 percent were the economic minimum MW of dispatchable units, 45.6 percent were offered as dispatchable MW, and 0.8 percent were offered as emergency maximum MW.
- **Virtual Offers and Bids.** Any market participant in the PJM Day-Ahead Energy Market can use increment offers, decrement bids, up to congestion transactions, import transactions and export transactions as financial instruments that do not require physical generation or load. The hourly average submitted increment offer MW decreased by 11.1 percent and cleared MW decreased by 6.6 percent in the first three months of 2021 compared to the first three months of 2020. The hourly average submitted

decrement offer MW increased by 56.4 percent and cleared MW increased by 53.1 percent in the first three months of 2021 compared to the first three months of 2020. The hourly average submitted up to congestion bid MW decreased by 44.2 percent and cleared MW decreased by 55.2 percent in the first three months of 2021 compared to the first three months of 2020.

Market Performance

- **Generation Fuel Mix.** In the first three months of 2021, coal units provided 25.1 percent, nuclear units 32.7 percent and natural gas units 34.4 percent of total generation. Compared to the first three months of 2020, generation from coal units increased 45.6 percent, generation from natural gas units decreased 9.4 percent and generation from nuclear units decreased 1.0 percent. The shares of coal and natural gas returned to 2019 levels.
- **Fuel Diversity.** The fuel diversity of energy generation for the first three months of 2021, measured by the fuel diversity index for energy (FDI_e), increased 3.2 percent compared to the first three months of 2020.
- **Marginal Resources.** In the PJM Real-Time Energy Market in the first three months of 2021, coal units were 18.0 percent and natural gas units were 69.4 percent of marginal resources. In the first three months of 2020, coal units were 17.5 percent and natural gas units were 73.4 percent of marginal resources.

In the PJM Day-Ahead Energy Market in the first three months of 2021, up to congestion transactions were 37.7 percent, INCs were 16.7 percent, DECs were 24.8 percent, and generation resources were 20.5 percent of marginal resources. In the first three months of 2020, up to congestion transactions were 48.5 percent, INCs were 16.2 percent, DECs were 12.6 percent, and generation resources were 22.5 percent of marginal resources.

- **Prices.** PJM load-weighted, average, real-time LMP in the first three months of 2021 increased 55.3 percent from the first three months of 2020, from \$19.85 per MWh to \$30.84 per MWh, a similar level to the first three months of 2019.

PJM load-weighted, average day-ahead LMP in the first three months of 2021 increased 57.0 percent from the first three months of 2020, from \$20.12 per MWh to \$31.58 per MWh.

- **Components of LMP.** In the PJM Real-Time Energy Market in the first three months of 2021, 14.0 percent of the load-weighted LMP was the result of coal costs, 56.0 percent was the result of gas costs and 2.8 percent was the result of the cost of emission allowances.

In the PJM Day-Ahead Energy Market, in the first three months of 2021, 33.4 percent of the load-weighted LMP was the result of gas costs, 24.4 percent was the result of DEC bids, 14.0 percent was the result of coal costs, 11.2 percent was the result of INC offers, -0.2 percent was the result of markup, and 1.5 percent was the result of up to congestion transaction offers.

- **Price Convergence.** Hourly and daily price differences between the day-ahead and real-time energy markets fluctuate continuously and substantially from positive to negative. The difference between average day-ahead and real-time prices was -\$0.50 per MWh in the first three months of 2021, and -\$0.24 per MWh in the first three months of 2020. The difference between average day-ahead and real-time prices, by itself, is not a measure of the competitiveness or effectiveness of the day-ahead energy market.

Scarcity

- There were four intervals with five minute shortage pricing in the first three months of 2021. There were no emergency actions that resulted in Performance Assessment Intervals in the first three months of 2021.
- There were 420 five minute intervals, or 1.6 percent of all five minute intervals in the first three months of 2021 for which at least one RT SCED solution showed a shortage of reserves, and 96 five minute intervals, or 0.4 percent of all five minute intervals in the first three months of 2021 for which more than one RT SCED solution showed a shortage of reserves. PJM triggered shortage pricing for four five minute intervals.

Competitive Assessment

Market Structure

- **Aggregate Pivotal Suppliers.** The PJM energy market, at times, requires generation from pivotal suppliers to meet load, resulting in aggregate market power even when the HHI level indicates that the aggregate market is unconcentrated.
- **Local Market Power.** In the first three months of 2021, 12 control zones experienced congestion resulting from one or more constraints binding for 25 or more hours. For six out of the top 10 congested facilities (by real-time binding hours) in the first three months of 2021, the average number of suppliers providing constraint relief was three or less. There is a high level of concentration within the local markets for providing relief to the most congested facilities in the PJM Real-Time Energy Market. The local market structure is not competitive.

Market Behavior

- **Offer Capping for Local Market Power.** PJM offer caps units when the local market structure is noncompetitive. Offer capping is an effective means of addressing local market power when the rules are designed and implemented properly. Offer capping levels have historically been low in PJM. In the day-ahead energy market, for units committed to provide energy for local constraint relief, offer-capped unit hours increased from 0.8 percent in the first three months of 2020 to 0.9 percent in the first three months of 2021. In the real-time energy market, for units committed to provide energy for local constraint relief, offer-capped unit hours increased from 0.7 percent in the first three months of 2020 to 1.2 percent in the first three months of 2021. While overall offer capping levels have been low, there are a significant number of units with persistent structural local market power that would have a significant impact on prices in the absence of local market power mitigation.

The analysis of the application of the TPS test to local markets demonstrates that it is working to identify pivotal owners when the market structure is

noncompetitive and to ensure that owners are not subject to offer capping when the market structure is competitive. There are, however, identified issues with the application of market power mitigation to resources whose owners fail the TPS test that can result in the exercise of local market power. These issues need to be addressed.

- **Offer Capping for Reliability.** PJM also offer caps units that are committed for reliability reasons, including for reactive support. In the day-ahead energy market, for units committed for reliability reasons, offer-capped unit hours increased from 0.00 percent in the first three months of 2020 to 0.03 percent in the first three months of 2021. In the real-time energy market, for units committed for reliability reasons, offer-capped unit hours increased from 0.00 percent in the first three months of 2020 to 0.03 percent in the first three months of 2021. The low offer cap percentages do not mean that units manually committed for reliability reasons do not have market power. All units manually committed for reliability have market power and all are treated as if they had market power. These units are not capped to their cost-based offers because they tend to offer with a negative markup in their price-based offers, particularly at the economic minimum level, which means that PJM's offer capping process results in the use of the price-based offer for commitment.
- **Frequently Mitigated Units (FMU) and Associated Units (AU).** One unit qualified for an FMU adder for the months of September and October, 2019. In 2020, five units qualified for an FMU adder in at least one month. In the first three months of 2021, one unit qualified for an FMU adder in January.
- **Markup Index.** The markup index is a summary measure of participant offer behavior for individual marginal units. While the average markup index in the real-time market was -0.2 in the first three months of 2021, some marginal units did have substantial markups. The highest markup for any marginal unit in the real-time market in the first three months of 2021 was more than \$200 per MWh when using unadjusted cost-based offers.

While the average markup index in the day-ahead market was 0.03 in the first three months of 2021, some marginal units did have substantial markups. The highest markup for any marginal unit in the day-ahead market in the first three months of 2021 was more than \$80 per MWh when using unadjusted cost-based offers.

- **Markup.** The markup frequency distributions show that a significant proportion of units make price-based offers less than the cost-based offers permitted under the PJM market rules. This behavior means that competitive price-based offers reveal actual unit marginal costs and that PJM market rules permit the inclusion of costs in cost-based offers that are not short run marginal costs.

The markup behavior shown in the markup frequency distributions also shows that a substantial number of units were offered with high markups, consistent with the exercise of market power. Markup for coal and gas fired units decreased in the first three months of 2021.

Market Performance

- **Markup.** The markup conduct of individual owners and units has an identifiable impact on market prices. Markup is a key indicator of the competitiveness of the energy market.

In the PJM Real-Time Energy Market in the first three months of 2021, the unadjusted markup component of LMP was -\$0.33 per MWh or 1.1 percent of the PJM load-weighted, average LMP. March had the highest peak markup component, \$0.16 per MWh, or 0.58 percent of the real-time, peak hour load-weighted, average LMP.

In the PJM Day-Ahead Energy Market, INCs, DECs and UTCs have zero markups. In the first three months of 2021, the markup component of LMP was -\$0.07 per MWh or -0.2 percent of the PJM day-ahead load-weighted, average LMP. February had the highest unadjusted peak markup component, \$2.13 per MWh.

Participant behavior was evaluated as competitive because the analysis of markup shows that marginal units generally make offers at, or close to, their marginal costs in both the day-ahead and real-time energy

markets, although the behavior of some participants represents economic withholding.

- **Markup and Local Market Power.** Comparison of the markup behavior of marginal units with TPS test results shows that for 4.2 percent of real-time marginal unit intervals in the first three months of 2021 the marginal unit had local market power as determined by the TPS test and a positive markup. The fact that units with market power had a positive markup means that the cost-based offer was not used, that a higher price-based offer was used, and that the process for offer capping units that fail the TPS test does not consistently result in competitive market outcomes in the presence of market power.
- **Markup and Aggregate Market Power.** In the first three months of 2021, pivotal suppliers in the aggregate market set prices with high markups for some real-time market intervals.

Recommendations

Market Power

- The MMU recommends that the market rules explicitly require that offers in the energy market be competitive, where competitive is defined to be the short run marginal cost of the units. The short run marginal cost should reflect opportunity cost when and where appropriate. The MMU recommends that the level of incremental costs includable in cost-based offers not exceed the short run marginal cost of the unit. (Priority: Medium. First reported 2009. Status: Not adopted.)

Fuel Cost Policies

- The MMU recommends that PJM require that all fuel cost policies be algorithmic, verifiable, and systematic, and accurately reflect short run marginal costs. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that the tariff be changed to allow units to have fuel cost policies that do not include fuel procurement practices, including fuel contracts. Fuel procurement practices, including fuel contracts, may

be used as the basis for fuel cost policies but should not be required. (Priority: Low. First reported 2018. Status: Adopted 2020.)

- The MMU recommends that PJM change the fuel cost policy requirement to apply only to units that will be offered with non-zero cost-based offers. The PJM market rules should require that the cost-based offers of units without an approved fuel cost policy be set to zero. (Priority: Low. First reported 2018. Status: Adopted 2020.)
- The MMU recommends that the temporary cost method be removed and that all units that submit nonzero cost-based offers be required to have an approved fuel cost policy. (Priority: Low. First reported 2020. Status: Not adopted.)
- The MMU recommends that the penalty exemption provision be removed and that all units that submit nonzero cost-based offers be required to follow their approved fuel cost policy. (Priority: Medium. First reported 2020. Status: Not adopted.)

Cost-Based Offers

- The MMU recommends that Manual 15 (Cost Development Guidelines) be replaced with a straightforward description of the components of cost-based offers based on short run marginal costs and the correct calculation of cost-based offers. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends removal of all use of FERC System of Accounts in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all use of cyclic starting and peaking factors from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of all labor costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends the removal of all maintenance costs from the Cost Development Guidelines. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that market participants be required to document the amount and cost of consumables used when operating in order to verify that the total operating cost is consistent with the total quantity used and the unit characteristics. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends, given that maintenance costs are currently allowed in cost-based offers, that market participants be permitted to include only variable maintenance costs, linked to verifiable operational events and that can be supported by clear and unambiguous documentation of the operational data (e.g. run hours, MWh, MMBtu) that support the maintenance cycle of the equipment being serviced/replaced. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends explicitly accounting for soak costs and changing the definition of the start heat input for combined cycles to include only the amount of fuel used from first fire to the first breaker close in the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends the removal of nuclear fuel and nonfuel operations and maintenance costs that are not short run marginal costs from the Cost Development Guidelines. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends revising the pumped hydro fuel cost calculation to include day-ahead and real-time power purchases. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends revisions to the calculation of energy market opportunity costs to incorporate all time based offer parameters and all limitations that impact the opportunity cost of generating unit output. (Priority: Medium. First reported 2016. Status: Adopted 2020.)

- The MMU recommends removing the catastrophic designation for force majeure fuel supply limitations in Schedule 2. (Priority: Medium. First reported 2016. Status: Not adopted.)

Market Power: TPS Test and Offer Capping

- The MMU recommends that the rules governing the application of the TPS test be clarified and documented. The TPS test application in the day-ahead energy market is not documented. (Priority: High. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM require every market participant to make available at least one cost schedule based on the same hourly fuel type(s) and parameters at least as flexible as their offered price schedule. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that markup be constant across the full MWh range of price and cost-based offers. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that offer capping be applied to units that fail the TPS test in the real-time market that were not offer capped at the time of commitment in the day-ahead market or at a prior time in the real-time market. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, and during high load conditions such as cold and hot weather alerts or more severe emergencies, that the operating parameters in the cost-based offer and the price-based parameter limited schedule (PLS) offer be at least as flexible as the operating parameters in the available price-based non-PLS offer, and that the price-MW pairs in the price-based PLS offer be exactly equal to the price-based non-PLS offer. (Priority: High. First reported 2015. Status: Not adopted.)

- The MMU recommends, in order to ensure effective market power mitigation, that PJM always enforce parameter limited values by committing units only on parameter limited schedules, when the TPS test is failed or during high load conditions such as cold and hot weather alerts or more severe emergencies. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM retain the \$1,000 per MWh offer cap in the PJM energy market except when cost-based offers exceed \$1,000 per MWh, and retain other existing rules that limit incentives to exercise market power. (Priority: High. First reported 1999. Status: Partially adopted, 1999, 2017.)
- The MMU recommends the elimination of FMU and AU adders. FMU and AU adders no longer serve the purpose for which they were created and interfere with the efficient operation of PJM markets. (Priority: Medium. First reported 2012. Status: Partially adopted, 2014.)

Offer Behavior

- The MMU recommends that resources not be allowed to violate the ICAP must offer requirement. The MMU recommends that PJM enforce the ICAP must offer requirement by assigning a forced outage to any unit that is derated in the energy market below its committed ICAP without an outage that reflects the derate. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that storage and intermittent resources be subject to an enforceable ICAP must offer rule that reflects the limitations of these resources. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that capacity resources not be allowed to offer any portion of their capacity market obligation as maximum emergency energy. (Priority: Medium. First reported 2012. Status: Not adopted.)

Capacity Performance Resources

- The MMU recommends that capacity performance resources be held to the OEM operating parameters of the capacity market CONE reference

resource for performance assessment and energy uplift payments and that this standard be applied to all technologies on a uniform basis. (Priority: Medium. First reported 2015. Status: Not adopted.)

- The MMU recommends that the parameters which determine nonperformance charges and the amounts of uplift payments should reflect the flexibility goals of the capacity performance construct. The operational parameters used by generation owners to indicate to PJM operators what a unit is capable of during the operating day should not determine capacity performance assessment or uplift payments. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM not include the balancing ratios calculated for localized Performance Assessment Intervals (PAIs) in the capacity market default offer cap, and only include those events that trigger emergencies at a defined zonal or higher level. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM clearly define the business rules that apply to the unit specific parameter adjustment process, including PJM's implementation of the tariff rules in the PJM manuals to ensure market sellers know the requirements for their resources. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the tariff to clarify that all generation resources are subject to unit specific parameter limits on their cost-based offers using the same standard and process as capacity performance capacity resources. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM institute rules to assess a penalty for resources that choose to submit real-time values that are less flexible than their unit specific parameter limits or approved parameter limit exceptions based on tariff defined reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM not approve temporary exceptions that are based on pipeline tariff terms that are not routinely enforced,

and based on inferior transportation service procured by the generator. (Priority: Medium. First reported 2019. Status: Not adopted.)

Accurate System Modeling

- The MMU recommends that PJM approve one RT SCED case for each five minute interval to dispatch resources during that interval using a five minute ramp time, and that PJM calculate prices using LPC for that five minute interval using the same approved RT SCED case. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM explicitly state its policy on the use of transmission penalty factors including: the level of the penalty factors; the triggers for the use of the penalty factors; the appropriate line ratings to trigger the use of penalty factors; the allowed duration of the violation; the use of constraint relaxation logic; and when the transmission penalty factors will be used to set the shadow price. (Priority: Medium. First reported 2015. Status: Partially adopted 2020.)
- The MMU recommends that PJM routinely review all transmission facility ratings and any changes to those ratings to ensure that the normal, emergency and load dump ratings used in modeling the transmission system are accurate and reflect standard ratings practice. (Priority: Low. First reported 2013. Status: Partially adopted.)
- The MMU recommends that PJM not use closed loop interface or surrogate constraints to artificially override nodal prices based on fundamental LMP logic in order to: accommodate rather than resolve the inadequacies of the demand side resource capacity product; address the inability of the power flow model to incorporate the need for reactive power; accommodate rather than resolve the flaws in PJM's approach to scarcity pricing; or for any other reason. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM not use CT price setting logic to modify transmission line limits to artificially override the nodal prices that are based on fundamental LMP logic in order to reduce uplift. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that if PJM believes it appropriate to implement CT price setting logic, PJM first initiate a stakeholder process to determine whether such modification is appropriate. PJM should file any proposed changes with FERC to ensure review. Any such changes should be incorporated in the PJM tariff. (Priority: Medium. First reported 2016. Status: Partially adopted.)
- The MMU recommends that PJM update the outage impact studies, the reliability analyses used in RPM for capacity deliverability, and the reliability analyses used in RTEP for transmission upgrades to be consistent with the more conservative emergency operations (post contingency load dump limit exceedance analysis) in the energy market that were implemented in June 2013. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM include in the tariff or appropriate manual an explanation of the initial creation of hubs, the process for modifying hub definitions and a description of how hub definitions have changed.^{4 5} (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that all buses with a net withdrawal be treated as load for purposes of calculating load and load-weighted LMP, even if the MW are settled to the generator. The MMU recommends that during hours when a load bus shows a net injection, the energy injection be treated as generation, not negative load, for purposes of calculating generation and load-weighted LMP, even if the injection MW are settled to the load serving entity. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM identify and collect data on available behind the meter generation resources, including nodal location information and relevant operating parameters. (Priority: Low. First reported 2013. Status: Partially adopted.)
- The MMU recommends that PJM document how LMPs are calculated when demand response is marginal. (Priority: Low. First reported 2014. Status: Not adopted.)

⁴ According to minutes from the first meeting of the Energy Market Committee (EMC) on January 28, 1998, the EMC unanimously agreed to be responsible for approving additions, deletions and changes to the hub definitions to be published and modeled by PJM. Since the EMC has become the Market Implementation Committee (MIC), the MIC now appears to be responsible for such changes.

⁵ There is currently no PJM documentation in the tariff or manuals explaining how hubs are created and how their definitions are changed. The general definition of a hub can be found in the PJM.com Glossary <<http://www.pjm.com/Glossary.aspx>>.

- The MMU recommends that PJM not allow nuclear generators which do not respond to prices or which only respond to manual instructions from the operator to set the LMPs in the real-time market. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM increase the coordination of outage and operational restrictions data submitted by market participants via eDART/eGADs and offer data submitted via Markets Gateway. (Priority: Low. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM model generators' operating transitions, including soak time for units with a steam turbine, configuration transitions for combined cycles, and peak operating modes. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that PJM clarify, modify and document its process for dispatching reserves and energy when SCED indicates that supply is less than total demand including forecasted load and reserve requirements. The modifications should define: a SCED process to economically convert reserves to energy; a process for the recall of energy from capacity resources; and the minimum level of synchronized reserves that would trigger load shedding. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM stop capping the system marginal price in RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh. (Priority: Medium. New recommendation. Status: Not adopted.)

Transparency

- The MMU recommends that PJM market rules require the fuel type be identified for every price and cost schedule and PJM market rules remove nonspecific fuel types such as other or co-fire other from the list of fuel types available for market participants to identify the fuel type associated with their price and cost schedules. (Priority: Medium. First reported 2015. Status: Adopted 2019.)

- The MMU recommends that PJM allow generators to report fuel type on an hourly basis in their offer schedules and to designate schedule availability on an hourly basis. (Priority: Medium. First reported 2015. Status: Partially adopted.)
- The MMU recommends that PJM clearly define the criteria for operator approval of RT SCED cases used to send dispatch signals to resources and for pricing, to minimize operator discretion and implement a rule based, scheduled approach. (Priority: High. First reported 2018. Status: Partially adopted.)

Virtual Bids and Offers

- The MMU recommends eliminating up to congestion (UTC) bidding at pricing nodes that aggregate only small sections of transmission zones with few physical assets. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating INC, DEC, and UTC bidding at pricing nodes that allow market participants to profit from modeling issues. (Priority: Medium. First reported 2020. Status: Not adopted.)

Conclusion

The MMU analyzed key elements of PJM energy market structure, participant conduct and market performance in the first three months of 2021, including aggregate supply and demand, concentration ratios, aggregate pivotal supplier results, local three pivotal supplier test results, offer capping, markup, marginal units, participation in demand response programs, virtual bids and offers, loads and prices.

PJM average hourly real-time load in the first three months of 2021 increased by 5.0 percent from the first three months of 2020, from 85,608 MWh to 89,887 MWh. The relationship between supply and demand, regardless of the specific market, along with market concentration and the extent of pivotal suppliers, is referred to as the supply-demand fundamentals or economic fundamentals or market structure. The market structure of the PJM aggregate

energy market is partially competitive because aggregate market power does exist for a significant number of hours. The HHI is not a definitive measure of structural market power. The number of pivotal suppliers in the energy market is a more precise measure of structural market power than the HHI. It is possible to have pivotal suppliers in the aggregate market even when the HHI level is not in the highly concentrated range. Even a low HHI may be consistent with the exercise of market power with a low price elasticity of demand. The current market power mitigation rules for the PJM energy market rely on the assumption that the ownership structure of the aggregate market ensures competitive outcomes. This assumption requires that the total demand for energy can be met without the supply from any individual supplier or without the supply from a small group of suppliers. This assumption is not correct. There are pivotal suppliers in the aggregate energy market at times. High markups for some units demonstrate the potential to exercise market power both routinely and during high demand conditions. The existing market power mitigation measures do not address aggregate market power. The MMU is developing an aggregate market power test and will propose market power mitigation rules to address aggregate market power.

The three pivotal supplier test is applied by PJM on an ongoing basis for local energy markets in order to determine whether offer capping is required for transmission constraints.⁶ However, there are some issues with the application of market power mitigation in the day-ahead energy market and the real-time energy market when market sellers fail the TPS test. Many of these issues can be resolved by simple rule changes.

The enforcement of market power mitigation rules is undermined if the definition of a competitive offer is not correct. A competitive offer is equal to short run marginal costs. The significance of competition metrics like markup is also undermined if the definition of a competitive offer is not correct. The definition of a competitive offer, under the PJM Market Rules, is not currently correct. The definition, that all costs that are related to electric production are short run marginal costs, is not clear or correct. All costs and investments for power generation are related to electric production. Under this definition,

some unit owners include costs that are not short run marginal costs in offers, especially maintenance costs. This issue can be resolved by simple rule changes to incorporate a clear and accurate definition of short run marginal costs.

Prices are a key outcome of markets. Prices vary across hours, days and years for multiple reasons. Price is an indicator of the level of competition in a market. In a competitive market, prices are directly related to the marginal cost to serve load at a given time. The pattern of prices within days and across months and years illustrates how prices are directly related to supply and demand conditions and thus also illustrates the potential significance of the impact of the price elasticity of demand on prices. Energy market results in the first three months of 2021 generally reflected supply-demand fundamentals, although the behavior of some participants both routinely and during high demand periods represents economic withholding. Economic withholding occurs when generator offers are greater than competitive levels. There are additional issues in the energy market including the uncertainties about the pricing and availability of natural gas, the way that generation owners incorporate natural gas costs in offers, and the lack of adequate incentives for unit owners to take all necessary actions to acquire fuel, staff their units, and operate rather than economically withhold or physically withhold.

Prices in PJM are not too low. Prices in PJM are the result of input prices, consistent with a competitive market. Low natural gas prices have been a primary cause of low PJM energy market prices. There is no evidence to support the need for a significant change to the calculation of LMP, such as fast start pricing or the extended ORDC. Fast start pricing and the extended ORDC will disconnect pricing from dispatch instructions and create greater reliance on uplift as an incentive to follow PJM's instructions. The extended ORDCs will create shortage pricing when no reserve shortages exist. Rather than undercutting the basic LMP logic that is core to market efficiency, it would make more sense to directly address the design of RT SCED/LPC, scarcity pricing, operator actions and the design of reserve markets. PJM has made progress in addressing the timing of RT SCED and LPC and accepting

⁶ The MMU reviews PJM's application of the TPS test and brings issues to the attention of PJM.

shortage pricing in some cases when SCED shows a shortage, but more progress is needed.

The PJM defined inputs to the dispatch tools, particularly the RT SCED, have substantial effects on energy market outcomes. Transmission line ratings, transmission penalty factors, load forecast bias, hydro resource schedules, and unit ramp rate adjustments change the dispatch of the system, affect prices, and can create significant price increases through transmission line limit violations or restrictions on the resources available to resolve constraints. The automated adjustment of ramp rates by PJM, called Degree of Generator Performance (DGP), modifies the values offered by generators and limits the MW available to the RT SCED. Rather than sending dispatch signals consistent with resource offers and holding resources accountable when they fail to follow them, DGP accommodates resources that do not follow dispatch. PJM should evaluate its interventions in the market, consider whether the interventions are appropriate, and provide greater transparency to enhance market efficiency.

The objective of efficient short run price signals is to minimize system production costs, not to minimize uplift. Repricing the market to reflect commitment costs prioritizes minimizing uplift over minimizing production costs. The tradeoff exists because when commitment costs are included in prices, the price signal no longer equals the short run marginal cost and therefore no longer provides the correct signal for efficient behavior for market participants making decisions on the margin, whether resources, load, interchange transactions, or virtual traders. This tradeoff will be created by PJM's fast start pricing proposal as approved by FERC and would be created in a much more extensive form by PJM's convex hull pricing proposal and the pending reserve pricing changes.⁷

Units that start in one hour are not actually fast start units, and their commitment costs are not marginal in a five minute market. The differences between the actual LMP and the fast start LMP will distort the incentive for market participants to behave competitively and to follow PJM's dispatch instructions. PJM will pay new forms of uplift in an attempt to counter the

⁷ See 173 FERC ¶ 61,244 (2020).

distorted incentives. The magnitude of the new payments and their effects on behavior are not well understood.

The fast start pricing and convex hull solutions would undercut LMP logic rather than directly addressing the underlying issues. The solution is not to accept that the inflexible CT should be paid or set price based on its commitment costs rather than its short run marginal costs. The question of why units make inflexible offers should be addressed directly. Are units inflexible because they are old and inefficient, because owners have not invested in increased flexibility or because they serve as a mechanism for the exercise of market power? The question of why the unit was built, whether it was built under cost of service regulation and whether it is efficient to retain the unit should be answered directly. The question of how to provide market incentives for investment in flexible units and for investment in increased flexibility of existing units should be addressed directly. The question of whether inflexible units should be paid uplift at all should be addressed directly. Marginal cost pricing without paying excess uplift to inflexible units would create incentives for market participants to provide flexible solutions including replacing inefficient units with flexible, efficient units.

With or without a capacity market, energy market design must permit scarcity pricing when such pricing is consistent with market conditions and constrained by reasonable rules to ensure that market power is not exercised. Scarcity pricing can serve two functions in wholesale power markets: revenue adequacy and price signals. Scarcity pricing for revenue adequacy, as in PJM's ORDC proposal, is not required in PJM. Scarcity pricing for price signals that reflect market conditions during periods of scarcity is required in PJM. Scarcity pricing is also part of an appropriate incentive structure facing both load and generation owners in a working wholesale electric power market design. Scarcity pricing must be designed to ensure that market prices reflect actual market conditions, that scarcity pricing occurs with transparent triggers based on measured reserve levels and transparent prices, that scarcity pricing only occurs when scarcity exists, and that there are strong incentives for competitive behavior and strong disincentives to exercise market power. Such administrative scarcity pricing is a key link between energy and capacity

markets. Administrative scarcity pricing that establishes scarcity pricing in about 85 percent of hours, as PJM's ORDC proposal would, is not scarcity pricing but simply a revenue enhancement mechanism, which could have unintended consequences in an emergency, as was the case in ERCOT in February 2021. PJM's pending ORDC changes are not consistent with efficient market design and are just a revenue enhancement mechanism.

The PJM Capacity Market is explicitly designed to provide revenue adequacy and the resultant reliability. However, the explicit balancing mechanism that included net revenues directly in unit offers in the prior capacity market design is not present in the Capacity Performance design. The nature of a direct and explicit energy pricing net revenue true up mechanism in the capacity market should be addressed if energy revenues are expected to increase as a result of scarcity events, as a result of increased demand for reserves, or as a result of PJM's inappropriate proposals related to fast start pricing and the inclusion of maintenance expenses as short run marginal costs. The true up mechanism must address both cleared auctions and subsequent auctions. There are also significant issues with PJM's scarcity pricing rules, including the absence of a clear trigger based on measured reserve levels (the current triggers are based on estimated reserves) and the lack of adequate locational scarcity pricing options.

The overall energy market results support the conclusion that energy prices in PJM are set, generally, by marginal units operating at, or close to, their marginal costs, although this was not always the case in the first three months of 2021 or prior years. In the first three months of 2021, marginal units were predominantly combined cycle gas generators with low fuel costs. The frequency of combined cycle gas units as the marginal unit type has risen rapidly, from 32.9 percent in the first three months of 2016 to 65.5 percent in the first three months of 2021. Overdue improvements in generator modeling in the energy market would allow PJM to more efficiently commit and dispatch combined cycle plants and to fully reflect the flexibility of these units. New combined cycle units have placed competitive pressure on less efficient generators, and the market has reliably served load with less congestion, less uplift, and less markup as a result. This is evidence of

generally competitive behavior and competitive market outcomes, although the behavior of some participants represents economic withholding. Given the structure of the energy market which can permit the exercise of aggregate and local market power, the change in some participants' behavior is a source of concern in the energy market and provides a reason to use correctly defined short run marginal cost as the sole basis for cost-based offers and a reason for implementing an aggregate market power test and correcting the offer capping process for resources with local market power. The MMU concludes that the PJM energy market results were competitive in the first three months of 2021.

Supply and Demand Market Structure

Supply

Supply includes physical generation, imports and virtual transactions.

In the first three months of 2021, 703.2 MW of new resources were added, and 430.4 MW of resources were retired. Figure 3-1 shows the average real-time and day-ahead supply curves in the winters of 2019/2020 and 2020/2021.^{8 9} The real-time supply curve includes average on peak hourly offers. The real-time supply curve includes available MW from units that are online or have a notification plus start time that is no more than one hour. The day-ahead supply curve shows the average of all available hourly offers.

⁸ Real-time supply includes real-time generation offers and import MWh.

⁹ The supply curve period is from December 1 to February 28.

Figure 3-1 Hourly real-time and aggregate day-ahead supply curve comparison: Winters of 2019/2020 and 2020/2021

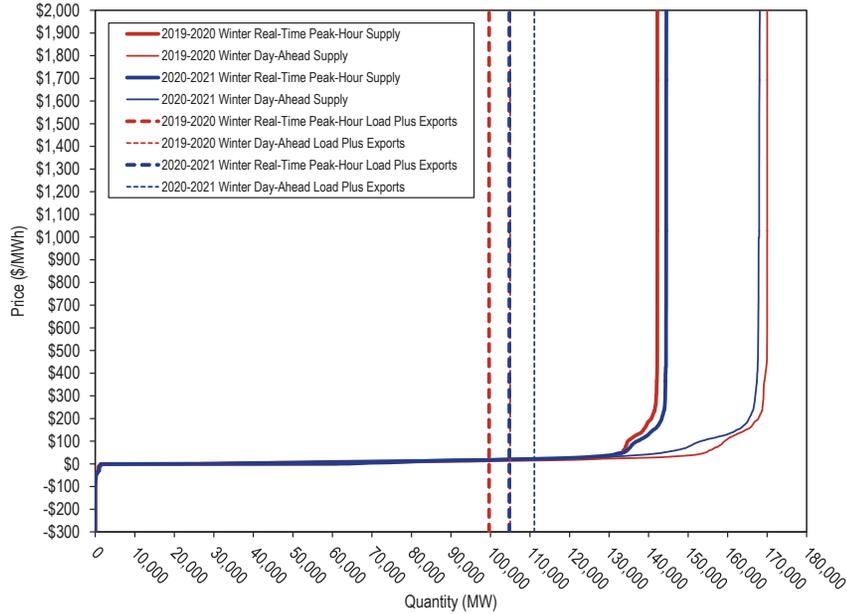


Figure 3-2 shows the typical dispatch range.

Figure 3-2 Typical dispatch range of supply curves

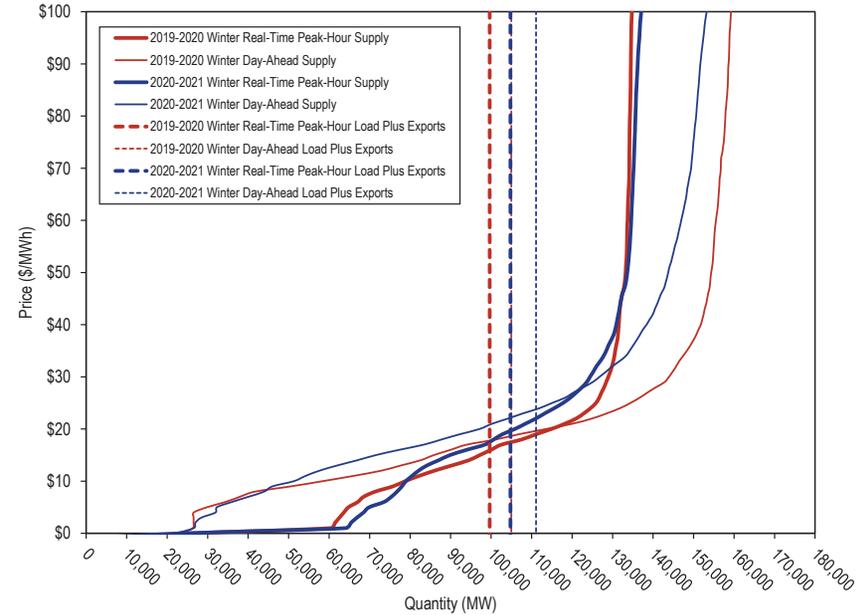


Table 3-2 shows the price elasticity of the real-time supply curve for the on peak hours in the winters of 2019/2020 and 2020/2021 by load level.

The price elasticity of the supply curve measures the responsiveness of the quantity supplied (GW) to a change in price:

$$\text{Elasticity of Supply} = \frac{\text{Percent change in quantity supplied}}{\text{Percent change in price}}$$

The supply curve is elastic when elasticity is greater than 1.0. The supply curve is more sensitive to changes in price the higher the elasticity. Although the aggregate supply curve may appear flat as a result of the wide range in prices and quantities, the calculated elasticity is low throughout.

Table 3-2 Price elasticity of the supply curve

GW	Elasticity of Supply	
	2019-2020 Winter	2020-2021 Winter
Min-75	0.035	0.029
75-95	0.477	0.255
95-115	0.546	0.422
115-135	0.033	0.061
135-Max	0.006	0.006

Real-Time Supply

The average on-peak hourly offered real-time supply was 140,120 MW for the 2019/2020 winter, and 144,457 MW for the 2020/2021 winter. The available supply at a defined time is less than the total capacity of the PJM system because real-time supply at a defined time is limited by unit ramp rates and start times.

PJM average hourly real-time cleared generation in the first three months of 2021 increased by 5.9 percent from the first three months of 2020, from 90,675 MWh to 96,005 MWh.¹⁰

PJM average hourly real-time cleared supply including imports in the first three months of 2021 increased by 5.9 percent from the first three months of 2020, from 91,698 MWh to 97,075 MWh.

In the PJM Real-Time Energy Market, there are three types of supply offers:

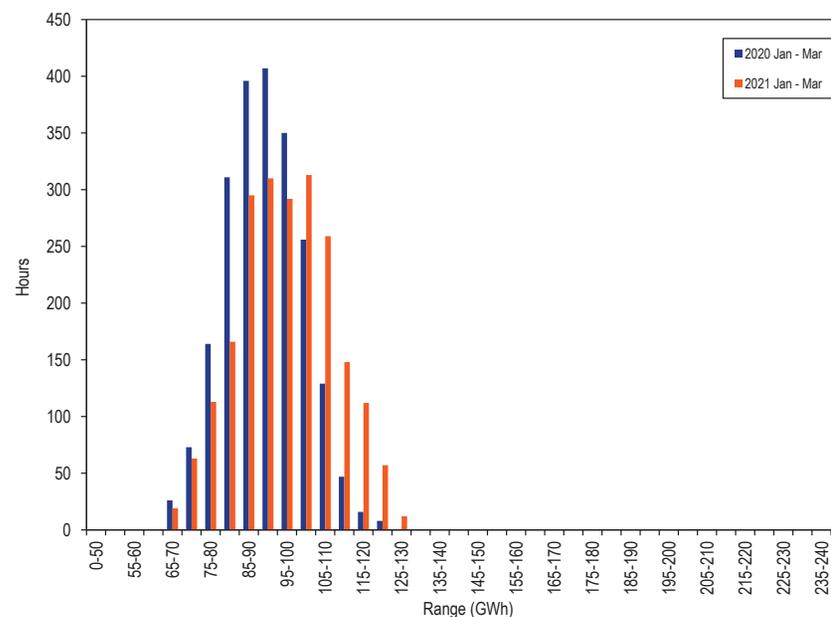
- **Self Scheduled Generation Offer.** Offer to supply a fixed block of MW, as a price taker, from a unit that may also have a dispatchable component above the fixed MW.
- **Dispatchable Generation Offer.** Offer to supply a schedule of MW and corresponding offer prices from a specific unit.
- **Import.** An import is an external energy transaction scheduled to PJM from another balancing authority. A real-time import must have a valid OASIS reservation when offered, must have available ramp room to support the import, must be accompanied by a NERC Tag, and must pass the neighboring balancing authority checkout process.

¹⁰ Generation data are the net MWh injections and withdrawals MWh at every generation bus in PJM.

PJM Real-Time Supply Frequency

Figure 3-3 shows the hourly distribution of PJM real-time generation plus imports for the first three months of 2020 and 2021.

Figure 3-3 Distribution of real-time generation plus imports: January through March, 2020 and 2021¹¹



¹¹ Each range on the horizontal axis excludes the start value and includes the end value.

PJM Real-Time, Average Supply

Table 3-3 shows real-time hourly supply for the first three months of each year from 2001 through 2021.

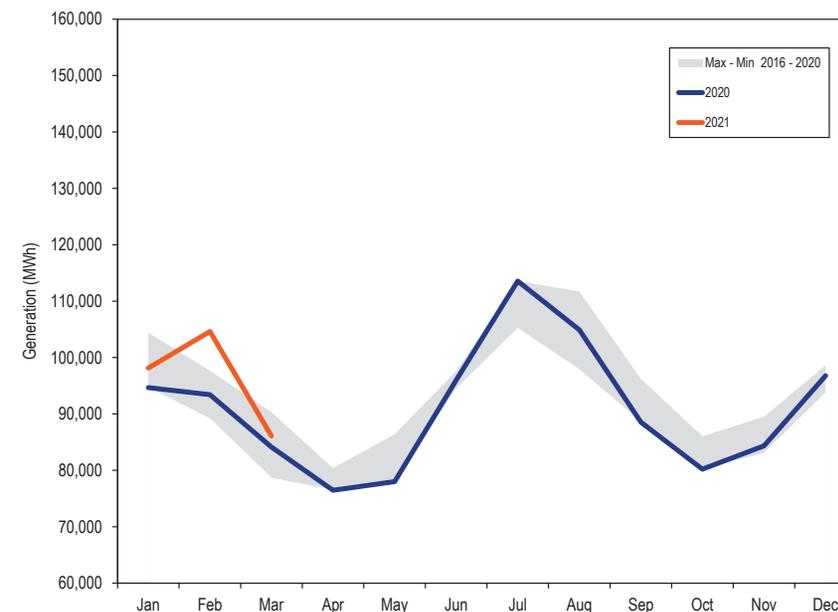
Table 3-3 Average hourly real-time generation and real-time generation plus imports: January through March, 2001 through 2021

		PJM Real-Time Supply (MWh)				Year-to-Year Change			
		Generation		Generation Plus Imports		Generation		Generation Plus Imports	
Jan-Mar	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation	Standard Deviation
Generation	Supply	Imports	Generation	Imports	Generation	Imports	Generation	Imports	Generation
2001	30,923	3,488	33,806	3,358	NA	NA	NA	NA	NA
2002	27,948	3,416	31,465	3,508	(9.6%)	(2.1%)	(6.9%)	4.5%	
2003	38,731	5,187	42,498	5,092	38.6%	51.8%	35.1%	45.2%	
2004	37,790	4,660	41,960	4,899	(2.4%)	(10.2%)	(1.3%)	(3.8%)	
2005	74,187	8,269	80,184	9,017	96.3%	77.4%	91.1%	84.1%	
2006	82,550	7,921	87,729	8,565	11.3%	(4.2%)	9.4%	(5.0%)	
2007	86,286	10,018	91,454	11,351	4.5%	26.5%	4.2%	32.5%	
2008	86,690	9,375	92,075	10,150	0.5%	(6.4%)	0.7%	(10.6%)	
2009	81,987	11,417	88,148	12,213	(5.4%)	21.8%	(4.3%)	20.3%	
2010	81,676	12,801	87,009	13,236	(0.4%)	12.1%	(1.3%)	8.4%	
2011	83,505	10,116	88,750	10,884	2.2%	(21.0%)	2.0%	(17.8%)	
2012	88,068	11,177	93,128	11,685	5.5%	10.5%	4.9%	7.4%	
2013	92,776	10,030	98,002	10,812	5.3%	(10.3%)	5.2%	(7.5%)	
2014	100,655	12,427	106,879	13,255	8.5%	23.9%	9.1%	22.6%	
2015	97,741	13,085	105,027	14,351	(2.9%)	5.3%	(1.7%)	8.3%	
2016	88,470	12,666	94,383	13,890	(9.5%)	(3.2%)	(10.1%)	(3.2%)	
2017	91,076	11,009	94,390	11,673	2.9%	(13.1%)	0.0%	(16.0%)	
2018	95,491	13,151	98,199	14,058	4.8%	19.5%	4.0%	20.4%	
2019	97,010	12,379	98,828	12,777	1.6%	(5.9%)	0.6%	(9.1%)	
2020	90,675	9,852	91,698	9,992	(6.5%)	(20.4%)	(7.2%)	(21.8%)	
2021	96,005	12,057	97,075	12,432	5.9%	22.4%	5.9%	24.4%	

PJM Real-Time, Monthly Average Generation

Figure 3-4 compares the real-time, monthly average hourly generation in 2020 and the first three months of 2021 with the historic five year range. In February 2021, the monthly average hourly generation was higher than the maximum of the past five years, primarily as a result of cold weather and exports to neighboring balancing authorities.

Figure 3-4 Real-time monthly average hourly generation: 2020 through March 2021



Day-Ahead Supply

PJM average hourly day-ahead cleared supply in the first three months of 2021, including INCs and up to congestion transactions, decreased by 4.7 percent from the first three months of 2020, from 112,939 MWh to 107,588 MWh. When imports are added, PJM average hourly, day-ahead cleared supply in the first three months of 2021 decreased by 4.8 percent from the first three months of 2020, from 113,274 MWh to 107,851 MWh. The decrease of day-ahead supply was a result of a decrease in UTCs.

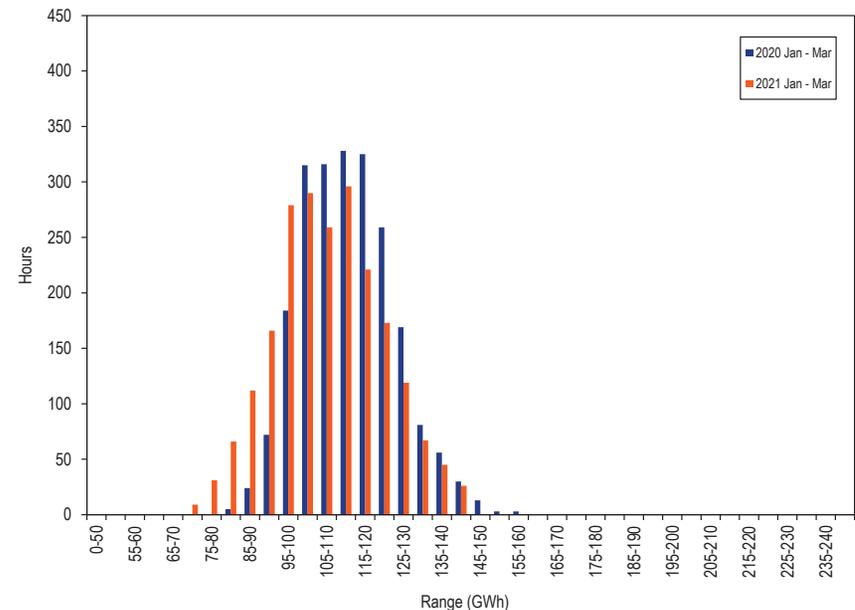
In the PJM Day-Ahead Energy Market, there are five types of financially binding supply offers:

- **Self Scheduled Generation Offer.** Offer to supply a fixed block of MW, as a price taker, from a unit that may also have a dispatchable component above the minimum.
- **Dispatchable Generation Offer.** Offer to supply a schedule of MW and corresponding offer prices from a unit.
- **Increment Offer (INC).** Financial offer to supply MW and corresponding offer prices. INCs can be submitted by any market participant.
- **Up to Congestion Transaction (UTC).** Conditional transaction that permits a market participant to specify a maximum price spread for a specific amount of MW between the transaction source and sink. An up to congestion transaction is a matched pair of an injection and a withdrawal.
- **Import.** An import is an external energy transaction for a specific MW amount scheduled to PJM from another balancing authority. An import must have a valid willing to pay congestion (WPC) OASIS reservation when offered. An import energy transaction that clears the day-ahead energy market is financially binding. There is no link between transactions submitted in the PJM Day-Ahead Energy Market and the PJM Real-Time Energy Market, so an import energy transaction approved in the day-ahead energy market will not physically flow in real time unless it is also submitted through the real-time energy market scheduling process.

PJM Day-Ahead Supply Duration

Figure 3-5 shows the hourly distribution of PJM day-ahead cleared supply, including increment offers, up to congestion transactions, and imports in the first three months of 2020 and 2021.

Figure 3-5 Distribution of day-ahead cleared supply plus imports: January through March, 2020 and 2021¹²



¹² Each range on the horizontal axis excludes the start value and includes the end value.

PJM Day-Ahead, Average Supply

Table 3-4 presents day-ahead hourly cleared supply summary statistics for the first three months of each year from 2001 through 2021.

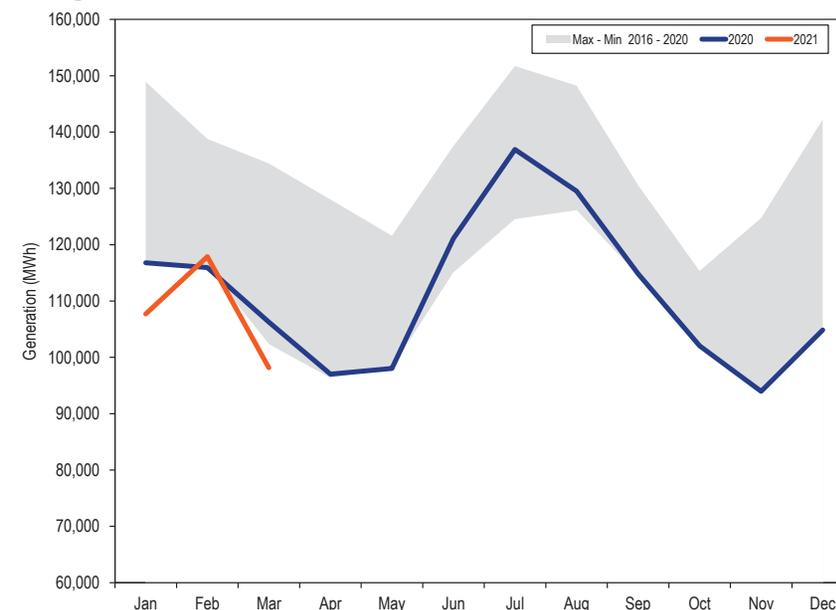
Table 3-4 Average hourly day-ahead cleared supply and day-ahead cleared supply plus imports: January through March, 2001 through 2021

Jan- Mar	PJM Day-Ahead Supply (MWh)				Year-to-Year Change			
	Supply		Supply Plus Imports		Supply		Supply Plus Imports	
	Supply	Standard Deviation	Supply	Standard Deviation	Supply	Standard Deviation	Supply	Standard Deviation
2001	28,494	2,941	29,252	3,021	NA	NA	NA	NA
2002	20,274	10,131	20,827	10,134	(28.8%)	244.5%	(28.8%)	235.5%
2003	37,147	4,337	37,807	4,389	83.2%	(57.2%)	81.5%	(56.7%)
2004	46,591	4,794	47,377	5,039	25.4%	10.5%	25.3%	14.8%
2005	89,011	9,434	90,502	9,443	91.0%	96.8%	91.0%	87.4%
2006	97,319	9,035	99,551	9,061	9.3%	(4.2%)	10.0%	(4.0%)
2007	110,099	11,938	112,561	12,141	13.1%	32.1%	13.1%	34.0%
2008	109,711	10,479	112,165	10,671	(0.4%)	(12.2%)	(0.4%)	(12.1%)
2009	104,880	13,895	107,325	14,031	(4.4%)	32.6%	(4.3%)	31.5%
2010	101,733	13,835	104,858	13,917	(3.0%)	(0.4%)	(2.3%)	(0.8%)
2011	110,310	12,200	112,854	12,419	8.4%	(11.8%)	7.6%	(10.8%)
2012	132,178	13,701	134,405	13,804	19.8%	12.3%	19.1%	11.2%
2013	147,246	13,054	149,300	13,244	11.4%	(4.7%)	11.1%	(4.1%)
2014	168,373	11,875	170,778	11,935	14.3%	(9.0%)	14.4%	(9.9%)
2015	123,431	14,671	125,980	14,916	(26.7%)	23.5%	(26.2%)	25.0%
2016	133,199	19,049	135,574	19,349	7.9%	29.8%	7.6%	29.7%
2017	140,771	16,923	142,094	16,938	5.7%	(11.2%)	4.8%	(12.5%)
2018	120,754	22,172	121,313	22,177	(14.2%)	31.0%	(14.6%)	30.9%
2019	122,368	13,778	122,865	13,822	1.3%	(37.9%)	1.3%	(37.7%)
2020	112,939	12,020	113,274	12,021	(7.7%)	(12.8%)	(7.8%)	(13.0%)
2021	107,588	13,940	107,851	14,003	(4.7%)	16.0%	(4.8%)	16.5%

PJM Day-Ahead, Monthly Average Cleared Supply

Figure 3-6 compares the day-ahead, monthly average hourly cleared supply, including increment offers and up to congestion transactions for the first three months of 2020 and 2021 with the historic five year range. In January and March, the average supply was lower than the minimum of the previous five years as a result of the decrease in UTCs.

Figure 3-6 Day-ahead monthly average cleared hourly supply: January 2020 through March 2021



Real-Time and Day-Ahead Supply

Table 3-5 presents summary statistics for the first three months of 2020 and 2021, for day-ahead cleared supply and real-time supply. The last two columns of Table 3-5 are the day-ahead supply minus the real-time supply. The first column is the total physical day-ahead generation less the total physical real-time generation and the second column is the total day-ahead supply less the total real-time supply.

Table 3-5 Day-ahead and real-time supply (MWh): January through March, 2020 and 2021

	Jan-Mar	Day-Ahead					Real-Time		Day-Ahead Less Real-Time	
		Generation	INC Offers	Up to Congestion	Imports	Total Supply	Generation	Total Supply	Generation	Supply
Average	2020	91,041	2,555	19,343	335	113,274	90,675	91,698	367	21,576
	2021	96,453	2,385	8,751	263	107,851	96,005	97,075	447	10,776
Median	2020	90,789	2,513	19,282	336	112,942	90,593	91,567	196	21,375
	2021	96,185	2,270	8,580	175	107,607	95,988	96,964	196	10,643
Standard Deviation	2020	10,768	720	3,287	155	12,021	9,852	9,992	916	2,028
	2021	12,650	885	2,795	322	14,003	12,057	12,432	593	1,571
Peak Average	2020	97,358	2,766	20,195	299	120,618	96,269	97,321	1,089	23,297
	2021	102,293	2,766	9,564	234	114,858	101,512	102,649	780	12,209
Peak Median	2020	97,042	2,707	20,144	300	119,888	96,152	97,229	890	22,659
	2021	102,182	2,748	9,259	171	114,529	101,696	102,814	486	11,715
Peak Standard Deviation	2020	8,427	704	3,439	157	9,884	7,779	8,003	649	1,881
	2021	11,133	848	2,739	275	12,052	10,712	11,142	421	910
Off-Peak Average	2020	85,460	2,368	18,590	367	106,785	85,732	86,730	(272)	20,055
	2021	91,338	2,050	8,038	288	101,715	91,183	92,193	155	9,522
Off-Peak Median	2020	84,796	2,299	18,461	387	105,297	85,191	86,194	(396)	19,103
	2021	90,989	1,930	7,848	180	100,936	91,659	92,281	(671)	8,655
Off-Peak Standard Deviation	2020	9,449	681	2,949	147	9,804	8,793	8,882	657	923
	2021	11,648	775	2,647	356	12,651	11,065	11,411	582	1,240

Figure 3-7 shows the average cleared volumes of day-ahead supply and real-time supply by hour of the day for the first three months of 2021. The day-ahead supply consists of cleared MW of physical generation, imports, increment offers and up to congestion transactions. The real-time supply consists of cleared MW of physical generation and imports.

Figure 3-7 Day-ahead and real-time supply (Average volumes by hour of the day): January through March, 2021

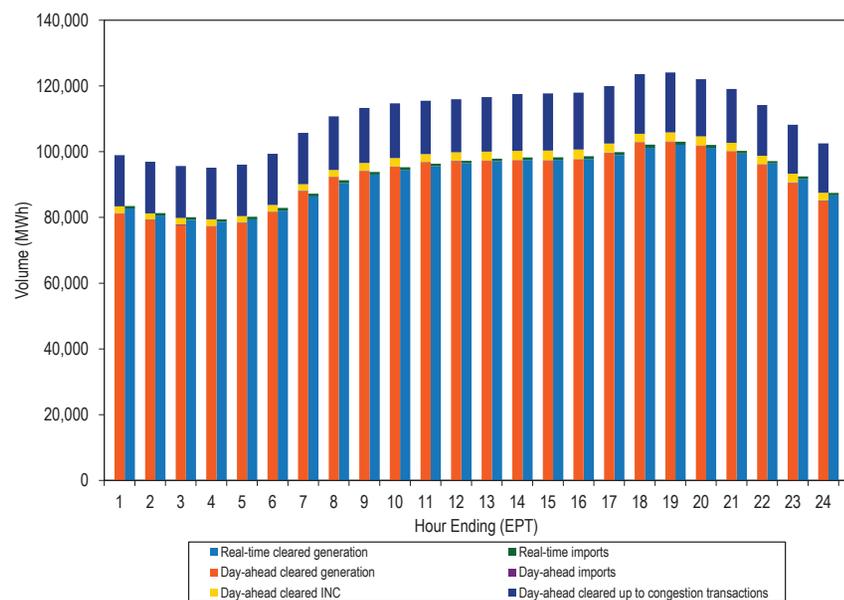
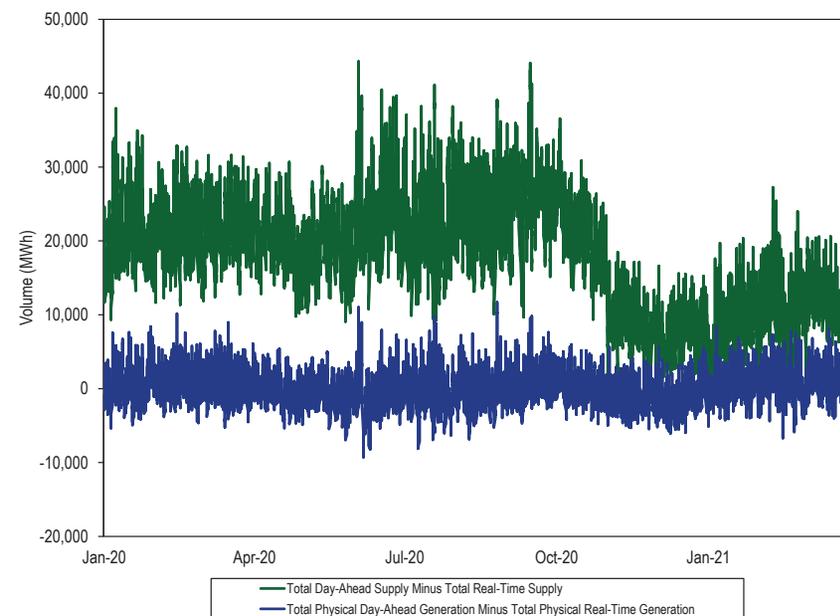


Figure 3-8 shows the difference between the day-ahead and real-time average daily supply in 2020 and the first three months of 2021.

Figure 3-8 Difference between cleared day-ahead and real-time supply (Average daily volumes): January 2020 through March 2021



Demand

Demand includes physical load and exports and virtual transactions.

Peak Demand

In this section, demand refers to accounting load and exports and, in the day-ahead energy market, includes virtual transactions.¹³

¹³ PJM reports peak load including accounting load plus an addback equal to PJM's estimated load drop from demand side resources. This will generally result in PJM reporting peak load values greater than accounting load values. PJM's load drop estimate is based on PJM Manual 19: Load Forecasting and Analysis, Attachment A: Load Drop Estimate Guidelines.

The PJM system real-time hourly peak load in the first three months of 2021 was 114,457 MWh in the HE 0900 on January 29, 2021, which was 2,303 MWh, or 2.0 percent, less than the peak load in the first three months of 2020, 116,761 MWh in the HE 0800 on January 22, 2020.

The PJM system real-time hourly peak load plus exports in the first three months of 2021 was 126,546 MWh in the HE 0900 on February 17, 2021, which was 4,384 MWh, or 3.6 percent more than the peak load plus exports in the first three months of 2020, 122,162 MWh in the HE 0800 on January 22, 2020.

Table 3-6 shows the peak loads for the first three months of 1999 through 2021.

Table 3-6 Actual footprint peak loads: January through March, 1999 through 2021^{14 15}

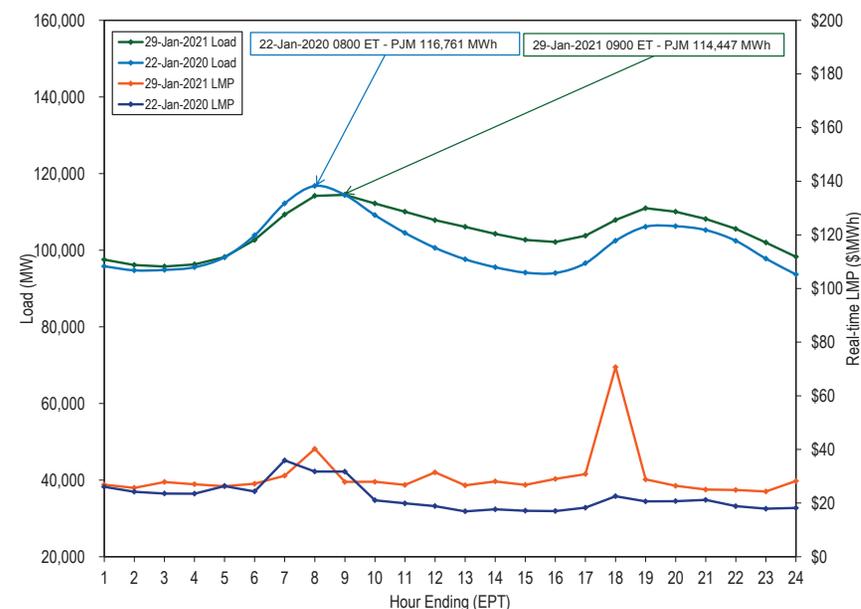
(Jan - Mar)	Date	Hour Ending (EPT)	PJM Load (MW)	Annual Change (MW)	Annual Change (%)
1999	Thu, January 14	18	40,706	NA	NA
2000	Thu, January 27	19	43,116	2,410	5.9%
2001	Tue, January 02	19	41,476	(1,640)	(3.8%)
2002	Wed, January 02	20	39,458	(2,018)	(4.9%)
2003	Thu, January 23	19	54,851	15,393	39.0%
2004	Fri, January 16	8	53,766	(1,085)	(2.0%)
2005	Tue, January 18	19	96,922	43,156	80.3%
2006	Mon, February 13	20	100,280	3,358	3.5%
2007	Mon, February 05	20	119,072	18,792	18.7%
2008	Thu, January 03	19	109,239	(9,833)	(8.3%)
2009	Fri, January 16	19	114,765	5,526	5.1%
2010	Mon, January 04	19	106,981	(7,784)	(6.8%)
2011	Mon, January 24	8	108,156	1,175	1.1%
2012	Tue, January 03	19	119,450	11,294	10.4%
2013	Tue, January 22	19	123,473	4,023	3.4%
2014	Tue, January 07	19	136,932	13,459	10.9%
2015	Fri, February 20	8	139,647	2,715	2.0%
2016	Tue, January 19	8	126,818	(12,830)	(9.2%)
2017	Mon, January 09	8	124,210	(2,608)	(2.1%)
2018	Fri, January 05	19	133,851	9,641	7.8%
2019	Thu, January 31	8	134,060	209	0.2%
2020	Wed, January 22	8	116,761	(17,299)	(12.9%)
2021	Fri, January 29	9	114,457	(2,303)	(2.0%)

¹⁴ Peak loads shown are Power accounting load. See the *MMU Technical Reference for the PJM Markets*, at "Load Definitions," for detailed definitions of load. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

¹⁵ Peak loads shown have been corrected to reflect the accounting load value excluding PJM loss adjustment. The values presented in this table do not include settlement adjustments made prior to January 1, 2017.

Figure 3-9 compares prices and load on the peak load days in the first three months of 2020 and 2021. The average, real-time LMP for January 29, 2021, peak load hour was \$27.87 and for January 22, 2020 peak load hour it was \$31.76.

Figure 3-9 Peak load day comparison: Wednesday, January 22, 2020 and Friday, January 29, 2021



Real-Time Demand

PJM average hourly real-time load in the first three months of 2021 increased by 5.0 percent from the first three months of 2020, from 85,608 MWh to 89,887 MWh.¹⁶ PJM average hourly real-time demand including exports in the first three months of 2021 increased by 5.7 percent from the first three months of 2020, from 90,093 MWh to 95,236 MWh.

¹⁶ Load data are the net MWh injections and withdrawals MWh at every load bus in PJM.

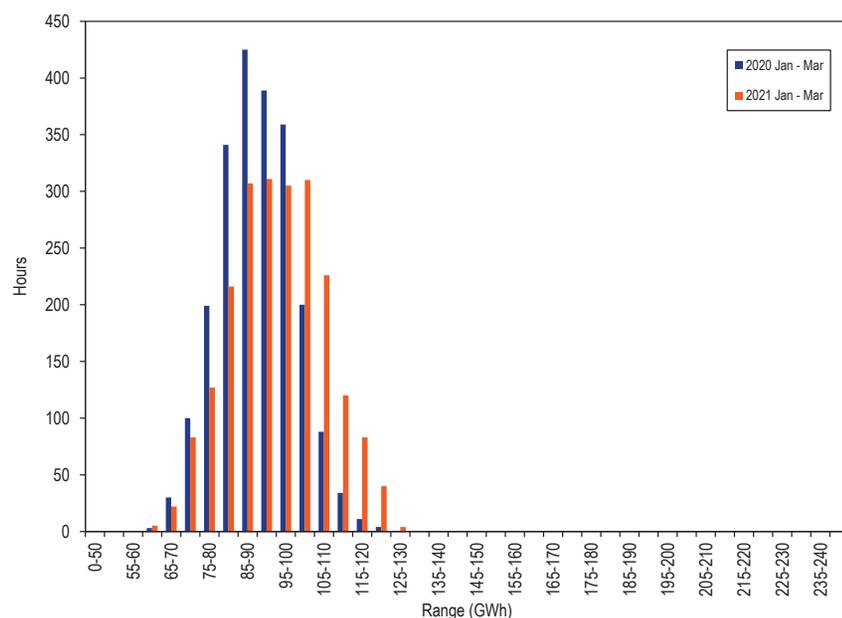
In the PJM Real-Time Energy Market, there are two types of demand:

- **Load.** The actual MWh level of energy used by load within PJM.
- **Export.** An export is an external energy transaction scheduled from PJM to another balancing authority. A real-time export must have a valid OASIS reservation when offered, must have available ramp room to support the export, must be accompanied by a NERC Tag, and must pass the neighboring balancing authority’s checkout process.

PJM Real-Time Demand Duration

Figure 3-10 shows the distribution of hourly PJM real-time load plus exports in the first three months of 2020 and 2021.¹⁷

Figure 3-10 Distribution of real-time accounting load plus exports: January through March, 2020 and 2021¹⁸



¹⁷ All real-time load data in Section 3, "Energy Market," "Market Performance: Load and LMP," are based on PJM accounting load. See the *Technical Reference for PJM Markets, "Load Definitions,"* for detailed definitions of accounting load. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

¹⁸ Each range on the horizontal axis excludes the start value and includes the end value.

PJM Real-Time, Average Load

Table 3-7 presents real-time hourly demand summary statistics for the first three months of each year from 2001 through 2021.¹⁹ The first three months of 2021 have the highest export volume since the first three months of 2015.

Table 3-7 Real-time load and real-time load plus exports: January through March, 2001 through 2021

Jan-Mar	PJM Real-Time Demand (MW)				Year to Year Change			
	Load		Load Plus Exports		Load		Load Plus Exports	
	Load	Standard Deviation	Demand	Standard Deviation	Load	Standard Deviation	Demand	Standard Deviation
2001	31,254	3,846	33,452	3,704	NA	NA	NA	NA
2002	29,968	4,083	30,988	3,932	(4.1%)	6.1%	(7.4%)	6.1%
2003	39,249	5,546	41,600	5,701	31.0%	35.8%	34.2%	45.0%
2004	39,549	5,761	41,198	5,394	0.8%	3.9%	(1.0%)	(5.4%)
2005	71,388	8,966	79,319	9,587	80.5%	55.6%	92.5%	77.8%
2006	80,179	8,977	86,567	9,378	12.3%	0.1%	9.1%	(2.2%)
2007	84,586	12,040	90,304	12,012	5.5%	34.1%	4.3%	28.1%
2008	82,235	10,184	89,092	10,621	(2.8%)	(15.4%)	(1.3%)	(11.6%)
2009	81,170	11,718	86,110	11,948	(1.3%)	15.1%	(3.3%)	12.5%
2010	81,121	10,694	86,843	11,262	(0.1%)	(8.7%)	0.9%	(5.7%)
2011	81,018	10,273	86,635	10,613	(0.1%)	(3.9%)	(0.2%)	(5.8%)
2012	86,329	10,951	91,090	11,293	6.6%	6.6%	5.1%	6.4%
2013	91,337	10,610	95,835	10,452	5.8%	(3.1%)	5.2%	(7.4%)
2014	98,317	13,484	104,454	12,843	7.6%	27.1%	9.0%	22.9%
2015	97,936	13,445	102,821	13,855	(0.4%)	(0.3%)	(1.6%)	7.9%
2016	89,322	13,262	92,777	13,409	(8.8%)	(1.4%)	(9.8%)	(3.2%)
2017	87,598	11,208	92,791	11,295	(1.9%)	(15.5%)	0.0%	(15.8%)
2018	92,761	13,244	96,216	13,487	5.9%	18.2%	3.7%	19.4%
2019	91,962	11,888	96,898	12,373	(0.9%)	(10.2%)	0.7%	(8.3%)
2020	85,608	10,004	90,093	9,736	(6.9%)	(15.8%)	(7.0%)	(21.3%)
2021	89,887	11,000	95,236	12,103	5.0%	10.0%	5.7%	24.3%

¹⁹ Accounting load is used because accounting load is the load customers pay for in PJM settlements. The use of accounting load with losses before June 1, and without losses after June 1, 2007, is consistent with PJM's calculation of LMP. Before June 1, 2007, transmission losses were included in accounting load. After June 1, 2007, transmission losses were excluded from accounting load and losses were addressed through the incorporation of marginal loss pricing in LMP.

PJM Real-Time, Monthly Average Load

Figure 3-11 compares the real-time, monthly average load plus exports in 2020 and the first three months of 2021, with the historic five year range. The February monthly average load plus exports in 2021 is higher than the maximum of the past five years.

Figure 3-11 Real-time monthly average hourly load plus exports: January 2020 through March 2021

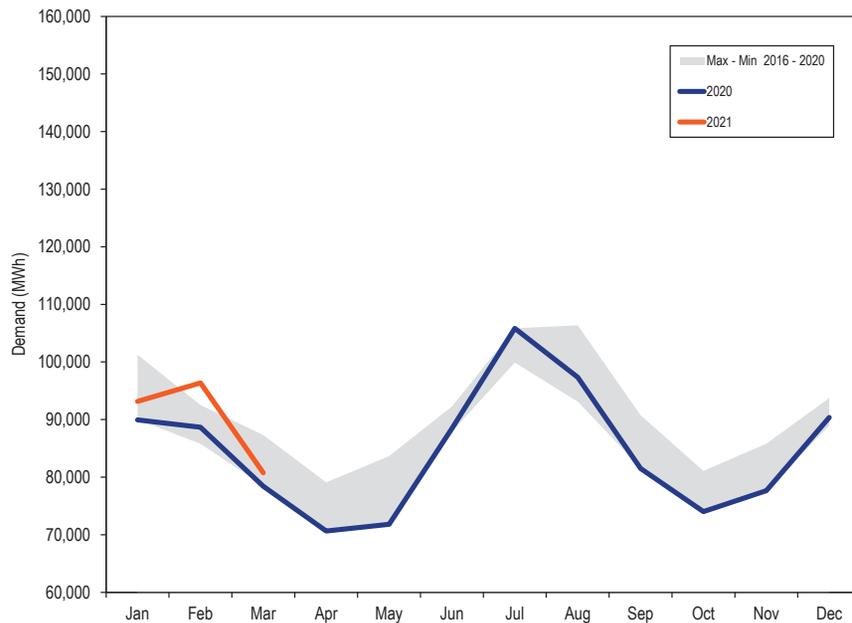
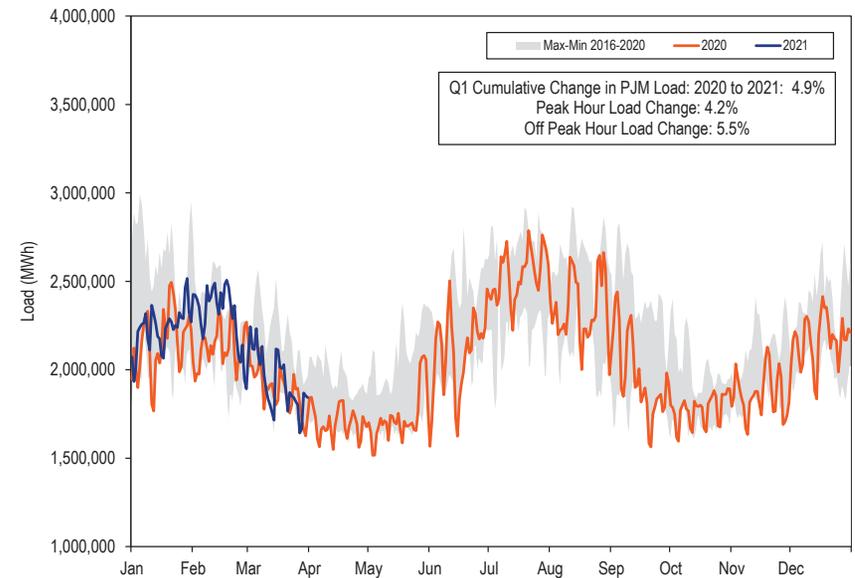


Figure 3-12 compares the real-time, average daily load in 2020 and the first three months of 2021, with the historic five year range.

Figure 3-12 Real-time daily load: January 2020 through March 2021



PJM real-time load is significantly affected by weather conditions. Table 3-8 compares the PJM monthly heating and cooling degree days in 2020 and the first three months of 2021.²⁰ Heating degree days increased 17.8 percent compared to the first three months of 2020.

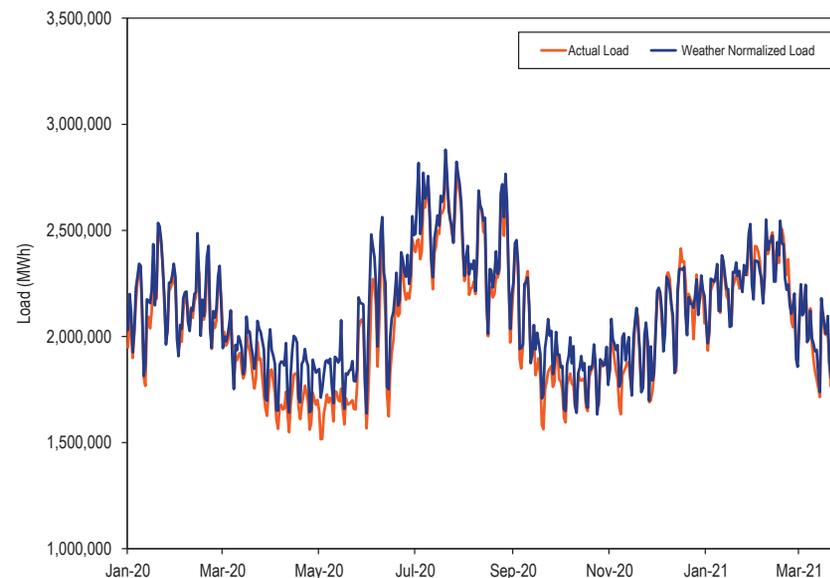
Table 3-8 Heating and cooling degree days: January 2020 through March 2021

	2020		2021		Percent Change	
	Heating Degree Days	Cooling Degree Days	Heating Degree Days	Cooling Degree Days	Heating Degree Days	Cooling Degree Days
Jan	698	0	816	0	16.9%	0.0%
Feb	652	0	822	0	26.1%	0.0%
Mar	385	0	405	0	5.3%	0.0%
Apr	279	0				
May	105	59				
Jun	0	262				
Jul	0	464				
Aug	0	342				
Sep	13	120				
Oct	139	1				
Nov	313	0				
Dec	719	0				
Jan-Mar	1,734	0	2,043	0	17.8%	0.0%

Figure 3-13 shows the real-time daily load and the weather normalized load for 2020 through the first three months of 2021.

Weather normalized load is calculated using the historic relationship between PJM daily load and HDD, CDD, and time of year for 2015 through 2018. Figure 3-13 shows that from March through May 2020, the actual load was significantly less than the weather normalized load. The difference was a result of changes in the pattern and level of activity due to COVID-19 and associated policy responses.

Figure 3-13 Real-time daily load and weather normalized load: January 2020 through March 2021



²⁰ A heating degree day is defined as the number of degrees that a day's average temperature is below 65 degrees F (the temperature below which buildings need to be heated). A cooling degree day is the number of degrees that a day's average temperature is above 65 degrees F (the temperature when people will start to use air conditioning to cool buildings). PJM uses 60 degrees F for a heating degree day as stated in Manual 19.

Heating and cooling degree days are calculated by weighting the temperature at each weather station in the individual transmission zones using weights provided by PJM in Manual 19. Then the temperature is weighted by the real-time zonal accounting load for each transmission zone. After calculating an average hourly temperature across PJM, the heating and cooling degree formulas are used to calculate the daily heating and cooling degree days, which are summed for monthly reporting. The weather stations that provided the basis for the analysis are ABE, ACY, AVP, BWI, CAK, CLE, CMH, CRW, CVG, DAY, DCA, ERI, EWR, FWA, IAD, ILG, IPT, LEX, ORD, ORF, PHL, PIT, RIC, ROA, TOL and WAL.

Table 3-9 compares the total monthly actual load and weather normalized load. The gap between actual load and weather normalized load in the first three months of 2021 is smaller than in the first three months of 2020.

Table 3-9 Actual load and weather normalized load: January 2020 through March 2021

	2020			2021		
	Actual Load	Weather Normalized Load	Percent Difference	Actual Load	Weather Normalized Load	Percent Difference
Jan	66,905,774	68,256,113	(2.0%)	69,303,496	69,689,108	(0.6%)
Feb	61,717,353	62,471,212	(1.2%)	64,761,103	64,275,946	0.8%
Mar	58,258,178	60,459,812	(3.6%)	60,002,018	61,459,726	(2.4%)
Apr	50,864,950	55,116,626	(7.7%)			
May	53,430,088	57,904,128	(7.7%)			
Jun	63,666,037	67,406,845	(5.5%)			
Jul	78,749,183	80,856,404	(2.6%)			
Aug	72,425,029	74,173,773	(2.4%)			
Sep	58,683,018	60,988,913	(3.8%)			
Oct	55,061,813	56,572,150	(2.7%)			
Nov	55,993,432	57,678,640	(2.9%)			
Dec	67,232,280	67,074,317	0.2%			
Jan - Mar	186,881,306	191,187,137	(2.3%)	194,066,617	195,424,781	(0.7%)

Day-Ahead Demand

PJM average hourly day-ahead demand in the first three months of 2021, including DECs and up to congestion transactions, decreased by 5.3 percent from the first three months of 2020, from 108,144 MWh to 102,372 MWh. When exports are added, PJM average hourly day-ahead demand in the first three months of 2021 decreased by 4.9 percent from the first three months of 2020, from 111,101 MWh to 105,639 MWh.

In the PJM Day-Ahead Energy Market, there are five types of financially binding demand bids:

- **Fixed-Demand Bid.** Bid to purchase a defined MWh level of energy, regardless of LMP.
- **Price-Sensitive Bid.** Bid to purchase a defined MWh level of energy only up to a specified LMP, above which the load bid is zero.

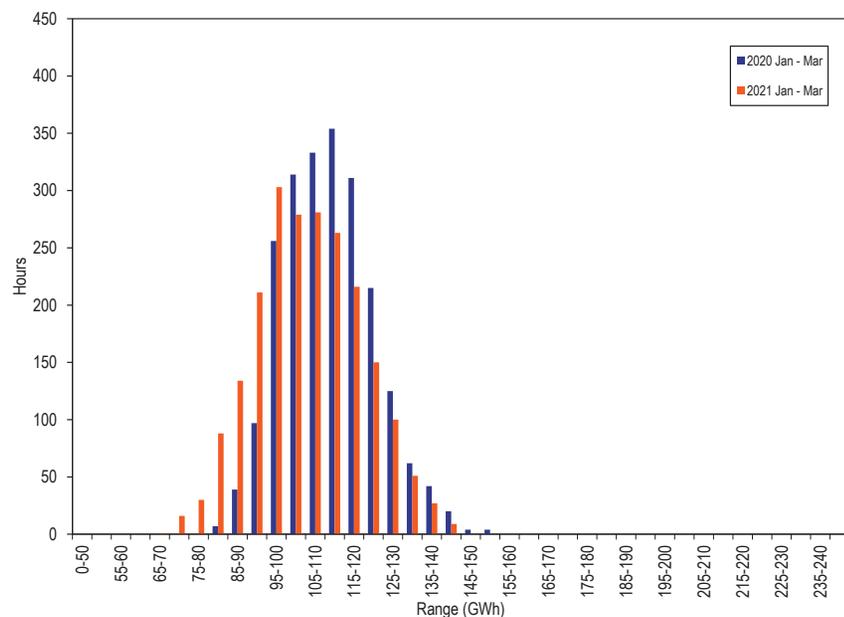
- **Decrement Bid (DEC).** Financial bid to purchase a defined MWh level of energy up to a specified LMP, above which the bid is zero.
- **Up to Congestion Transaction (UTC).** A conditional transaction that permits a market participant to specify a maximum price spread between the transaction source and sink. An up to congestion transaction is evaluated as a matched pair of an injection and a withdrawal.
- **Export.** An external energy transaction scheduled from PJM to another balancing authority. An export must have a valid willing to pay congestion (WPC) OASIS reservation when offered. There is no link between transactions submitted in the PJM Day-Ahead Energy Market and the PJM Real-Time Energy Market, so an export energy transaction approved in the day-ahead energy market will not physically flow in real time unless it is also submitted through the real-time energy market scheduling process.

PJM day-ahead demand is the total of the five types of cleared demand bids.

PJM Day-Ahead Demand Duration

Figure 3-14 shows the hourly distribution of PJM day-ahead demand for the first three months of 2020 and 2021.

Figure 3-14 Distribution of day-ahead demand plus exports: January through March, 2020 and 2021²¹



21 Each range on the horizontal axis excludes the start value and includes the end value.

PJM Day-Ahead, Average Demand

Table 3-10 shows day-ahead hourly demand for the first three months of 2001 through 2021. The monthly average hourly demand in first three months of 2021, with and without exports, is lower than any year since 2010, as a result of the reduction in UTC transaction volumes.

Table 3-10 Average hourly day-ahead demand and day-ahead demand plus exports: January through March, 2001 through 2021

Jan-Mar	PJM Day-Ahead Demand (MWh)				Year to Year Change			
	Demand		Demand Plus Exports		Demand		Demand Plus Exports	
	Demand	Standard Deviation	Demand	Standard Deviation	Demand	Standard Deviation	Demand	Standard Deviation
2001	33,731	4,557	34,523	4,390	NA	NA	NA	NA
2002	33,976	4,960	34,004	4,964	0.7%	8.8%	(1.5%)	13.1%
2003	47,034	6,841	47,147	6,853	38.4%	37.9%	38.7%	38.1%
2004	46,885	5,591	47,123	5,537	(0.3%)	(18.3%)	(0.1%)	(19.2%)
2005	87,341	9,810	90,288	9,947	86.3%	75.5%	91.6%	79.6%
2006	96,244	9,453	99,342	9,777	10.2%	(3.6%)	10.0%	(1.7%)
2007	108,699	12,601	111,831	12,746	12.9%	33.3%	12.6%	30.4%
2008	105,995	10,677	109,428	10,975	(2.5%)	(15.3%)	(2.1%)	(13.9%)
2009	102,366	13,619	105,023	13,758	(3.4%)	27.6%	(4.0%)	25.4%
2010	101,012	11,937	104,866	12,103	(1.3%)	(12.4%)	(0.1%)	(12.0%)
2011	107,116	11,890	110,865	12,157	6.0%	(0.4%)	5.7%	0.4%
2012	129,258	13,163	132,757	13,481	20.7%	10.7%	19.7%	10.9%
2013	143,585	13,120	146,878	13,108	11.1%	(0.3%)	10.6%	(2.8%)
2014	163,031	11,914	167,318	11,717	13.5%	(9.2%)	13.9%	(10.6%)
2015	119,084	14,227	123,115	14,573	(27.0%)	19.4%	(26.4%)	24.4%
2016	130,469	18,627	133,137	18,806	9.6%	30.9%	8.1%	29.0%
2017	135,574	16,264	139,299	16,454	3.9%	(12.7%)	4.6%	(12.5%)
2018	116,635	21,378	119,023	21,606	(14.0%)	31.4%	(14.6%)	31.3%
2019	117,251	13,075	120,386	13,423	0.5%	(38.8%)	1.1%	(37.9%)
2020	108,144	11,625	111,101	11,658	(7.8%)	(11.1%)	(7.7%)	(13.1%)
2021	102,372	12,828	105,639	13,599	(5.3%)	10.4%	(4.9%)	16.6%

PJM Day-Ahead, Monthly Average Demand

Figure 3-15 compares the day-ahead, monthly average hourly demand, including decrement bids and up to congestion transactions in 2020 and first three months of 2021 with the historic five-year range.

Figure 3-15 Day-ahead monthly average hourly demand plus exports: January 2020 through March 2021



Real-Time and Day-Ahead Demand

Table 3-11 presents summary statistics for the first three months of 2020 and 2021 day-ahead and real-time demand. The last two columns of Table 3-11 are the day-ahead demand minus the real-time demand: the first column is the total physical day-ahead load (fixed demand plus price-sensitive demand) less the physical real-time load; and the second column is the total day-ahead demand less the total real-time demand. The data show the impact of the reduction in UTC bids on day-ahead demand.

Table 3-11 Cleared day-ahead and real-time demand (MWh): January through March, 2020 and 2021

Jan-Mar	Year	Day-Ahead						Real-Time		Day-Ahead Less Real-Time	
		Fixed Demand	Price Sensitive	DEC Bids	Up-to Congestion	Exports	Total Demand	Load	Total Demand	Load	Demand
Average	2020	84,744	1,146	2,911	19,343	2,956	111,101	85,608	90,093	283	21,008
	2021	87,761	1,400	4,460	8,751	3,267	105,639	89,887	95,236	(727)	10,403
Median	2020	84,696	1,159	2,614	19,282	2,960	110,797	85,475	89,916	380	20,881
	2021	88,272	1,417	4,045	8,580	2,913	105,299	90,249	95,210	(561)	10,089
Standard Deviation	2020	9,968	214	1,374	3,287	661	11,658	10,004	9,736	178	1,923
	2021	10,550	245	1,718	2,795	1,246	13,599	11,000	12,103	(206)	1,496
Peak Average	2020	90,524	1,242	3,287	20,195	3,055	118,303	91,075	95,610	691	22,693
	2021	93,168	1,498	4,815	9,564	3,465	112,510	95,070	100,725	(405)	11,785
Peak Median	2020	90,525	1,296	3,123	20,144	3,084	117,551	91,247	95,541	574	22,010
	2021	94,341	1,563	4,493	9,259	3,116	112,279	96,550	100,977	(646)	11,302
Peak Standard Deviation	2020	7,815	235	1,304	3,439	578	9,507	8,061	7,779	(12)	1,728
	2021	8,849	277	1,747	2,739	1,292	11,681	9,697	10,819	(571)	863
Off-Peak Average	2020	79,637	1,061	2,579	18,590	2,869	104,737	80,777	85,218	(78)	19,519
	2021	83,026	1,314	4,149	8,038	3,095	99,621	85,348	90,430	(1,009)	9,192
Off-Peak Median	2020	79,396	1,064	2,245	18,461	2,838	103,381	80,293	84,739	167	18,641
	2021	83,557	1,335	3,671	7,848	2,750	98,974	86,348	90,495	(1,456)	8,480
Off-Peak Standard Deviation	2020	8,811	149	1,348	2,949	715	9,480	9,021	8,628	(61)	852
	2021	9,602	171	1,631	2,647	1,178	12,244	10,028	11,084	(254)	1,160

Figure 3-16 shows the average hourly cleared volumes of day-ahead demand and real-time demand for the first three months of 2021. The day-ahead demand includes day-ahead load, decrement bids, up to congestion transactions, and day-ahead exports. The real-time demand includes real-time load and real-time exports.

Figure 3-16 Day-ahead and real-time demand (Average hourly volumes): January through March, 2021

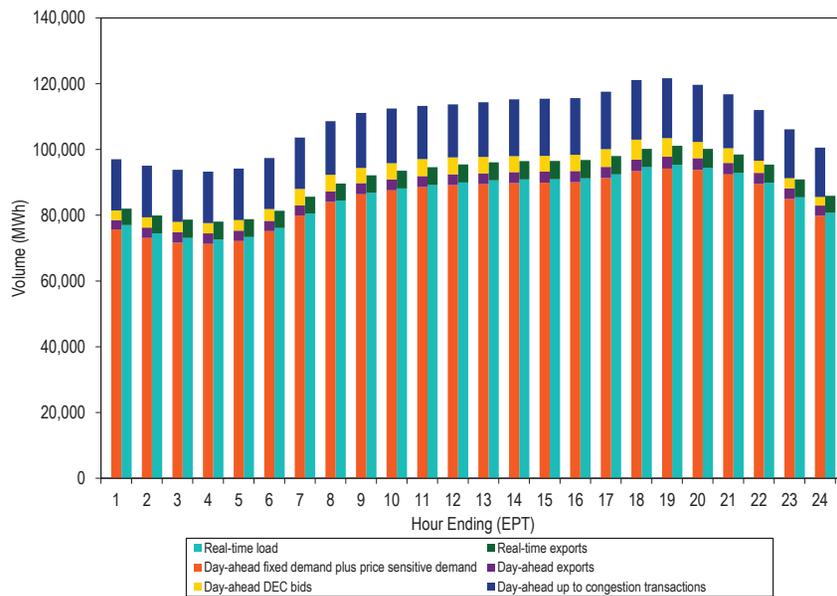
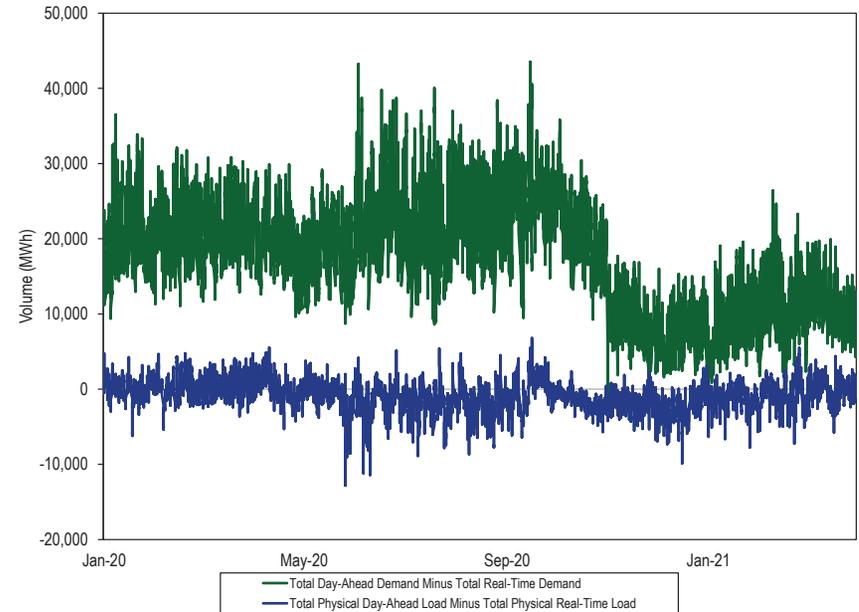


Figure 3-17 shows the difference between the day-ahead and real-time average daily demand for 2020 and the first three months of 2021.

Figure 3-17 Difference between day-ahead and real-time demand (Average daily volumes): January 2020 through March 2021



Market Behavior

Generator Offers

In day-ahead market offers, generators define the commitment status and the dispatch status of their units. The commitment status indicates whether the generation owner will turn the unit on, regardless of market signals, or whether the generation owner will allow the energy market to commit the unit. The dispatch status indicates whether the generation owner will produce at full output regardless of market signals or whether the generation owner will follow PJM market dispatch signals. Market commitment is designated as economic status in the offer, allowing the market to decide whether to commit the unit at its economic minimum MW level. The Eco Min column in Table 3-12 is the economic minimum MW of units offering with economic commitment status. Self scheduling is designated as must run status in the offer, meaning the unit owner will commit the unit to run regardless of market signals. Self scheduling includes committing the unit at economic minimum and permitting the balance to be dispatchable or block loading the full output of the unit. The Must Run column in Table 3-12 is the economic minimum MW of units offering with must run commitment status. Economic minimum for a self scheduled unit (must run commitment status) means the output level at which the unit self commits, including any point between the actual, physical economic minimum level and economic maximum level of the unit.

Table 3-12 shows the percent of MW offered as must run, the percent of MW of economic minimum levels of units offered as dispatchable, the percent of MW offered as dispatchable by price range, the percent of MW offered as maximum emergency and the total percent of MW offered as dispatchable. For example, combined cycle offers in the day-ahead energy

market are comprised of 8.9 percent must run MW, 37.2 percent economic minimum MW of dispatchable units, 53.3 percent dispatchable MW, and 0.6 percent emergency maximum MW.

For each price level along the energy offer curves of units in both must run and economic status, Table 3-12 shows the dispatchable MW for each price level by unit type. Units can also designate all or a portion of their capacity as emergency MW. Table 3-12 shows that 0.8 percent of offered MW are emergency MW. Emergency MW are calculated as the difference between the day-ahead submitted emergency max MW and economic max MW. In some cases, the higher share of emergency MW is a result of offer behavior and does not necessarily represent the actual availability of the emergency MW in real time.

In the day-ahead market in the first three months of 2021, 22.4 percent of MW were offered as must run, 31.1 percent were the economic minimum MW for dispatchable units, 45.6 percent were offered as dispatchable MW, and 0.8 percent were offered as emergency maximum MW.

Table 3-12 Dispatchable status of day-ahead energy offers: January through March, 2021

Unit Type	Must Run	Eco Min	Dispatchable Range										Emergency MW	Dispatchable Percent
			(\$300) - \$0	\$0 - \$25	\$25 - \$50	\$50 - \$75	\$75 - \$100	\$100 - \$200	\$200 - \$400	\$400 - \$600	\$600 - \$800	\$800 - \$1000		
CC	8.9%	37.2%	0.2%	31.1%	14.1%	2.6%	1.6%	2.8%	0.8%	0.0%	0.0%	0.0%	0.6%	53.3%
CT	0.2%	68.6%	0.0%	2.3%	9.6%	2.7%	1.2%	11.7%	2.0%	0.4%	0.0%	0.1%	1.1%	30.0%
Diesel	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydro	82.8%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.3%	1.9%
Nuclear	68.9%	5.7%	15.3%	10.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.4%
Solar	28.5%	0.0%	71.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	71.5%
Steam - Coal	21.9%	17.4%	0.0%	41.9%	15.2%	1.5%	0.5%	0.2%	0.1%	0.5%	0.0%	0.0%	0.7%	60.0%
Steam - Other	6.6%	35.9%	4.1%	5.3%	19.1%	3.4%	2.9%	18.6%	3.5%	0.1%	0.0%	0.1%	0.6%	57.0%
Wind	7.2%	1.0%	80.8%	2.8%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.3%	84.5%
Other	19.5%	45.5%	3.9%	3.8%	5.8%	0.7%	1.1%	12.3%	3.4%	0.0%	0.0%	0.0%	4.0%	30.9%
Total	22.4%	31.1%	4.6%	22.1%	10.8%	1.8%	1.0%	4.2%	0.8%	0.2%	0.0%	0.0%	0.8%	45.6%

Hourly Offers and Intraday Offer Updates

All participants are able to make hourly offers. Participants must opt in on a monthly basis to make intraday offer updates. Participants that have opted in can make updates only based on the process defined in their fuel cost policies. Table 3-13 shows the daily average number of units that make hourly offers, that opted in to intraday offer updates and that make intraday offer updates. In the first three months of 2021, an average of 313 units per day made hourly offers, an increase of three units from 2020. In the first three months of 2021, 419 units opted in for intraday offer updates, an increase of 21 units from 2019. In the first three months of 2020, an average of 129 units made intraday offer updates each day, a decrease of two units from 2019.

Table 3-13 Daily average number of units making hourly offers, opted in for intraday offers and making intraday offer updates: January through March, 2020 and 2021

	Fuel Type	2020	2021	Difference
Hourly Offers	Natural Gas	291	290	(1)
	Other Fuels	19	23	4
	Total	310	313	3
Opt In	Natural Gas	349	363	14
	Other Fuels	49	56	7
	Total	398	419	21
Intraday Offer Updates	Natural Gas	127	125	(2)
	Other Fuels	4	4	0
	Total	131	129	(2)

ICAP Must Offer Requirement

Generation capacity resources are required to offer their full ICAP MW into the day-ahead and real-time energy market, or report an outage for the difference.²² The full installed capacity (ICAP) is the ICAP of the resources that cleared in the capacity market. This is known as the ICAP must offer requirement.

Solar, wind, landfill gas, hydro and batteries can satisfy the must offer requirement by self scheduling or offering as dispatchable. There is no defined amount of capacity that these resources must offer. The must offer requirement

²² Section 1.10.1A(d) of Schedule 1 to the PJM Operating Agreement.

is thus not applied to these intermittent resource types and compliance is not enforceable.

The current enforcement of the ICAP must offer requirement is inadequate. The problem is a complex combination of generator behavior, and inadequate and inconsistent reporting tools that are not synchronized. Compliance is subject to mistakes and susceptible to manipulation.

Resources are required to submit their available capacity in three different systems. Resources are required to make offers in the energy market. Resources are required to report outages in the Dispatch Application Reporting Tool (eDART) in advance or in real time. Resources are required to report outages in the Generator Availability Data System (eGADS) after the fact. The three applications are not linked in a systematic way to ensure consistency.

Ambient derates are an example issue. When the weather is hotter than test conditions, the capacity of some units is reduced below the ICAP levels. While this fact may be reported by unit owners in eDART and reflected in lower offered MW in the energy market, the derates are never reported as outages in eGADS and are therefore not outages for purposes of defining capacity using EFORD.

The MMU recommends that PJM enforce the ICAP must offer requirement by assigning a forced outage to any unit that is derated in the energy market below its committed ICAP without an outage that reflects the derate.

The MMU recommends that intermittent resources be subject to an enforceable ICAP must offer rule that reflects the limitations of these resources.

Table 3-14 shows average hourly MW, for each month, that violated the ICAP must offer requirement in the first three months of 2021. On average for all hours, 1,408 MW did not meet the ICAP must offer requirement, but for 10 percent of the hours 3,110 MW did not meet the must offer requirement. These MW levels are larger than the reserve shortages that triggered scarcity pricing in the first three months of 2021 and larger than most supply contingencies that led to synchronized reserve events in the first three months of 2021.

Table 3-14 Average hourly estimated capacity (MW) failing the ICAP must offer requirement: January through March, 2021

Month	90th Percentile	Average	10th Percentile
Jan-21	1,810	846	178
Feb-21	1,257	767	313
Mar-21	3,484	2,550	1,662
2021	3,110	1,408	321

Emergency Maximum MW

Generation resources are offered with economic maximum MW and emergency maximum MW. The economic maximum MW is the output level the resource can achieve following economic dispatch. The emergency maximum MW is the output level the resource can achieve when emergency conditions are declared by PJM. The MW difference between the two ratings equals emergency maximum MW. The PJM Market Rules allow generators to include emergency maximum MW as part of ICAP offered in the capacity market.²³

Generation resources have to meet one of four conditions to offer any MW as emergency in the energy market: environmental limits imposed by a federal, state or other governmental agency that significantly limit availability; fuel limits beyond the control of the generation owner; temporary emergency conditions that significantly limit availability; or temporary MW additions not ordinarily available.²⁴

The MMU recommends that capacity resources not be allowed to offer any portion of their capacity market obligation as maximum emergency energy.²⁵ Capacity resources should offer their full output in the energy market and subject to economic dispatch. The result will be incentives for correct reporting of ICAP, more efficient energy market pricing, and a reduction in the need for manual overrides by PJM dispatchers during emergency conditions. Resources that do have capacity that can only be achieved with extraordinary measures could offer such capacity in the energy market but should not take on a

²³ See 151 FERC ¶ 61, 208 at P 476 (2015).

²⁴ OA Schedule 1 Section 1.10.1A (d)

²⁵ This recommendation was accepted by PJM and filed with FERC in 2014 as part of the capacity performance updates to the RPM. See PJM Filing, Attachment A (Redlines of OA Schedule 1 § 1.10.1A(d), EL15-29-000 (December 12, 2014). FERC rejected the proposed change. See 151 FERC ¶ 61,208 at P 476 (2015).

capacity market obligation. The capacity performance rules in the capacity market provide incentives for such output during PAI.

Table 3-15 shows average hourly maximum emergency MW, for each month. The levels of maximum emergency MW change hourly, daily and seasonally. For example, 10 percent of hours in January 2021 had maximum emergency MW greater than or equal to 2,966 MW while 10 percent of hours in January 2021 had maximum emergency MW less than 1,778 MW. The hourly average, in the first three months of 2021, was 2,292 MW offered as maximum emergency, 2.0 percent higher than in 2020.

Table 3-15 Maximum emergency MW by month: 2021

Month	90th Percentile	Average	10th Percentile
Jan-21	2,966	2,310	1,778
Feb-21	2,887	2,304	1,765
Mar-21	2,999	2,262	1,638
2021	2,978	2,292	1,710

Parameter Limited Schedules

Cost-Based Offers

All capacity resources in PJM are required to submit at least one cost-based offer. For the 2020/2021 Delivery Year, PJM procured only capacity performance resources. Cost-based offers, submitted by capacity resources for a defined set of technologies, are parameter limited based on unit specific parameter limits. Nuclear, wind, solar and hydro units are not subject to parameter limits.

Price-Based Offers

All capacity resources that choose to offer price-based offers are required to make available at least one price-based parameter limited offer (referred to as price-based PLS). For resources that are not capacity resources, the price-based parameter limited schedule is to be used by PJM for committing generation resources when a maximum emergency generation alert is declared. For capacity performance resources, the price-based parameter limited schedule

is to be used by PJM for committing generation resources when hot weather alerts and cold weather alerts are declared.

The MMU recommends that in order to ensure effective market power mitigation, PJM always enforce parameter limited values when the TPS test is failed and during high load conditions such as cold and hot weather alerts and emergency conditions.²⁶ Instead of ensuring that parameter limits apply, PJM chooses the lower of the price-based schedule and the price-based parameter limited schedule during hot and cold weather alerts. Instead of ensuring that parameter limits apply, PJM chooses the lower of the price-based schedule and the cost-based parameter limited schedule when a resource fails the TPS test. The current implementation is not consistent with the goal of having parameter limited schedules, which is to prevent the use of inflexible operating parameters to exercise market power.

The MMU analyzed the extent of parameter mitigation in the day-ahead energy market when units are committed after failing the TPS test for transmission constraints in the first three months of 2021. The analysis includes units with technologies that are subject to parameter limits and offer both price-based and cost-based schedules.²⁷ Table 3-16 shows the number and percentage of day-ahead unit run hours that failed the TPS test but were committed on price schedules. Table 3-16 shows that 45.8 percent of unit hours for units that failed the TPS test were committed on price-based schedules that were less flexible than their cost-based schedules.

Table 3-16 Parameter mitigation for units failing TPS test: January through March, 2021

Day-ahead commitment for units that failed TPS test	Day-ahead Unit Hours	Percent Day-ahead Unit Hours
Committed on price schedule less flexible than cost	8,873	45.8%
Committed on price schedule as flexible as cost	1,424	7.4%
Total committed on price schedule without parameter limits	10,297	53.2%
Committed on cost (cost capped)	9,070	46.8%
Committed on price PLS	6	0.0%
Total committed on PLS schedules (cost or price PLS)	9,076	46.8%

²⁶ See Protest of the Independent Market Monitor for PJM, Docket No. ER20-995 (February 25, 2020).

²⁷ Nuclear, wind, solar and hydro units are not subject to parameter limits.

The MMU analyzed the extent of parameter mitigation in the day-ahead energy market for units in regions where a cold weather alert was declared in the first three months of 2021. PJM declared cold weather alerts on six days and no hot weather alerts in the first three months of 2021.²⁸ The analysis includes units with technologies that are subject to parameter limits, with a CP commitment, in the zones where the cold weather alerts were declared. Table 3-17 shows that 35.9 percent of unit hours in the day-ahead energy market were committed on price-based schedules that were less flexible than their price PLS schedules.²⁹

Table 3-17 Parameter mitigation during weather alerts: January through March, 2021

Day-ahead commitment during hot and cold weather alerts	Day-ahead Unit Hours	Percent Day-ahead Unit Hours
Committed on price schedule less flexible than PLS	2,692	35.9%
Committed on price schedule as flexible as PLS	1,044	13.9%
Total committed on price schedule without parameter limits	3,736	49.8%
Committed on cost (cost capped)	4	0.1%
Committed on price PLS	3,759	50.1%
Total committed on PLS schedules (cost or price PLS)	3,763	50.2%

Currently, there are no rules in the PJM tariff or manuals that limit the markup attributes of price-based PLS offers. The intent of the price-based PLS offer is to prevent the exercise of market power during high demand conditions by preventing units from offering inflexible operating parameters in order to extract higher market revenues or higher uplift payments. However, a generator can include a higher markup in the price-based PLS offer than in the price-based non-PLS schedule. The result is that the offer is higher and market prices are higher as a result of the exercise of market power using the PLS offer. This defeats the purpose of requiring price-based PLS offers.

The MMU recommends that in order to ensure effective market power mitigation when the TPS test is failed and during high load conditions such as cold and hot weather alerts or more severe emergencies, the operating parameters in the cost-based offer and the price-based parameter limited schedule (PLS) offer be at least as flexible as the operating parameters in the available non-

²⁸ 2021 Quarterly State of the Market Report for PJM: January through March, Section 3: Energy Market, at Emergency Procedures.

²⁹ Nuclear, wind, solar and hydro units are not subject to parameter limits.

PLS price-based offer, and that the price-MW pairs in the price-based PLS offer be exactly equal to the price-based non-PLS offer. This recommendation would ensure that market power that results from inflexible parameters is mitigated during high load conditions and when a market seller fails the TPS test, consistent with the goal of having parameter limited schedules.

Parameter Limits

Beginning June 1, 2020, all capacity resources, including resources in FRR capacity plans, are capacity performance resources. The unit specific parameter limits for capacity performance resources are based on default minimum operating parameter limits posted by PJM by technology type, and any adjustments based on a unit specific review process. These default parameters were based on analysis by the MMU.

The PJM tariff specifies that all generation capacity resources, regardless of the current commitment status, are subject to parameter limits on their cost-based offers. However, the tariff currently does not make it clear what parameter limit values are applicable for resources without a capacity commitment. The MMU recommends that PJM update the tariff to clarify that all generation resources are subject to unit specific parameter limits on their cost-based offers using the same standard and process as capacity performance resources.

Unit Specific Adjustment Process

Market participants can request an adjustment to the default values of parameter limits for capacity performance resources by submitting supporting documentation which is reviewed by PJM and the MMU. The default minimum operating parameter limits or approved adjusted values are used by capacity performance resources for their parameter limited schedules.

PJM has the authority to approve adjusted parameters with input from the MMU. PJM has inappropriately applied different review standards to coal units than to CTs and CCs despite the objections of the MMU. PJM has approved parameter limits for boiler based steam units based on historical performance

and existing equipment while holding CTs and CCs to higher standards based on OEM documentation and a best practices equipment configuration.

The PJM process for the review of unit specific parameter limit adjustments is generally described in Manual 11: Energy and Ancillary Services Market Operations. The standards used by PJM to review the requests are currently not described in the tariff or PJM manuals. The MMU recommends that PJM clearly define the business rules that apply to the unit specific parameter adjustment process, including PJM's implementation of the tariff rules in the PJM manuals to ensure market sellers know the requirements for their resources.

Only certain technology types are subject to limits on operating parameters in their parameter limited schedules.³⁰ Solar units, wind units, run of river hydro units, and nuclear units are currently not subject to parameter limits. The MMU analyzed, for the units that are subject to parameter limits, the proportion of units that use the default limits published by PJM and the proportion of units that have been provided unit specific adjustments for some of the parameters. Table 3-18 shows, for the delivery year beginning June 1, 2020, the number of units that submitted and had approved unit specific parameter limit adjustments, and the number of units that used the default parameter limits published by PJM.

Table 3-18 Adjusted unit specific parameter limit statistics: 2020/2021 Delivery Year

Technology Classification	Units Using Default Parameter Limits	Units with One or More Adjusted Parameter Limits	Percentage of Units with One or More Adjusted Parameter Limits
Aero CT	125	40	24.2%
Frame CT	178	96	35.0%
Combined Cycle	80	37	31.6%
Reciprocating Internal Combustion Engines	68	3	4.2%
Solid Fuel NUG	36	6	14.3%
Oil and Gas Steam	10	15	60.0%
Subcritical Coal Steam	10	58	85.3%
Supercritical Coal Steam	5	38	88.4%
Pumped Storage	10	0	0.0%

³⁰ For the default parameter limits by technology type, see PJM. "Unit-Specific Minimum Operating Parameters for Capacity Performance and Base Capacity Resources," which can be accessed at <<https://www.pjm.com/~media/committees-groups/committees/elc/postings/20150612-june-2015-capacity-performance-parameter-limitations-informational-posting.ashx>>.

Real-Time Values

PJM market rules allow generators to communicate a resource's current operational capabilities to PJM when a resource cannot operate according to the unit specific parameters. These values are called real-time values (RTVs). The real-time values submittal process is not specified in the PJM Operating Agreement. The process is defined in PJM Manual 11. Unlike parameter exceptions, the use of real-time values makes a unit ineligible for make whole payments, unless the market seller can justify such operation based on an actual constraint.³¹ There are no ramifications for the use of real time values to withhold generation.

In practice, real-time values were meant to be used to communicate lower Turn Down Ratios which result from reduced Economic Max MW due to a derate (partial outage) on a unit, or from a requirement to operate at a defined output for equipment tests, environmental tests, or inspections. The RTV functionality allows units to communicate accurate short term operational parameters to PJM without requiring PJM customers to pay additional uplift charges, if the unit operates out of the money for routine tests and inspections. However, using real-time values to extend the time to start parameters (startup times and notification times) or minimum run time or minimum down time is inconsistent with the goal of real-time values. The protection offered by making units ineligible for uplift is only effective if the unit is committed and operated out of the money because of the RTVs. In the case of the notification time parameter, start time parameter, minimum run time and minimum down time parameters, a longer real-time value decreases the likelihood of the unit being committed at all, and may prevent unit commitment in real time, making the RTV a mechanism for exercising market power through withholding and for failing to meet the obligations of capacity resources.

Currently, a resource that is staffed or has remote start capability and offers according to its physical capability, and a resource that makes the economic choice not to staff or invest in remote start and economically or physically withholds to decrease the likelihood of commitment, are compensated identically in the capacity market. If a market seller makes an economic

³¹ See PJM Operating Agreement, Schedule 1, Section 3.2.3 (e).

decision to not staff the unit or to not have remote start capability, and uses real-time values to communicate the longer time to start to PJM, the unit's actual parameters are not recognized as inconsistent with its obligations as a capacity resource, not reflected in forced outages, and not reflected in eligibility for uplift payments. The market seller is able to withhold the unit in the energy market with no consequence, while other similarly situated units incur the costs associated with meeting their obligations.

The MMU recommends that PJM institute rules to assess a penalty for resources that choose to submit real-time values that are less flexible than their unit specific parameter limits or approved parameter limit exceptions based on tariff defined justifications. The changes to the RTV rules proposed by PJM in the stakeholder process do not include a penalty and do not create incentives for resources to offer flexibly. PJM's proposed rules on RTVs instead encourage resources to use RTVs to offer parameter limited schedules with parameter values that violate the unit specific limits on days without weather alerts, with no consequences. PJM's proposed RTV rules weaken the market power protections offered by the parameter limited schedules rules in the PJM tariff.

Generator Flexibility Incentives under Capacity Performance

In its June 9, 2015, order on capacity performance, the Commission determined that capacity performance resources should be able to reflect actual constraints based on not just the resource physical constraints, but also other constraints, such as contractual limits that are not based on the physical characteristics of the generator.³² The Commission directed that capacity performance resources with parameters based on nonphysical constraints should receive uplift payments.³³ The Commission directed PJM to submit tariff language to establish a process through which capacity performance resources that operate outside the defined unit specific parameter limits can justify such operation and therefore remain eligible for make whole payments.³⁴

³² 151 FERC ¶ 61,208 at P 437 (2015) (June 9th Order).

³³ *Id.* at P 439.

³⁴ *Id.* at P 440.

A primary goal of the capacity performance market design is to assign performance risk to generation owners and to ensure that capacity prices reflect underlying supply and demand conditions, including the cost of taking on performance risk. The June 9th Order's determination on parameters is not consistent with that goal. By permitting generation owners to establish unit parameters based on nonphysical limits, the June 9th Order weakened the incentives for units to be flexible and weakened the assignment of performance risk to generation owners. Contractual limits, unlike generating unit operational limits, are a function of the interests and incentives of the parties to the contracts. If a generation owner expects to be compensated through uplift payments for running for 24 hours regardless of whether the energy is economic or needed, that generation owner has no incentive to pay more to purchase the flexible gas service that would permit the unit to be flexible in response to dispatch.

The fact that a contract may be entered into by two willing parties does not mean that is the only possible arrangement between the two parties or that it is consistent with an efficient market outcome or that such a contract can reasonably impose costs on customers who were not party to the contract. The actual contractual terms are a function of the incentives and interests of the parties, who may be affiliates or have market power. The fact that a just and reasonable contract exists between a generation owner and a gas supplier does not mean that it is appropriate or efficient to impose the resultant costs on electric customers or that it incorporates an efficient allocation of performance risk between the generation owner and other market participants.

The approach to parameters defined in the June 9th Order will increase energy market uplift payments substantially. While some uplift is necessary and efficient in an LMP market, this uplift is not. Electric customers are not in a position to determine the terms of the contracts that resources enter into. Customers rely on the market rules to create incentives that protect them by assigning operational risk to generators, who are in the best position to efficiently manage those risks.

The MMU recommends that capacity performance resources be held to the OEM operating parameters of the capacity market reference resource used for the Cost of New Entry (CONE) calculation for performance assessment and energy uplift payments and that this standard be applied to all technologies on a uniform basis. This solution creates the incentives for flexibility and preserves, to the extent possible, the incentives to follow PJM's dispatch instructions during high demand conditions. The proposed operating parameters should be based on the physical capability of the Reference Resource used in the Cost of New Entry, currently two GE Frame 7FA turbines with dual fuel capability. All resources that are less flexible than the reference resource are expected to be scheduled and running during high demand conditions anyway, while the flexible CTs that are used as peaking plants would still have the incentive to follow LMP and dispatch instructions. CCs would also have the capability to be as flexible as the reference resource. These units will be exempt from nonperformance charges and made whole as long as they perform in accordance with their parameters. This ensures that all the peaking units that are needed by PJM for flexible operation do not self schedule at their maximum output, and follow PJM dispatch instructions during high demand conditions. If any of the less flexible resources need to be dispatched down by PJM for reliability reasons, they would be exempt from nonperformance charges.

Such an approach is consistent with the Commission's no excuses policy for nonperformance because the flexibility target is set based on the optimal OEM-defined capability for the marginal resource that is expected to meet peak demand, which is consistent with the level of performance that customers are paying for in the capacity market. Any resource that is less flexible is not excused for nonperformance and any resource that meets the flexibility target is performing according to the commitments made in the capacity market.

The June 9th Order pointed out that the way to ensure that a resource's parameters are exposed to market consequences is to not allow any parameter limitations as an excuse for nonperformance. The same logic should apply to energy market uplift rules. A resource's parameters should be exposed to market consequences and the resource should not be made whole if it

is operating less flexibly than the reference resource. Paying energy market uplift on the basis of parameters consistent with the flexibility goals of the capacity performance construct would ensure that performance incentives are consistent across the capacity and energy markets and ensure that performance risk is appropriately assigned to generation owners.

Parameter Impacts of Gas Pipeline Conditions

During extreme cold weather conditions, and recently, during hot weather conditions, a number of gas fired generators request temporary exceptions to parameter limits for their parameter limited schedules due to restrictions imposed by natural gas pipelines. The parameters affected include notification time, minimum run time (MRT) and turn down ratio (TDR, the ratio of economic maximum MW to economic minimum MW). When pipelines issue critical notices and enforce ratable take requirements, generators may, depending on the nature of the transportation service purchased, be forced to nominate an equal amount of gas for each hour in a 24 hour period, with penalties for deviating from the nominated quantity. This leads to requests for 24 hour minimum run times and turn down ratios close to 1.0, to avoid deviations from the hourly nominated quantity. In the first three months of 2021, there were 51 units in PJM that experienced gas pipeline restrictions leading to requests for 24 hour minimum run time on their parameter limited schedules.

Key parameters like startup and notification time were not included in the PLS matrix in 2017 and prior periods, even though other parameters were subject to parameter limits. Some resource owners notified PJM that they needed extended notification times based on the claimed necessity for generation owners to nominate gas prior to gas nomination cycle deadlines.

The MMU observed instances when generators submitted temporary parameter exceptions based on claimed pipeline constraints even though these constraints are based on the nature of the transportation service that the generator procured from the pipeline. In some instances, generators requested temporary exceptions based on ratable take requirements stated in pipeline tariffs, even though the requirement is not enforced by the pipelines

on a routine basis. If a unit were to be dispatched uneconomically using the inflexible parameters, the unit would receive make whole payments based on these temporary exceptions. The MMU recommends that PJM not approve temporary exceptions that are based on pipeline tariff terms that are not routinely enforced or on inferior transportation service chosen by the generator.

Virtual Offers and Bids

There is a substantial volume of virtual offers and bids in the PJM Day-Ahead Energy Market and such offers and bids may be marginal.

Any market participant in the PJM Day-Ahead Energy Market can use increment offers, decrement bids, up to congestion transactions, import transactions and export transactions as financial instruments that do not require physical generation or load. Because virtual positions do not require physical generation or load, participants must buy or sell out of their virtual positions at real-time energy market prices. On February 20, 2018, FERC issued an order limiting the eligible bidding points for up to congestion transactions to hubs, interfaces and residual aggregate metered load nodes, and limiting the eligible bidding points for INCs and DECs to the same nodes plus active generation and load nodes.³⁵ Up to congestion transactions may be submitted between any two buses on a list of 47 buses eligible for up to congestion transaction bidding.³⁶ Import and export transactions may be submitted at any interface pricing point, where an import is equivalent to a virtual offer that is injected into PJM and an export is equivalent to a virtual bid that is withdrawn from PJM.

Figure 3-18 shows the PJM day-ahead daily aggregate supply curve of increment offers, the system aggregate supply curve of imports, the system aggregate supply curve without increment offers and imports, the system aggregate supply curve with increment offers, and the system aggregate supply curve with increment offers and imports for an example day in 2021.

³⁵ 162 FERC ¶ 61,139.

³⁶ Prior to November 1, 2012, market participants were required to specify an interface pricing point as the source for imports, an interface pricing point as the sink for exports or an interface pricing point as both the source and sink for transactions wheeling through PJM. For the list of eligible sources and sinks for up to congestion transactions, see www.pjm.com "OASIS-Source-Sink-Link.xls," <<http://www.pjm.com/~media/etools/oasis/references/oasis-source-sink-link.xls>>.

Figure 3-18 Day-ahead aggregate supply curves: 2021 example day

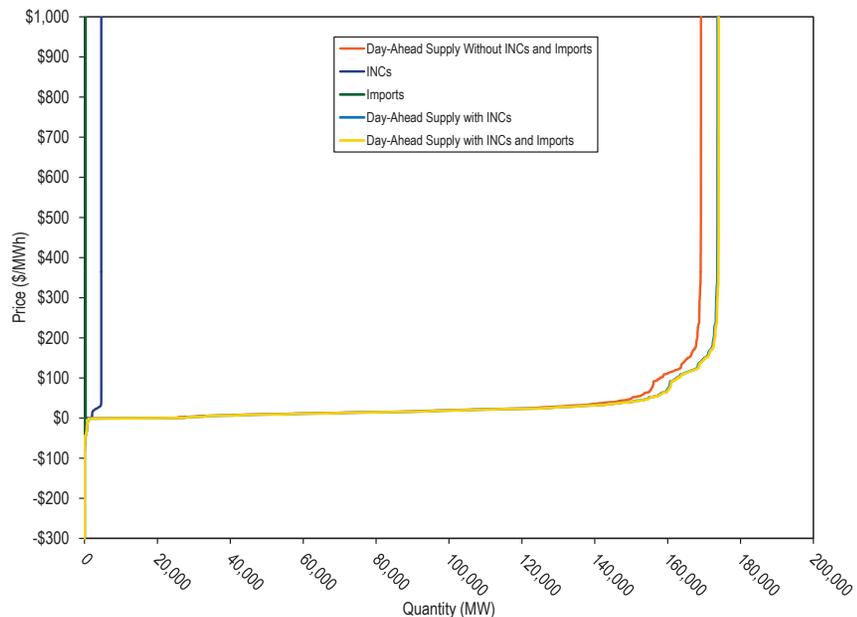


Table 3-19 Average hourly number of cleared and submitted INCs and DECs by month: January 2020 through March 2021

Year	Increment Offers				Decrement Bids			
	Average Cleared MW	Average Submitted MW	Average Cleared Volume	Average Submitted Volume	Average Cleared MW	Average Submitted MW	Average Cleared Volume	Average Submitted Volume
2020 Jan	2,684	6,395	261	1,063	2,547	5,856	187	662
2020 Feb	2,544	7,043	233	1,046	2,990	6,653	222	702
2020 Mar	2,435	7,119	258	1,069	3,203	7,688	251	762
2020 Apr	2,655	7,738	299	1,167	3,400	8,312	261	840
2020 May	2,695	6,931	254	1,050	4,361	8,257	307	814
2020 Jun	2,353	7,185	235	1,011	5,140	9,843	404	1,083
2020 Jul	2,247	6,936	252	1,071	5,515	11,233	436	1,293
2020 Aug	1,915	6,084	209	973	5,148	10,165	451	1,217
2020 Sep	2,472	6,486	254	1,150	5,217	9,414	468	1,156
2020 Oct	2,492	6,086	309	1,084	4,884	9,696	392	1,229
2020 Nov	2,505	7,000	277	1,125	4,612	9,570	335	1,037
2020 Dec	2,141	5,911	241	974	4,746	10,450	321	1,190
2020 Annual	2,427	6,737	257	1,065	4,318	8,937	337	1,000
2021 Jan	2,208	6,221	259	1,068	3,916	10,076	297	1,194
2021 Feb	2,078	5,476	264	972	5,123	11,556	280	1,303
2021 Mar	2,838	6,524	273	947	4,406	10,063	280	1,149
2021 Jan-Mar	2,385	6,093	265	997	4,460	10,532	286	1,212

Table 3-19 shows the hourly average number of cleared and submitted increment offers and decrement bids by month for 2020 and the first three months of 2021. The hourly average submitted increment MW decreased by 11.1 percent and cleared increment MW decreased by 6.6 percent in the first three months of 2021 compared to the first three months of 2020. The hourly average submitted decrement MW increased by 56.4 percent and cleared decrement MW increased by 53.1 percent in the first three months of 2021 compared to the first three months of 2020.

Table 3-20 shows the average hourly number of up to congestion transactions and the average hourly MW from by month in 2020 and the first three months of 2021. In the first three months of 2021, the average hourly submitted and cleared up to congestion MW decreased by 44.2 percent and 55.2 percent, compared to the first three months of 2020.

Table 3-20 Average hourly cleared and submitted up to congestion bids by month: January 2020 through March 2021

		Up to Congestion			
Year		Average Cleared MW	Average Submitted MW	Average Cleared Volume	Average Submitted Volume
2020	Jan	19,106	37,533	1,127	2,087
2020	Feb	19,415	40,281	1,100	2,133
2020	Mar	19,513	40,998	990	1,970
2020	Apr	18,267	37,298	955	1,859
2020	May	18,028	41,503	1,122	2,425
2020	Jun	23,038	59,520	1,403	2,726
2020	Jul	21,014	64,376	1,227	2,539
2020	Aug	22,478	63,368	1,159	2,306
2020	Sep	22,900	65,866	1,136	2,315
2020	Oct	19,587	55,904	933	1,957
2020	Nov	8,667	21,141	578	1,053
2020	Dec	7,156	17,968	526	942
2020	Annual	18,257	45,501	1,021	2,026
2021	Jan	7,277	20,412	546	1,062
2021	Feb	10,354	23,732	691	1,227
2021	Mar	8,776	24,571	548	1,087
2021	Jan-Mar	8,751	22,876	592	1,122

Table 3-21 shows the average hourly number of day-ahead import and export transactions and the average hourly MW from January 2020 through March 2021. In the first three months of 2021, the average hourly submitted and cleared import transaction MW decreased by 9.2 and 9.3 percent, and the average hourly submitted and cleared export transaction MW increased by 12.0 and 10.7 percent, compared to the first three months of 2020.

Table 3-21 Hourly average day-ahead number of cleared and submitted import and export transactions by month: January 2020 through March 2021

		Imports				Exports			
Year	Month	Average Cleared MW	Average Submitted MW	Average Cleared Volume	Average Submitted Volume	Average Cleared MW	Average Submitted MW	Average Cleared Volume	Average Submitted Volume
2020	Jan	427	445	5	6	3,034	3,041	28	28
2020	Feb	324	346	4	5	2,737	2,742	29	29
2020	Mar	254	269	3	4	3,084	3,085	27	27
2020	Apr	173	188	2	3	3,057	3,062	25	25
2020	May	207	231	3	4	3,075	3,080	23	23
2020	Jun	159	152	2	2	3,782	3,798	31	31
2020	Jul	83	112	2	2	3,907	3,922	31	31
2020	Aug	100	128	2	2	3,909	3,920	29	29
2020	Sep	118	115	2	2	3,424	3,448	28	28
2020	Oct	171	164	2	2	3,268	3,231	26	26
2020	Nov	189	199	2	2	3,158	3,182	32	32
2020	Dec	173	180	2	2	3,106	3,113	31	31
2020	Annual	215	223	3	3	3,298	3,304	28	28
2021	Jan	389	408	4	4	2,854	2,862	30	30
2021	Feb	267	285	3	4	4,581	4,658	41	42
2021	Mar	250	266	2	3	2,493	2,542	27	28
2021	Jan-Mar	304	321	3	4	3,267	3,311	32	33

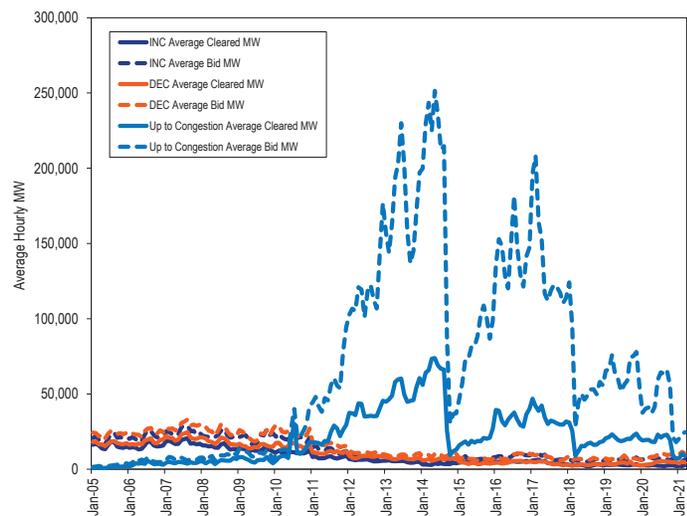
Table 3-22 shows the frequency with which generation offers, import or export transactions, up to congestion transactions, decrement bids, increment offers and price-sensitive demand were marginal in January 2020 through March 2021. The frequency of marginal up to congestion transactions decreased significantly in November 2020, due to decreased UTC activity beginning November 1, 2020, when FERC required UTCs to pay uplift.³⁷

Table 3-22 Type of day-ahead marginal resources: January 2020 through March 2021

	2020						2021					
	Generation	Dispatchable Transaction	Up to Congestion Transaction	Decrement Bid	Increment Offer	Price Sensitive Demand	Generation	Dispatchable Transaction	Up to Congestion Transaction	Decrement Bid	Increment Offer	Price Sensitive Demand
Jan	27.7%	0.1%	44.7%	10.6%	16.9%	0.0%	23.1%	0.1%	35.7%	24.2%	16.9%	0.0%
Feb	20.7%	0.1%	48.5%	12.5%	18.2%	0.0%	20.3%	0.4%	45.1%	23.1%	11.1%	0.0%
Mar	19.5%	0.0%	52.2%	14.7%	13.6%	0.0%	18.9%	0.1%	33.9%	26.5%	20.6%	0.0%
Apr	18.2%	0.0%	49.3%	16.6%	15.9%	0.0%						
May	16.6%	0.1%	55.2%	15.2%	13.0%	0.0%						
Jun	14.1%	0.0%	60.8%	15.5%	9.6%	0.0%						
Jul	11.8%	0.1%	57.4%	20.4%	10.3%	0.0%						
Aug	10.5%	0.0%	55.3%	24.9%	9.2%	0.0%						
Sep	13.1%	0.1%	54.8%	21.9%	10.1%	0.0%						
Oct	14.7%	0.2%	58.2%	15.0%	12.0%	0.0%						
Nov	21.0%	0.1%	27.6%	27.1%	24.2%	0.0%						
Dec	20.8%	0.2%	32.7%	30.7%	15.5%	0.0%						
Annual	16.5%	0.1%	51.4%	18.8%	13.2%	0.0%	20.5%	0.2%	37.7%	24.8%	16.7%	0.0%

Figure 3-19 shows the monthly volume of bid and cleared INC, DEC and up to congestion bids by month from 2005 through March 2021.

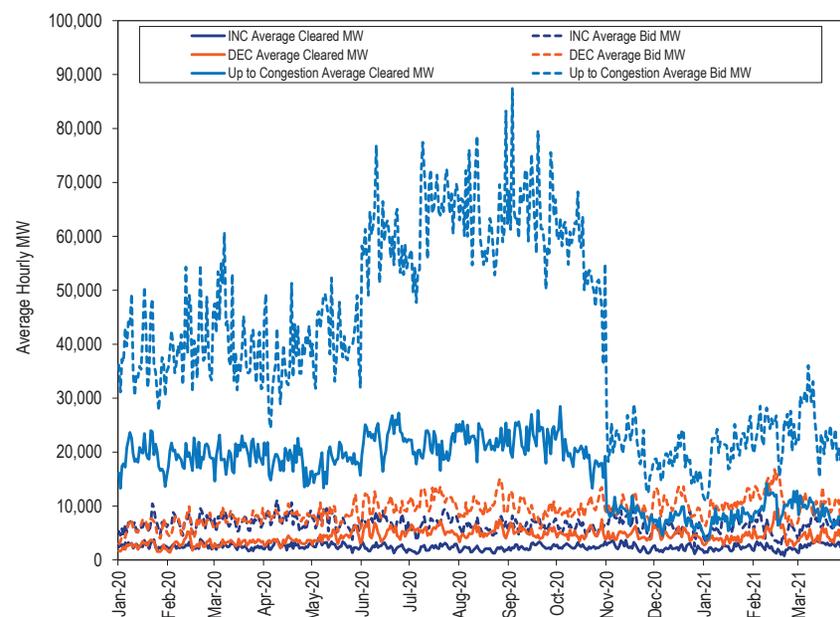
Figure 3-19 Monthly bid and cleared INCs, DECs and UTCs (MW): January 2005 through March 2021



37 172 FERC ¶ 61,046 (2020).

Figure 3-20 shows the daily volume of bid and cleared INC, DEC and up to congestion bids from January 2020 through March 2021.

Figure 3-20 Daily bid and cleared INCs, DECs, and UTCs (MW): January 2020 through March 2021



In order to evaluate the ownership of virtual bids, the MMU categorizes all participants making virtual bids in PJM as either physical or financial. Physical entities include utilities and customers which primarily take physical positions in PJM markets. Financial entities include banks and hedge funds which primarily take financial positions in PJM markets. International market participants that primarily take financial positions in PJM markets are generally considered to be financial entities even if they are utilities in their own countries.

Table 3-23 shows, in the first three months of 2020 and 2021, the total increment offers and decrement bids and cleared MW by type of parent organization.

Table 3-23 INC and DEC bids and cleared MWh by type of parent organization (MWh): January through March, 2020 and 2021

Category	2020 (Jan-Mar)				2021 (Jan-Mar)			
	Total Virtual Bid MWh	Percent	Total Virtual Cleared MWh	Percent	Total Virtual Bid MWh	Percent	Total Virtual Cleared MWh	Percent
Financial	25,788,889	87.0%	9,975,978	83.7%	32,449,539	90.5%	12,051,971	81.7%
Physical	3,837,803	13.0%	1,940,141	16.3%	3,417,488	9.5%	2,705,715	18.3%
Total	29,626,693	100.0%	11,916,118	100.0%	35,867,027	100.0%	14,757,686	100.0%

Table 3-24 shows, in the first three months of 2020 and 2021, the total up to congestion bids and cleared MWh by type of parent organization.

Table 3-24 Up to congestion transactions by type of parent organization (MWh): January through March, 2020 and 2021

Category	2020 (Jan-Mar)				2021 (Jan-Mar)			
	Total Up to Congestion Bid MWh	Percent	Total Up to Congestion Cleared MWh	Percent	Total Up to Congestion Bid MWh	Percent	Total Up to Congestion Cleared MWh	Percent
Financial	80,442,957	93.1%	38,566,131	91.3%	42,594,309	86.2%	15,888,559	84.1%
Physical	5,978,558	6.9%	3,659,602	8.7%	6,795,980	13.8%	3,004,317	15.9%
Total	86,421,514	100.0%	42,225,733	100.0%	49,390,289	100.0%	18,892,875	100.0%

Table 3-25 shows, in the first three months of 2020 and 2021, the total import and export transactions by whether the parent organization was financial or physical.

Table 3-25 Import and export transactions by type of parent organization (MW): January through March, 2020 and 2021

		2020 (Jan-Mar)		2021 (Jan-Mar)	
Category		Total Import and Export MW	Percent	Total Import and Export MW	Percent
Day-Ahead	Financial	2,085,351	29.0%	2,835,007	37.2%
	Physical	5,099,457	71.0%	4,787,035	62.8%
	Total	7,184,808	100.0%	7,622,043	100.0%
Real-Time	Financial	3,434,767	28.6%	3,857,607	27.8%
	Physical	8,589,992	71.4%	9,999,478	72.2%
	Total	12,024,759	100.0%	13,857,085	100.0%

Table 3-26 shows increment offers and decrement bids by top 10 locations in the first three months of 2020 and 2021.

Table 3-26 Virtual offers and bids by top 10 locations (MW): January through March, 2020 and 2021

2020 (Jan-Mar)					2021 (Jan-Mar)				
Aggregate/Bus Name	Aggregate/Bus Type	INC MW	DEC MW	Total MW	Aggregate/Bus Name	Aggregate/Bus Type	INC MW	DEC MW	Total MW
MISO	INTERFACE	14,445	1,169,382	1,183,827	MISO	INTERFACE	61,707	1,475,257	1,536,964
WESTERN HUB	HUB	167,868	467,388	635,255	WESTERN HUB	HUB	172,446	425,322	597,768
BGE_RESID_AGG	RESIDUAL METERED EDC	78,576	272,351	350,927	LINDENVFT	INTERFACE	11,964	564,232	576,196
SOUTHIMP	INTERFACE	350,635	0	350,635	AEP-DAYTON HUB	HUB	92,378	340,778	433,156
AEP-DAYTON HUB	HUB	94,756	226,372	321,128	DOM_RESID_AGG	RESIDUAL METERED EDC	48,394	349,022	397,416
DOM_RESID_AGG	RESIDUAL METERED EDC	56,211	237,552	293,762	NYIS	INTERFACE	155,196	233,200	388,396
PECO_RESID_AGG	RESIDUAL METERED EDC	211,336	47,647	258,983	N ILLINOIS HUB	HUB	103,545	258,721	362,266
NORTHWEST	INTERFACE	170,458	69,208	239,666	HUDSONTP	INTERFACE	9,147	311,858	321,005
NYIS	INTERFACE	188,901	16,389	205,290	BGE_RESID_AGG	RESIDUAL METERED EDC	42,126	259,687	301,813
N ILLINOIS HUB	HUB	67,208	129,870	197,078	COMED_RESID_AGG	RESIDUAL METERED EDC	86,793	194,125	280,918
Top ten total		1,400,393	2,636,158	4,036,551			783,695	4,412,203	5,195,898
PJM total		5,576,998	6,355,354	11,932,352			5,148,445	9,629,638	14,778,083
Top ten total as percent of PJM total		25.1%	41.5%	33.8%			15.2%	45.8%	35.2%

Table 3-27 shows up to congestion transactions for the top 10 source and sink pairs and associated source, sink and overall profits at each path in the first three months of 2020 and 2021. While the total cleared MW was much lower in the first three months of 2021 compared to the first three months of 2020, total profits were higher in the first three months of 2021. The NIPSCO Interface was eliminated effective June 1, 2020. The NORTHWEST Interface was eliminated effective October 1, 2020. Before the elimination of these interface, trades located at these two nodes were among the largest sources of revenue for up-to congestion transactions in 2020.³⁸

Table 3-27 Cleared up to congestion bids by top 10 source and sink pairs (MW): January through March, 2020 and 2021

2020 (Jan-Mar)							
Top 10 Paths by Cleared MW							
Source	Source Type	Sink	Sink Type	MW	Source Profit	Sink Profit	UTC Profit
NORTHWEST	INTERFACE	N ILLINOIS HUB	HUB	1,574,058	\$1,328,622	(\$768,663)	\$559,959
SMECO_RESID_AGG	AGGREGATE	BGE_RESID_AGG	AGGREGATE	1,200,986	\$590,728	(\$650,182)	(\$59,454)
NORTHWEST	INTERFACE	COMED_RESID_AGG	AGGREGATE	1,176,513	\$1,160,149	(\$553,878)	\$606,271
AEP GEN HUB	HUB	AEPOHIO_RESID_AGG	AGGREGATE	1,167,229	\$669,595	(\$647,868)	\$21,727
COMED_RESID_AGG	AGGREGATE	NIPSCO	INTERFACE	946,486	\$1,012,324	(\$926,318)	\$86,005
OVEC_RESID_AGG	AGGREGATE	DEOK_RESID_AGG	AGGREGATE	797,813	\$463,922	(\$478,652)	(\$14,731)
NORTHWEST	INTERFACE	CHICAGO GEN HUB	HUB	797,190	\$742,282	(\$447,924)	\$294,358
NORTHWEST	INTERFACE	MISO	INTERFACE	681,539	\$900,044	(\$480,500)	\$419,545
AEP GEN HUB	HUB	EKPC_RESID_AGG	AGGREGATE	651,478	\$408,650	(\$313,382)	\$95,268
OVEC_RESID_AGG	AGGREGATE	DAY_RESID_AGG	AGGREGATE	643,826	\$258,214	(\$298,187)	(\$39,973)
Top ten total				9,637,117	\$7,534,530	(\$5,565,554)	\$1,968,976
PJM total				40,575,453	\$19,081,736	(\$14,198,871)	\$4,882,865
Top ten total as percent of PJM total				23.8%	39.5%	39.2%	40.3%
2021 (Jan-Mar)							
Top 10 Paths by Cleared MW							
Source	Source Type	Sink	Sink Type	MW	Source Profit	Sink Profit	UTC Profit
COMED_RESID_AGG	AGGREGATE	AEPIIM_RESID_AGG	AGGREGATE	1,160,592	\$1,224,676	(\$456,153)	\$768,523
AEP GEN HUB	HUB	EKPC_RESID_AGG	AGGREGATE	763,961	\$915,432	(\$35,766)	\$879,666
CHICAGO GEN HUB	HUB	MISO	INTERFACE	479,012	(\$221,029)	\$454,093	\$233,064
SMECO_RESID_AGG	AGGREGATE	BGE_RESID_AGG	AGGREGATE	408,798	\$705,464	(\$395,991)	\$309,472
CHICAGO GEN HUB	HUB	AEPIIM_RESID_AGG	AGGREGATE	403,268	\$221,693	(\$164,658)	\$57,034
MISO	INTERFACE	AEPIIM_RESID_AGG	AGGREGATE	376,892	\$549,995	\$23,733	\$573,728
CHICAGO GEN HUB	HUB	EKPC_RESID_AGG	AGGREGATE	368,747	\$393,515	(\$58,131)	\$335,384
AEP GEN HUB	HUB	MISO	INTERFACE	363,605	\$674,349	\$78,446	\$752,796
N ILLINOIS HUB	HUB	AEPIIM_RESID_AGG	AGGREGATE	323,492	\$144,257	\$187,474	\$331,731
COMED_RESID_AGG	AGGREGATE	PSEG_RESID_AGG	AGGREGATE	318,914	\$747,899	(\$196,328)	\$551,571
Top ten total				4,967,280	\$5,356,251	(\$563,281)	\$4,792,970
PJM total				18,892,875	\$19,723,708	\$1,728,115	\$21,451,822
Top ten total as percent of PJM total				26.3%	27.2%	(32.6%)	22.3%

³⁸ The source and sink aggregates in these tables refer to the name and location of a bus and do not include information about the behavior of any individual market participant.

Table 3-28 shows the average daily number of source-sink pairs that were offered and cleared each month from January 2020 through March 2021.

Table 3-28 Number of offered and cleared source and sink pairs: January 2020 through March 2021

Daily Number of Source-Sink Pairs						
Year	Month	Average Offered	Max Offered	Average Cleared	Max Cleared	
2020	Jan	1,658	1,942	1,523	1,857	
2020	Feb	1,710	1,975	1,568	1,725	
2020	Mar	1,789	2,013	1,591	1,832	
2020	Apr	1,804	1,978	1,567	1,760	
2020	May	1,913	2,126	1,681	1,900	
2020	Jun	1,974	2,111	1,803	2,020	
2020	Jul	1,886	2,085	1,749	1,970	
2020	Aug	1,760	1,993	1,575	1,854	
2020	Sep	1,656	1,851	1,498	1,641	
2020	Oct	1,544	1,689	1,358	1,525	
2020	Nov	1,306	1,497	1,203	1,387	
2020	Dec	1,305	1,508	1,184	1,359	
2020	Annual	1,692	1,897	1,525	1,736	
2021	Jan	1,286	1,470	1,132	1,302	
2021	Feb	1,303	1,514	1,210	1,449	
2021	Mar	1,314	1,542	1,189	1,386	
2021	Jan-Mar	1,301	1,509	1,177	1,379	

Table 3-29 and Figure 3-21 show total cleared up to congestion transactions and share of the top 10 up to congestion paths by transaction type (import, export, or internal) in the first three months of 2020 and 2021. Total up to congestion transactions decreased by 55.2 percent from 42.2 million MWh in the first three months of 2020 to 18.9 million MWh in the first three months of 2021. Internal up to congestion transactions in the first three months of 2021 were 75.7 percent of all up to congestion transactions compared to 63.0 percent in the first three months of 2020.

Table 3-29 Cleared up to congestion transactions and share of top 10 paths by type (MW): January through March, 2020 and 2021

2020 (Jan-Mar)					
	Cleared Up to Congestion Bids				
	Import	Export	Wheel	Internal	Total
Top ten total (MW)	5,711,376	3,290,830	2,450,213	7,146,482	18,598,902
PJM total (MW)	8,369,907	4,636,874	2,626,014	26,592,938	42,225,733
Top ten total as percent of PJM total	68.2%	71.0%	93.3%	26.9%	44.0%
PJM total as percent of all up to congestion transactions	19.8%	11.0%	6.2%	63.0%	100.0%
2021 (Jan-Mar)					
	Cleared Up to Congestion Bids				
	Import	Export	Wheel	Internal	Total
Top ten total (MW)	1,107,711	1,766,200	257,059	4,447,442	7,578,412
PJM total (MW)	1,761,524	2,543,242	292,749	14,295,360	18,892,875
Top ten total as percent of PJM total	62.9%	69.4%	87.8%	31.1%	40.1%
PJM total as percent of all up to congestion transactions	9.3%	13.5%	1.5%	75.7%	100.0%

Figure 3-21 shows the initial increase and continued increase in internal up to congestion transactions by month following the November 1, 2012, rule change permitting such transactions, until September 8, 2014. The reduction in up to congestion transactions (UTC) that followed a FERC order setting September 8, 2014, as the effective date for any uplift charges subsequently assigned to UTCs, was reversed.³⁹ There was an increase in up to congestion volume as a result of the expiration of the 15 month refund period for the proceeding related to uplift charges for UTC transactions. In 2018, total UTC activity and the percent of marginal up to congestion transactions again decreased significantly as the result of a FERC order issued on February 20, 2018, and implemented on February 22, 2018.⁴⁰ The order limited UTC trading to hubs, residual metered load, and interfaces. UTC activity increased following that reduction. UTC activity decreased again beginning November 1, 2020, after a FERC order requiring UTCs to pay day-ahead and balancing operating reserve charges equivalent to a DEC at the UTC sink point became effective on that date.⁴¹

³⁹ See 162 FERC ¶ 61,139 (2018).

⁴⁰ *Id.*

⁴¹ See 172 FERC ¶ 61,046 (2020).

Figure 3-21 Monthly cleared up to congestion transactions by type (MW): January 2005 through March 2021

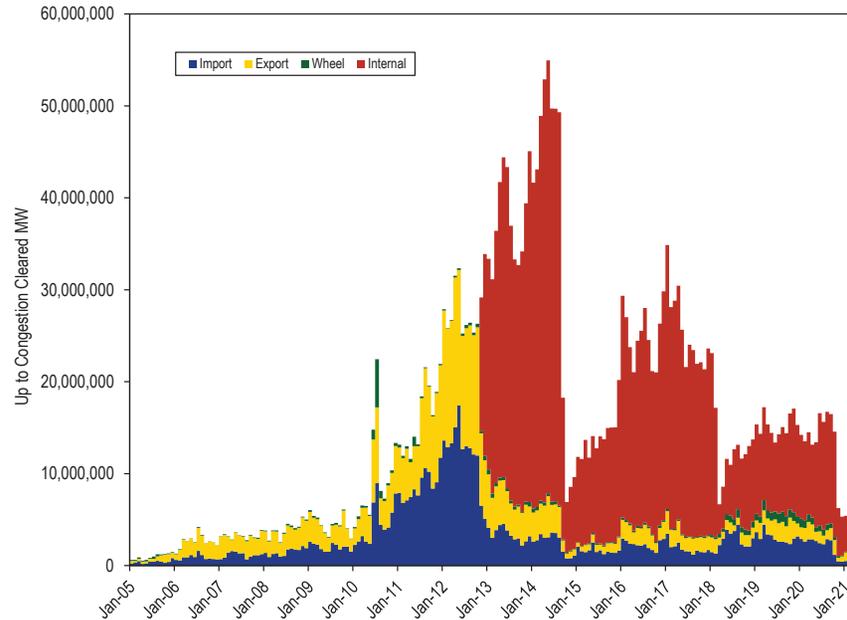
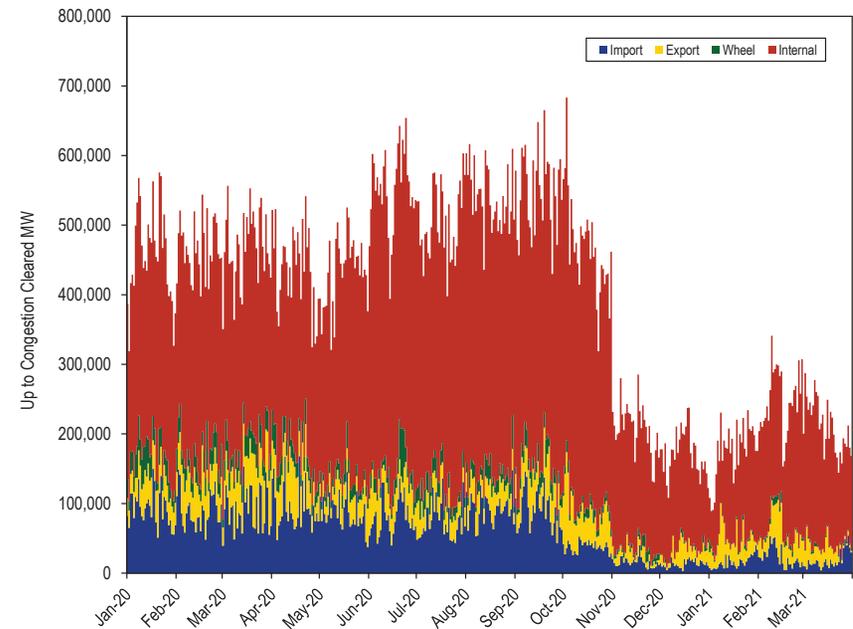


Figure 3-22 shows the daily cleared up to congestion MW by transaction type from January 1, 2020 through March 31, 2021.

Figure 3-22 Daily cleared up to congestion transaction by type (MW): January 2020 through March 2021



One of the goals of the February 2018 FERC order accepting PJM's proposal limiting UTC bidding to hubs, interfaces and residual aggregate metered load nodes, and limiting INC and DEC bidding to the same nodes plus active generation nodes, was to limit the opportunities for traders to profit from opportunities for false arbitrage in which price spreads between the day-ahead and real-time energy markets result from differences in the models used to operate each market that cannot be corrected through virtual bidding.⁴²

⁴² PJM Interconnection, LLC, "Proposed Revisions To Reduce Bidding Points for Virtual Transactions," Docket No. ER18-88, October 17, 2017 at 9-10: "Discrepancies between the models can occur for various reasons despite PJM's best attempts to minimize them...Because individual nodes are more highly impacted by modeling discrepancies than aggregated locations due to averaging, they are often locations where Virtual Transactions can profit. Profits collected by Virtual Transactions in these cases lead to additional costs for PJM members without any benefits."

A key assumption underlying the February 2018 order is that the limited set of nodes available for virtual trading is sufficiently protected from false arbitrage trades because price spreads resulting from modeling differences between the day-ahead and real-time markets are mitigated by the averaging of prices over a large number of buses at aggregate nodes.⁴³ This assumption is not correct, given the large share of INC, DEC, and UTC profits still attributable to modeling or operational differences between day-ahead and real-time since the February 2018 order.

The assumption that modeling differences are averaged out over aggregate nodes does not hold for multiple nodes in the current list of available up to congestion bidding nodes. The MMU recommends eliminating up to congestion (UTC) bidding at pricing nodes that aggregate only small sections of transmission zones with few physical assets. For this reason, the MMU recommends eliminating UTC bidding at the following nodes: DPLEASTON_RESID_AGG, PENNPOWER_RESID_AGG, UGI_RESID_AGG, SMECO_RESID_AGG, AEPKY_RESID_AGG, and VINELAND_RESID_AGG.

Prices at larger aggregate nodes can also be affected by transmission constraints, especially when constraints are violated and transmission penalty factors are applied in the real-time energy market. Even when the same constraints are modeled in day ahead and real time, constraint violations in real time may result from differences in the day ahead and real time operational environments such as intra hourly ramping limitations, changes to constraint limits, and unit commitments and decommitments. Price spreads due to modeling or operational differences can be in the tens to hundreds of dollars, even when averaged over an aggregate node, and may persist for days or weeks. Virtual traders can often identify and profit from price spreads resulting from systematic modeling and operational differences between day ahead and real time affecting specific generators or aggregate nodes. The MMU recommends eliminating INC, DEC, and UTC bidding at pricing nodes that allow market participants to profit from modeling issues.

⁴³ 162 FERC ¶ 61,139 at PP 35–36: “We accept PJM’s proposal to limit eligible bidding points for UTCs to hubs, residual metered load, and interfaces. First, we agree with the IMM’s statement that PJM’s proposal to limit the UTC bid locations to interfaces, zones, and hubs will minimize false arbitrage opportunities for UTCs currently being pursued through penny bids, as the effect of modeling differences between the day-ahead and real-time markets are minimized at these aggregates.”

Market Performance

PJM locational marginal prices (LMPs) are a direct measure of market performance. The market performs optimally when the market structure provides incentives for market participants to behave competitively. In a competitive market, prices equal the short run marginal cost of the marginal unit of output and reflect the most efficient and least cost allocation of resources to meet demand.

LMP

The behavior of individual market entities within a market structure is reflected in market prices. PJM locational marginal prices (LMPs) are a direct measure of market performance. Price level is a good, general indicator of market performance, although overall price results must be interpreted carefully because of the multiple factors that affect them. Among other things, overall average prices reflect changes in supply and demand, generation fuel mix, the cost of fuel, emission related expenses, markup and local price differences caused by congestion. PJM also may administratively set prices with the creation of a closed loop interface related to demand side resources, surrogate constraints for reactive power and generator stability, or influence prices through manual interventions such as load biasing, changing constraint limits and penalty factors, and committing reserves beyond the requirement.

Real-time and day-ahead energy market load-weighted prices were 55.3 percent and 57.0 percent higher in the first three months of 2021 compared to the same time period of 2020.

The average real-time LMP in the first three months of 2021 increased 53.4 percent from the first three months of 2020, from \$19.42 per MWh to \$29.78 per MWh. The load-weighted average real-time LMP in the first three months of 2021 increased 55.3 percent from the first three months of 2020, from \$19.85 per MWh to \$30.84 per MWh.

The, load-weighted average real-time LMP for the first three months of 2021 was 51.9 percent lower than the fuel-cost adjusted, load-weighted, average

real-time LMP for the first three months of 2021. If fuel and emission costs in the first three months of 2021 had been the same as in the first three months of 2020, holding everything else constant, the load-weighted LMP would have been lower, \$20.30 per MWh instead of the observed \$30.84 per MWh.

The average day-ahead LMP in the first three months of 2021 increased 54.0 percent from the first three months of 2020, from \$19.66 per MWh to \$30.28 per MWh. The load-weighted average day-ahead LMP increased 57.0 percent from the first three months of 2020, from \$20.12 per MWh to \$31.58 per MWh.

Occasionally, in a constrained market, the LMPs at some pricing nodes can exceed the offer price of the highest cleared generator in the supply curve.⁴⁴ In the nodal pricing system, the LMP at a pricing node is the total cost of meeting incremental demand at that node. When there are binding transmission constraints, satisfying the marginal increase in demand at a node may require increasing the output of some generators while simultaneously decreasing the output of other generators, such that the transmission constraints are not violated. The total cost of redispatching multiple generators can at times exceed the cost of marginally increasing the output of the most expensive generator offered. Thus, the LMPs at some pricing nodes exceed \$1,000 per MWh, the cap on the generators' offer price in the PJM market.⁴⁵

LMP may, at times, be set by transmission penalty factors, which exceed \$1,000 per MWh. When a transmission constraint is binding and there are no generation alternatives to resolve the constraint, the transmission limits may be violated in the market dispatch solution. When this occurs, the shadow price of the constraint is set by transmission penalty factors. The shadow price directly affects the LMP. Transmission penalty factors are administratively determined and can be thought of as a form of locational scarcity pricing.

Real-Time Average LMP

Real-time, average LMP is the hourly average LMP for the PJM Real-Time Energy Market.⁴⁶

PJM Real-Time, Average LMP

Table 3-30 shows the PJM real-time, average LMP for the first three months of 1998 through 2021.⁴⁷

Table 3-30 Real-time, average LMP (Dollars per MWh): January through March, 1998 through 2021

(Jan-Mar)	Real-Time LMP			Year to Year Change		
	Average	Median	Standard Deviation	Average	Median	Standard Deviation
1998	\$17.51	\$15.30	\$7.84	NA	NA	NA
1999	\$18.79	\$16.56	\$7.29	7.3%	8.3%	(7.0%)
2000	\$23.66	\$17.73	\$16.22	25.9%	7.0%	122.4%
2001	\$33.77	\$26.01	\$20.79	42.8%	46.8%	28.2%
2002	\$22.23	\$19.22	\$9.61	(34.2%)	(26.1%)	(53.8%)
2003	\$49.57	\$43.08	\$30.54	123.0%	124.2%	217.9%
2004	\$46.37	\$41.04	\$24.07	(6.5%)	(4.8%)	(21.2%)
2005	\$46.51	\$40.62	\$22.07	0.3%	(1.0%)	(8.3%)
2006	\$52.98	\$46.15	\$23.29	13.9%	13.6%	5.5%
2007	\$55.34	\$47.15	\$33.29	4.5%	2.2%	43.0%
2008	\$66.75	\$57.05	\$35.54	20.6%	21.0%	6.8%
2009	\$47.29	\$40.56	\$21.99	(29.2%)	(28.9%)	(38.1%)
2010	\$44.13	\$37.82	\$21.87	(6.7%)	(6.8%)	(0.6%)
2011	\$44.76	\$38.14	\$23.10	1.4%	0.8%	5.6%
2012	\$30.38	\$28.82	\$11.63	(32.1%)	(24.4%)	(49.7%)
2013	\$36.33	\$32.29	\$18.47	19.6%	12.1%	58.9%
2014	\$84.04	\$48.77	\$119.84	131.3%	51.0%	548.8%
2015	\$47.39	\$31.95	\$42.42	(43.6%)	(34.5%)	(64.6%)
2016	\$25.60	\$22.91	\$12.99	(46.0%)	(28.3%)	(69.4%)
2017	\$29.39	\$25.71	\$12.28	14.8%	12.2%	(5.4%)
2018	\$44.65	\$26.83	\$49.68	51.9%	4.4%	304.5%
2019	\$29.13	\$25.36	\$15.09	(34.8%)	(5.5%)	(69.6%)
2020	\$19.42	\$18.56	\$6.98	(33.3%)	(26.8%)	(53.8%)
2021	\$29.78	\$23.66	\$23.91	53.4%	27.5%	242.6%

44 See O'Neill R. P, Mead D. and Malvadkar P. "On Market Clearing Prices Higher than the Highest Bid and Other Almost Paranormal Phenomena." *The Electricity Journal* 2005; 18(2) at 19-27.

45 The offer cap in PJM was temporarily increased to \$1,800 per MWh prior to the winter of 2014/2015. A new cap of \$2,000 per MWh, only for offers with costs exceeding \$1,000 per MWh, went into effect on December 14, 2015. See 153 FERC ¶ 61,289 (2015).

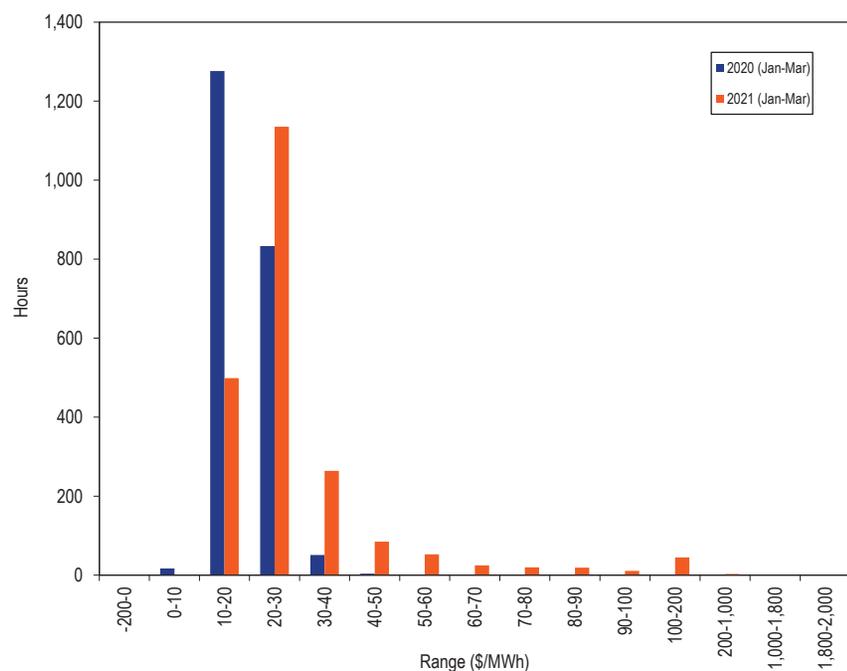
46 See the *Technical Reference for PJM Markets*, at "Calculating Locational Marginal Price," p 16-18 for detailed definition of Real-Time LMP. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

47 The system average LMP is the average of the hourly LMP without any weighting. The only exception is that market-clearing prices (MCPs) are included for January to April 1998. MCP was the single market-clearing price calculated by PJM prior to implementation of LMP.

PJM Real-Time Average LMP Duration

Figure 3-23 shows the hourly distribution of PJM real-time, average LMP for the first three months of 2020 and 2021. There were 1,278 hours with an average LMP between the \$10 to \$20 per MWh in the first three months of 2020, but only 499 hours were in the same range in the first three months of 2021.

Figure 3-23 Average LMP for the real-time energy market: January through March, 2020 and 2021



Real-Time, Load-Weighted, Average LMP

Higher demand (load) generally results in higher prices, all else constant. As a result, load-weighted, average prices are generally higher than average prices. Load-weighted LMP reflects the average LMP paid for actual MWh consumed during a year. Load-weighted, average LMP is the average of PJM hourly LMP, each weighted by the PJM total hourly load.

PJM Real-Time, Load-Weighted, Average LMP

Table 3-31 shows the PJM real-time, load-weighted, average LMP for the first three months of 1998 through 2021.

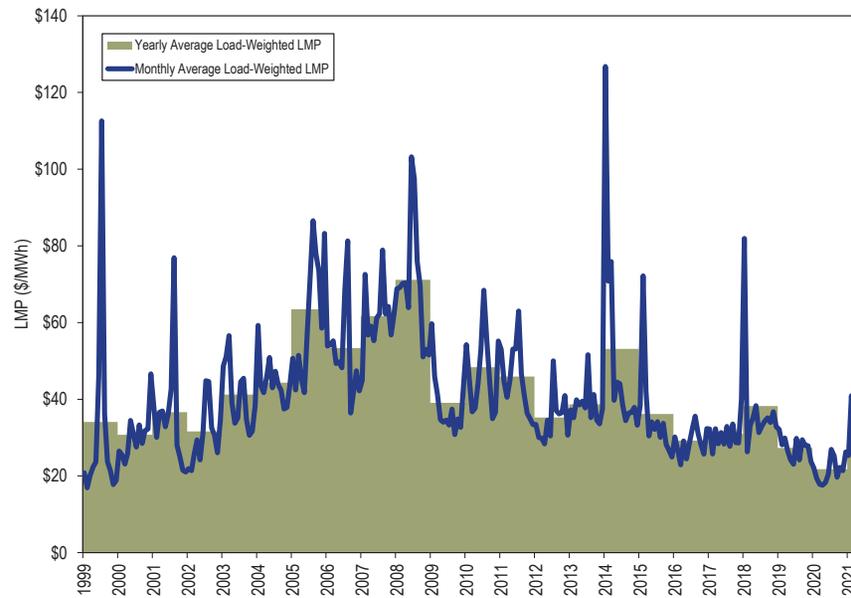
Table 3-31 Real-time, load-weighted, average LMP (Dollars per MWh): January through March, 1998 through 2021

(Jan-Mar)	Real-Time, Load-Weighted, Average LMP			Year to Year Change		
	Average	Median	Standard Deviation	Average	Median	Standard Deviation
1998	\$18.13	\$15.80	\$8.14	NA	NA	NA
1999	\$19.38	\$16.90	\$7.66	6.9%	7.0%	(5.9%)
2000	\$25.10	\$18.25	\$17.22	29.5%	8.0%	124.9%
2001	\$35.16	\$27.38	\$21.52	40.1%	50.0%	25.0%
2002	\$23.01	\$19.89	\$9.93	(34.6%)	(27.4%)	(53.8%)
2003	\$51.93	\$46.12	\$30.99	125.6%	131.9%	211.9%
2004	\$48.77	\$43.22	\$24.62	(6.1%)	(6.3%)	(20.6%)
2005	\$48.37	\$42.20	\$22.62	(0.8%)	(2.4%)	(8.1%)
2006	\$54.43	\$47.62	\$23.69	12.5%	12.9%	4.7%
2007	\$58.07	\$50.60	\$34.44	6.7%	6.3%	45.4%
2008	\$69.35	\$60.11	\$36.56	19.4%	18.8%	6.2%
2009	\$49.60	\$42.23	\$23.38	(28.5%)	(29.8%)	(36.1%)
2010	\$45.92	\$39.01	\$22.99	(7.4%)	(7.6%)	(1.7%)
2011	\$46.35	\$39.11	\$24.26	0.9%	0.3%	5.5%
2012	\$31.21	\$29.25	\$12.02	(32.7%)	(25.2%)	(50.5%)
2013	\$37.41	\$32.79	\$19.90	19.9%	12.1%	65.7%
2014	\$92.98	\$51.62	\$134.40	148.5%	57.4%	575.3%
2015	\$50.91	\$33.51	\$46.43	(45.2%)	(35.1%)	(65.5%)
2016	\$26.80	\$23.45	\$13.98	(47.4%)	(30.0%)	(69.9%)
2017	\$30.28	\$26.26	\$13.08	13.0%	12.0%	(6.4%)
2018	\$49.45	\$27.96	\$55.22	63.3%	6.5%	322.1%
2019	\$30.16	\$25.84	\$16.18	(39.0%)	(7.6%)	(70.7%)
2020	\$19.85	\$18.87	\$7.20	(34.2%)	(27.0%)	(55.5%)
2021	\$30.84	\$24.13	\$24.58	55.3%	27.9%	241.3%

PJM Real-Time, Monthly, Load-Weighted, Average LMP

Figure 3-24 shows the PJM real-time monthly and annual load-weighted LMP for January 1999 through March 2021.

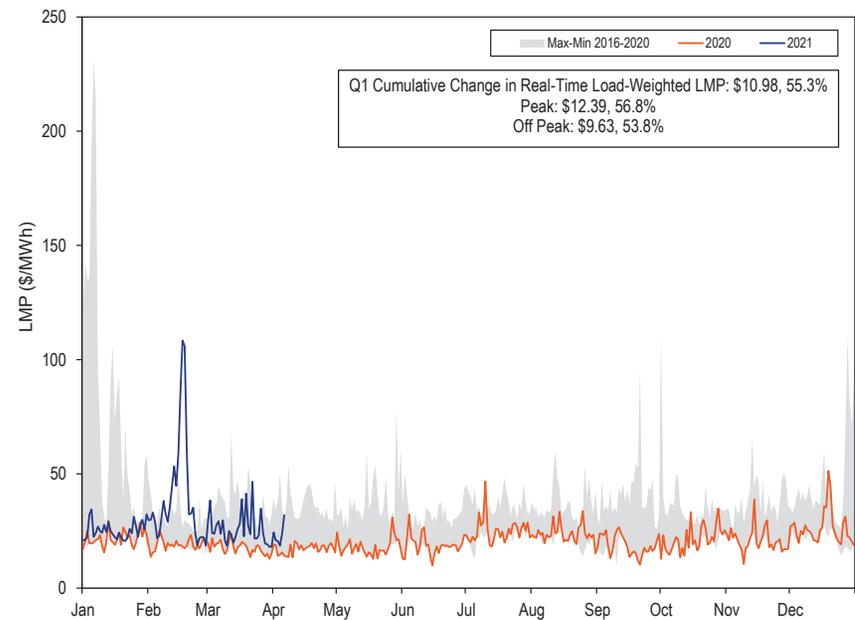
Figure 3-24 Real-time, monthly and annual, load-weighted, average LMP: January 1999 through March 2021



PJM Real-Time, Daily, Load-Weighted, Average LMP

Figure 3-25 shows the PJM real-time, daily, load-weighted LMP for 2020 through the first three months of 2021.

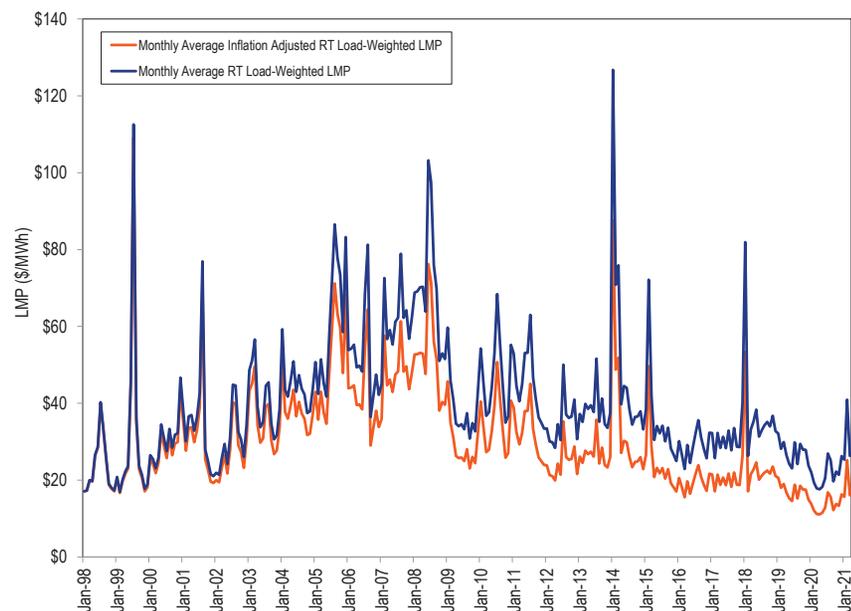
Figure 3-25 Real-time, daily, load-weighted, average LMP: January 2020 through March 2021



PJM Real-Time, Monthly, Inflation Adjusted Load-Weighted, Average LMP

Figure 3-26 shows the PJM real-time, monthly, load-weighted, average LMP and inflation adjusted, monthly, load-weighted, average LMP from January 1998 through March 2021.⁴⁸ Table 3-32 shows the PJM real-time, load-weighted, average LMP and inflation adjusted load-weighted, average LMP for the first three months of every year from 1998 through 2021. The PJM real-time inflation adjusted, load-weighted, average LMP for the first three months of 2021 was the fourth lowest value since PJM real-time markets started on April 1, 1999 at \$18.94 per MWh. The real-time, inflation adjusted, monthly, load-weighted, average LMP for April 2020 was the lowest monthly value since PJM markets started in April 1999 at \$11.08 per MWh.

Figure 3-26 Real-time, monthly, load-weighted, average LMP unadjusted and adjusted for inflation: January 1998 through March 2021



⁴⁸ To obtain the inflation adjusted, monthly, load-weighted, average LMP, the PJM system-wide load-weighted average LMP is deflated using the US Consumer Price Index for all items, Urban Consumers (base period: January 1998), published by Bureau of Labor Statistics <<http://download.bls.gov/pub/time.series/cu/cu.data.1.AllItems>> (Accessed April 13, 2021)

Table 3-32 Real-time, load-weighted, average LMP unadjusted and adjusted for inflation: January through March, 1998 through 2021

	Load-Weighted, Average LMP	Inflation Adjusted Load-Weighted, Average LMP
	Jan-Mar	Jan-Mar
1998	\$18.13	\$18.10
1999	\$19.38	\$19.03
2000	\$25.10	\$23.89
2001	\$35.16	\$32.35
2002	\$23.01	\$20.90
2003	\$51.93	\$45.86
2004	\$48.77	\$42.36
2005	\$48.37	\$40.73
2006	\$54.43	\$44.21
2007	\$58.07	\$46.05
2008	\$69.35	\$52.85
2009	\$49.60	\$37.83
2010	\$45.92	\$34.21
2011	\$46.35	\$33.83
2012	\$31.21	\$22.14
2013	\$37.41	\$26.09
2014	\$92.98	\$64.01
2015	\$50.91	\$35.04
2016	\$26.80	\$18.25
2017	\$30.28	\$20.11
2018	\$49.45	\$32.17
2019	\$30.16	\$19.28
2020	\$19.85	\$12.42
2021	\$30.84	\$18.94

Real-Time Dispatch and Pricing

The PJM Real-Time Energy Market consists of a series of applications that produce the generator dispatch for energy and reserves, and five minute locational marginal prices (LMPs). These applications include the ancillary services optimizer (ASO), real-time security constrained economic dispatch (RT SCED), and the locational pricing calculator (LPC).⁴⁹ The final real-time LMPs and ancillary service clearing prices are determined for every five minute interval by LPC.

⁴⁹ See PJM. "Manual 11: Energy & Ancillary Services Market Operations," Rev. 112 (Jan. 5, 2021)

Real-Time SCED and LPC

LPC uses data from an approved RT SCED solution that was used to dispatch the resources in the system. RT SCED solves to meet load and reserve requirements forecast at a future point in time, called the target time. Prior to 2021, on average, PJM operators approved more than one RT SCED solution per five minute target time to send dispatch signals to resources. In the first three months of 2021, on average, PJM operators approved one RT SCED solution per five minute target time to send dispatch signals to resources. PJM uses a subset of these approved RT SCED solutions in LPC to calculate real-time LMPs every five minutes. Prior to October 15, 2020, LPC used the latest available approved RT SCED solution to calculate prices, regardless of the target dispatch time of the RT SCED solution, but LPC assigned the prices to a five minute interval that did not contain the target time of the RT SCED case it used. On October 15, 2020, PJM updated its pricing process to use an approved RT SCED solution that solves for the same target time as the end of each five minute pricing interval to calculate LMPs applicable for that five minute interval, although the SCED cases are still for 10 minutes ahead while the LPC cases are for each five minute interval. As a result, under the default timing of case approvals, resources follow the dispatch signal in the first five minutes after the RT SCED case approval and the corresponding pricing occurs five minutes after the same case approval, when resources are following a new dispatch signal.

Table 3-33 shows, on a monthly basis in the first three months of 2021, the number of RT SCED case solutions, the number of solutions that were approved and the number and percent of approved solutions used in LPC. Until February 24, 2020, RT SCED was automatically executed every three minutes with operators having the ability to execute additional cases in between the automatically executed cases. Beginning February 24, 2020, PJM changed the RT SCED automatic execution frequency to once every four minutes. On June 22, 2020, PJM changed the RT SCED execution frequency to once every five minutes. PJM operators continue to have the ability to execute additional RT SCED cases. PJM retains the discretion to change the automatic RT SCED execution frequency at any time, as the frequency is not documented in

the PJM market rules. Each execution of RT SCED produces three solutions, using three different levels of load bias. Since prices are calculated every five minutes while three SCED solutions are produced every five minutes, there is, by definition, a larger number of SCED solutions than there are five minute intervals in any given period.

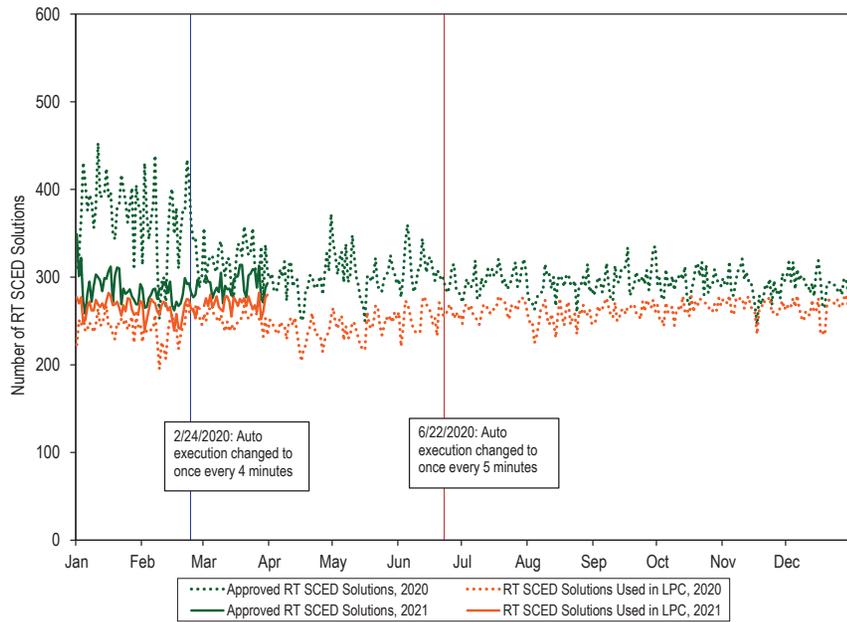
Table 3-33 shows that in the first three months of 2021, 92.2 percent of approved RT SCED solutions that were used to send dispatch signals to generators were used in calculating real-time energy market prices. The percent of approved solutions used for pricing increased in 2020 with the decrease in the frequency of executed RT SCED cases.

Figure 3-27 shows the daily number of RT SCED cases approved by PJM operators to send dispatch signals to resources and the subset of approved RT SCED cases that were used in LPC to calculate LMPs in 2020 and the first three months of 2021, and the dates when the frequency of RT SCED auto execution was changed in 2020. Figure 3-27 shows that changing the auto execution frequency of RT SCED from once every three minutes to once every four minutes on February 24, 2020 and to five minutes on June 22, 2020 reduced the number of approved RT SCED cases used to send dispatch signals in 2020. This change in the frequency of approved solutions reduced the difference between the number of approved solutions and the number of solutions used in pricing in the first three months of 2021 relative to the first three months of 2020.

Table 3-33 RT SCED cases solved, approved and used in pricing: January through March, 2021

Month (2021)	Number of RT SCED Solutions	Number of Approved RT SCED Solutions	Number of Approved RT SCED Solutions Used in LPC	RT SCED Solutions Used in LPC as Percent of Approved RT SCED Solutions
Jan	31,395	9,022	8,276	91.7%
Feb	30,489	7,888	7,308	92.6%
Mar	32,456	9,069	8,372	92.3%
Total	94,340	25,979	23,956	92.2%

Figure 3-27 Daily RT SCED solutions approved for dispatch signals and solutions used in pricing: January 2020 through March 2021



PJM’s process for solving and approving RT SCED cases, and selecting approved RT SCED cases to use in LPC to calculate LMPs has inconsistencies that lead to downstream impacts for energy and reserve dispatch and settlements. PJM does not link dispatch and settlement intervals. RT SCED moved from automatically executing a case every three minutes to every five minutes in 2020, while settlements are linked to five minute intervals. In the first three months of 2021, the frequency of automatic execution of RT SCED cases was one every five minutes. RT SCED solves the dispatch problem for a target time that is generally 14 minutes in the future. An RT SCED case is approved and sends dispatch signals to generators based on a 10 minute ramp time. The look ahead time for the load forecast and the look ahead time for the resource dispatch target do not match, and a new RT SCED case overrides the previously approved case before resources have time to achieve the previous

target dispatch. Prior to October 15, 2020, the interval that was priced in LPC was consistently before the target time from the RT SCED case used for the dispatch signal. LPC took the most recently approved RT SCED case to calculate LMPs for the present five minute interval. For example, the LPC case that calculated prices for the interval ending 10:05 EPT used an approved RT SCED case that sent MW dispatch signals for the target time of 10:10 EPT. This discrepancy created a mismatch between the MW dispatch and real-time LMPs and undermined generators’ incentive to follow dispatch. Under new RT SCED changes that were implemented on October 15, 2020, PJM resolved the mismatch between LPC and the RT SCED target time, but prices no longer apply at the time when resources receive and follow that dispatch signal.⁵⁰ For example, the LPC case that calculates prices for the interval ending 10:05 EPT uses an approved RT SCED case that sent MW dispatch signals at 9:55 EPT which are no longer effective from 10:00 to 10:05 EPT. There is still a mismatch between the MW dispatch and real-time LMPs that undermines generators’ incentive to follow dispatch. The timing remains incorrect until all three (the pricing interval, the dispatch interval, and the RT SCED target time) all correspond to one another.

The extent to which dispatch instructions from approved SCED solutions are reflected in concurrent prices in the PJM Real-Time Energy Market can be measured by comparing the start and end times when the dispatch instructions from the RT SCED solution were effective with the start and end times when the corresponding prices applied. The start time for a dispatch instruction is the time at which PJM approves the RT SCED solution, which triggers sending the resulting dispatch instructions to resources. The end time for a dispatch instruction is the time when the next RT SCED solution is approved. Dispatch and pricing would be perfectly aligned if the start and end times of the dispatch instructions from an approved RT SCED solution matched with the start and end times of the LPC pricing interval that used the same RT SCED solution. In a perfectly aligned five minute market, these times would both be five minutes in duration. However, RT SCED uses a 10 minute ramp time to dispatch resources, while LPC applies prices to five minute intervals.

⁵⁰ See Docket No. ER19-2573-000.

Table 3-34 shows the average duration of the period when dispatch instructions corresponded to the prevailing prices in the first three months of 2021. Prior to October 15, 2020, PJM used the latest approved RT SCED solution available at the time of LPC execution, regardless of the SCED target time, to calculate prices for the current five minute pricing interval. The average duration of correspondence ranged from 3 minutes 11 seconds to 3 minutes 37 seconds from January through October 15, 2020, varying with changes to the frequency of automatic RT SCED execution. The percent of time that prices were consistent with the dispatch instructions was 67.2 to 69.9 percent, on average. This is far from the goal of 100 percent correspondence between five minute dispatch instructions and prices. With the short term changes to RT SCED that were implemented on October 15, 2020, the prices no longer correspond to the dispatch instructions. Table 3-34 shows that during the first three months of 2021, the dispatch instructions were consistent with prevailing prices for only 38 seconds. During this period, the percent of time that prices were consistent with the dispatch instructions was 9.7 percent. This is because by the time LMPs reflect the dispatch signals from an approved RT SCED solution, dispatchers have approved a new solution, and resources are instructed to follow new dispatch signals that do not align with the LMPs used to settle the current five minute interval. In other words, prices consistently lag dispatch instructions by five minutes, except in cases where dispatchers have not approved a new SCED solution five minutes after a previously approved solution.

Table 3-34 Dispatch instructions reflected in prices: January through March, 2021

Period	RT SCED Automatic Execution Frequency	Dispatch Duration Reflected in Prices (Minutes:Seconds)	Percent Dispatch Duration Reflected in Prices
Jan 1, 2020 - Feb 23, 2020	Every 3 minutes	03:11	67.9%
Feb 24, 2020 - Jun 22, 2020	Every 4 minutes	03:27	67.2%
Jun 23, 2020 - Oct 14, 2020	Every 5 minutes	03:37	69.9%
Oct 15, 2020 - Dec 31, 2020	Every 5 minutes	00:39	9.9%
Jan 1, 2021 - Mar 31, 2021	Every 5 minutes	00:38	9.7%

For correct price signals and compensation, energy (LMP) and ancillary service pricing should align with the dispatch solution that is the basis for those prices and with the actual physical dispatch period during which that dispatch solution is realized for each and every real-time market interval.⁵¹ This will only happen if RT SCED and LPC both use a five minute ramp time, consistent with the five minute real-time settlement period in PJM. The MMU recommends that PJM approve one RT SCED case for each five minute interval to dispatch resources during that interval using a five minute ramp time, and that PJM calculate prices using LPC for that five minute interval using the same approved RT SCED case. This will result in prices used to settle energy for the five minute interval that ends at the RT SCED dispatch target time.

Recalculation of Five Minute Real-Time Prices

PJM's five minute interval LMPs are obtained from solved LPC cases. PJM recalculates five minute interval real-time LMPs as it believes necessary to correct errors. To do so, PJM reruns LPC cases with modified inputs. The PJM OATT allows for posting of recalculated real-time prices no later than 17:00 of the tenth calendar day following the operating day. The OATT also requires PJM to notify market participants of the underlying error no later than 17:00 of the second business day following the operating day.⁵² Table 3-35 shows the number of five minute intervals in each month and number of five minute intervals in each month for which PJM recalculated real-time prices in 2020 and the first three months of 2021. In the first three months of 2021, PJM recalculated LMPs for 557 five minute intervals or 2.15 percent of the total 25,908 five minute intervals. PJM later reconstructed LMPs based on the manual dispatch instructions that were sent out during the outage period.⁵³

⁵¹ See *Settlement Intervals and Shortage Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Order No. 825, 155 FERC ¶ 61,276 (2016).

⁵² OATT Schedule 1 § 1.10.8(e).

⁵³ PJM changed this practice effective November 19, 2020. See PJM Manual 11: Energy and Ancillary Services Market Operations, Section 2.10 PJM Real-Time Price Verification Procedure, Rev. 111 (November 19, 2020).

Table 3-35 Number of five minute interval real-time prices recalculated: January 2020 through March 2021

Month	2020		2021	
	Number of Five Minute Intervals	Number of Five Minute Intervals for which LMPs were recalculated	Number of Five Minute Intervals	Number of Five Minute Intervals for which LMPs were recalculated
January	8,928	193	8,928	12
February	8,352	12	8,064	496
March	8,916	110	8,916	49
April	8,640	50	-	-
May	8,928	37	-	-
June	8,640	64	-	-
July	8,928	67	-	-
August	8,928	251	-	-
September	8,640	20	-	-
October	8,928	37	-	-
November	8,652	22	-	-
December	8,928	80	-	-
Total	105,408	943	25,908	557

Day-Ahead Average LMP

Day-ahead, average LMP is the hourly average LMP for the PJM Day-Ahead Energy Market.⁵⁴

PJM Day-Ahead, Average LMP

Table 3-36 shows the PJM day-ahead, average LMP for the first three months of 2001 through 2021.

Table 3-36 Day-ahead, average LMP (Dollars per MWh): January through March, 2001 through 2021

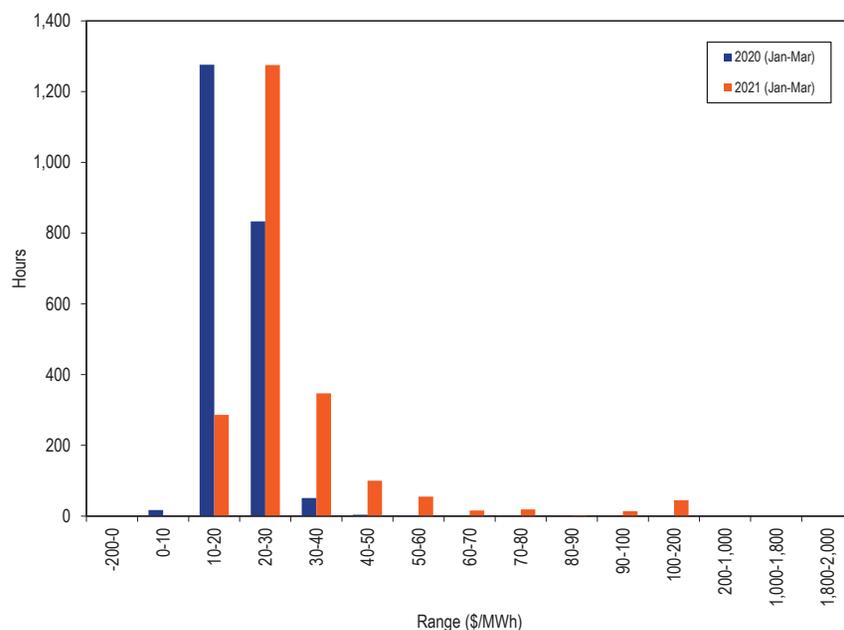
(Jan-Mar)	Day-Ahead LMP			Year to Year Change		
	Average	Median	Standard Deviation	Average	Median	Standard Deviation
2001	\$36.45	\$32.72	\$16.39	NA	NA	NA
2002	\$22.43	\$20.59	\$7.56	(38.5%)	(37.1%)	(53.9%)
2003	\$51.20	\$46.06	\$25.65	128.2%	123.7%	239.3%
2004	\$45.84	\$43.01	\$18.85	(10.5%)	(6.6%)	(26.5%)
2005	\$45.14	\$41.56	\$16.19	(1.5%)	(3.4%)	(14.1%)
2006	\$51.23	\$48.53	\$14.16	13.5%	16.8%	(12.6%)
2007	\$52.76	\$49.43	\$22.59	3.0%	1.9%	59.5%
2008	\$66.10	\$62.57	\$23.90	25.3%	26.6%	5.8%
2009	\$47.41	\$43.43	\$16.85	(28.3%)	(30.6%)	(29.5%)
2010	\$46.13	\$41.99	\$15.93	(2.7%)	(3.3%)	(5.5%)
2011	\$45.60	\$41.10	\$16.82	(1.2%)	(2.1%)	5.6%
2012	\$30.82	\$30.04	\$6.63	(32.4%)	(26.9%)	(60.6%)
2013	\$36.46	\$34.45	\$9.78	18.3%	14.7%	47.5%
2014	\$86.52	\$52.80	\$92.80	137.3%	53.3%	848.8%
2015	\$48.62	\$35.48	\$36.77	(43.8%)	(32.8%)	(60.4%)
2016	\$26.90	\$25.11	\$8.83	(44.7%)	(29.2%)	(76.0%)
2017	\$29.59	\$27.33	\$8.54	10.0%	8.8%	(3.3%)
2018	\$43.59	\$29.01	\$38.64	47.3%	6.2%	352.5%
2019	\$29.65	\$26.82	\$11.28	(32.0%)	(7.6%)	(70.8%)
2020	\$19.66	\$19.14	\$4.43	(33.7%)	(28.6%)	(60.7%)
2021	\$30.28	\$25.44	\$18.64	54.0%	32.9%	320.9%

⁵⁴ See the *MMU Technical Reference for the PJM Markets*, at "Calculating Locational Marginal Price" for a detailed definition of day-ahead LMP. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

PJM Day-Ahead Average LMP Duration

Figure 3-28 shows the hourly distribution of PJM day-ahead, average LMP in the first three months of 2020 and 2021.

Figure 3-28 Average LMP for the day-ahead energy market: January through March, 2020 and 2021



Day-Ahead, Load-Weighted, Average LMP

Day-ahead, load-weighted LMP reflects the average LMP paid for day-ahead MWh. Day-ahead, load-weighted LMP is the average of PJM day-ahead, hourly LMP, each weighted by the PJM total cleared day-ahead, hourly load, including day-ahead fixed load, price-sensitive load, decrement bids and up to congestion.

PJM Day-Ahead, Load-Weighted, Average LMP

Table 3-37 shows the PJM day-ahead, load-weighted, average LMP in the first three months of 2001 through 2021.

Table 3-37 Day-ahead, load-weighted, average LMP (Dollars per MWh): January through March, 2001 through 2021

(Jan-Mar)	Day-Ahead, Load-Weighted, Average LMP			Year to Year Change		
	Average	Median	Standard Deviation	Average	Median	Standard Deviation
2001	\$37.70	\$34.55	\$16.66	NA	NA	NA
2002	\$23.17	\$21.18	\$7.76	(38.5%)	(38.7%)	(53.4%)
2003	\$53.16	\$48.69	\$25.75	129.5%	129.9%	231.7%
2004	\$47.75	\$45.02	\$19.19	(10.2%)	(7.5%)	(25.4%)
2005	\$46.54	\$42.88	\$16.46	(2.5%)	(4.8%)	(14.2%)
2006	\$52.40	\$49.51	\$14.29	12.6%	15.5%	(13.2%)
2007	\$54.87	\$51.89	\$23.16	4.7%	4.8%	62.0%
2008	\$68.00	\$64.70	\$24.35	23.9%	24.7%	5.1%
2009	\$49.44	\$44.85	\$17.54	(27.3%)	(30.7%)	(28.0%)
2010	\$47.77	\$43.62	\$16.52	(3.4%)	(2.7%)	(5.8%)
2011	\$47.14	\$42.49	\$17.73	(1.3%)	(2.6%)	7.3%
2012	\$31.51	\$30.44	\$6.83	(33.2%)	(28.3%)	(61.5%)
2013	\$37.26	\$35.02	\$10.26	18.3%	15.0%	50.3%
2014	\$94.97	\$56.53	\$102.23	154.9%	61.4%	896.7%
2015	\$52.02	\$36.94	\$40.10	(45.2%)	(34.7%)	(60.8%)
2016	\$27.94	\$25.99	\$9.28	(46.3%)	(29.6%)	(76.8%)
2017	\$30.40	\$27.99	\$8.98	8.8%	7.7%	(3.3%)
2018	\$47.55	\$30.24	\$42.58	56.4%	8.0%	374.2%
2019	\$30.76	\$27.28	\$12.56	(35.3%)	(9.8%)	(70.5%)
2020	\$20.12	\$19.54	\$4.54	(34.6%)	(28.4%)	(63.9%)
2021	\$31.58	\$26.11	\$20.01	57.0%	33.6%	341.0%

PJM Day-Ahead, Monthly, Load-Weighted, Average LMP

Figure 3-29 shows the PJM day-ahead, monthly and annual, load-weighted LMP from January 2001 through March 2021.

Figure 3-29 Day-ahead, monthly and annual, load-weighted, average LMP: January 2001 through March 2021

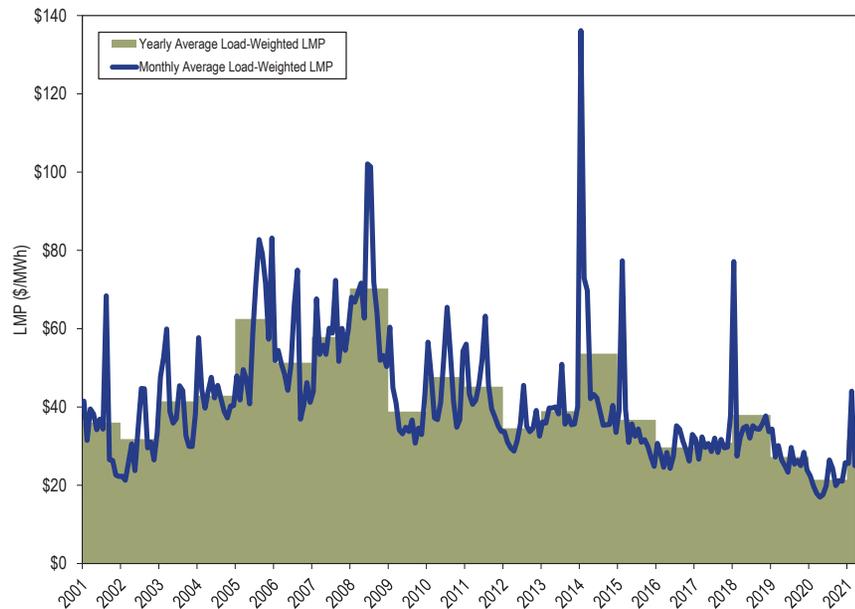
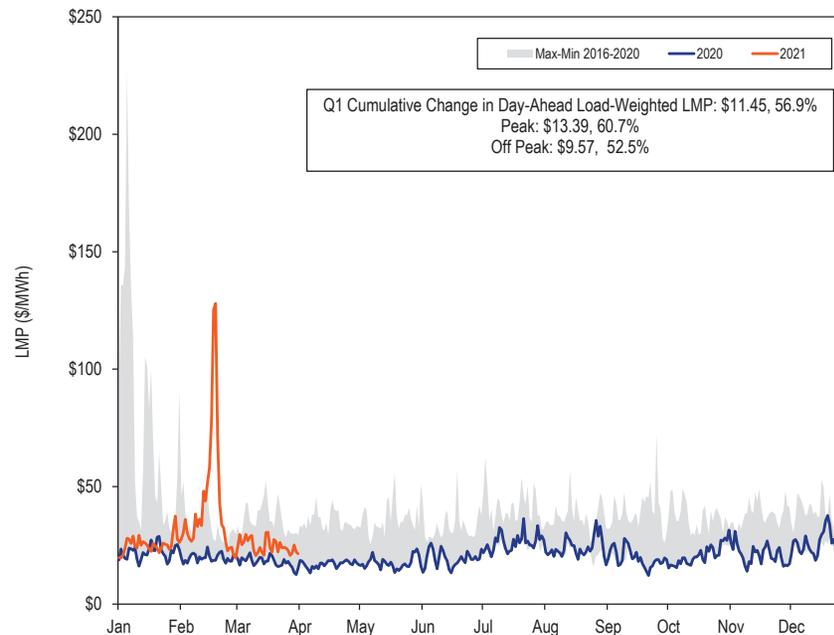


Figure 3-30 shows the PJM day-ahead daily, load-weighted, LMP for 2020 through the first three months 2021 compared to the historic five year price range.

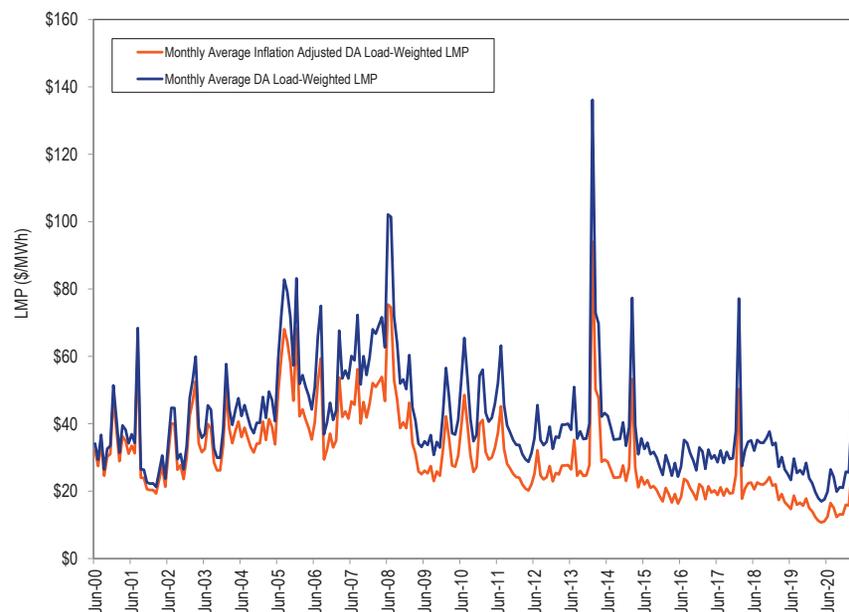
Figure 3-30 Day-ahead, daily, load-weighted, average LMP: January 2020 through March 2021



PJM Day-Ahead, Monthly, Inflation Adjusted Load-Weighted, Average LMP

Figure 3-31 shows the PJM day-ahead, monthly, load-weighted, average LMP and inflation adjusted monthly day-ahead, load-weighted, average LMP for June 2000 through March 2021.⁵⁵ Table 3-38 shows the PJM day-ahead, load-weighted, average LMP and inflation adjusted load-weighted, average LMP for the first three months of every year from 2001 through 2021. The PJM day-ahead, inflation adjusted, load-weighted, average LMP for the first three months of 2021 was the third lowest (\$19.40 per MWh) since PJM day-ahead markets started in 2000. The day-ahead inflation adjusted monthly load-weighted, average LMP for April 2020 (\$10.70 per MWh) was the lowest monthly value since the day-ahead markets started.

Figure 3-31 Day-ahead, monthly, load-weighted, average LMP unadjusted and inflation adjusted: June 2000 through March 2021



⁵⁵ To obtain the inflation adjusted monthly load-weighted average LMP, the PJM system-wide load-weighted average LMP is deflated using US Consumer Price Index for all items, Urban Consumers (base period: January 1998), published by Bureau of Labor Statistics. <<http://download.bls.gov/pub/time.series/cu/cu.data.1.AllItems>> (Accessed April 13, 2021).

Table 3-38 Day-ahead, yearly, load-weighted, average LMP unadjusted and inflation adjusted: January through March, 2001 through 2021

	Load-Weighted, Average LMP	Inflation Adjusted Load-Weighted, Average LMP
	Jan-Mar	Jan-Mar
2001	\$37.70	\$34.68
2002	\$23.17	\$21.04
2003	\$53.16	\$46.94
2004	\$47.75	\$41.47
2005	\$46.54	\$39.19
2006	\$52.40	\$42.57
2007	\$54.87	\$43.51
2008	\$68.00	\$51.82
2009	\$49.44	\$37.71
2010	\$47.77	\$35.59
2011	\$47.14	\$34.41
2012	\$31.51	\$22.35
2013	\$37.26	\$25.98
2014	\$94.97	\$65.40
2015	\$52.02	\$35.80
2016	\$27.94	\$19.03
2017	\$30.40	\$20.18
2018	\$47.55	\$30.93
2019	\$30.76	\$19.66
2020	\$20.12	\$12.59
2021	\$31.58	\$19.40

Price Convergence

The introduction of the PJM Day-Ahead Energy Market with virtuals as part of the design created the possibility that competition, exercised through the use of virtual offers and bids, could tend to cause prices in the day-ahead and real-time energy markets to converge more than would be the case without virtuals. Convergence is not the goal of virtual trading, but it is a possible outcome.

In practice, virtuals can profit anytime there is a difference in prices at any location in any hour between the day-ahead and real-time energy markets. Profitable virtual trading can only result in price convergence at a given location and market hour if the factors affecting prices at that location and hour, such as modeled contingencies, transmission constraint limits and sources of flows, are the same in both the day-ahead and real-time models.

Where arbitrage incentives are created by systematic modeling differences, such as differences between the day-ahead and real-time modeled transmission contingencies and marginal loss calculations, virtual bids and offers cannot result in more efficient market outcomes. Such offers may be profitable but cannot change the underlying reason for the price difference. The virtual transactions will continue to profit from the activity for that reason regardless of the volume of those transactions and without improving the efficiency of the energy market. This is termed false arbitrage.

The degree of convergence, by itself, is not a measure of the competitiveness or effectiveness of the day-ahead energy market. Price convergence does not necessarily mean a zero or even a very small difference in prices between day-ahead and real-time energy markets. There may be factors, from uplift charges to differences in risk that result in a competitive, market-based differential. In addition, convergence in the sense that day-ahead and real-time prices are equal at individual buses or aggregates on a day to day basis is not a realistic expectation as a result of uncertainty, lags in response time and modeling differences.

INCs, DECs and UTCs allow participants to profit from price differences between the day-ahead and real-time energy market. In theory, profitable virtual transactions contribute to price convergence, but with false arbitrage, high profits result with little or no price convergence. The seller of an INC must buy energy in the real-time energy market to fulfill the financial obligation to provide energy. If the day-ahead price for energy is higher than the real-time price for energy, the INC makes a profit. The buyer of a DEC must sell energy in the real-time energy market to fulfill the financial obligation to buy energy. If the day-ahead price for energy is lower than the real-time price for energy, the DEC makes a profit.

The profitability of a UTC transaction is the net of the separate profitability of the component INC and DEC. A UTC can be net profitable if the profit on one side of the UTC transaction exceeds the losses on the other side.

Table 3-39 shows the number of cleared UTC transactions, the number of profitable cleared UTCs, the number of cleared UTCs that were profitable at their source point and the number of cleared UTCs that were profitable at their sink point in the first three months of 2020 and 2021. In the first three months of 2021, 46.8 percent of all cleared UTC transactions were net profitable. Of cleared UTC transactions, 72.5 percent were profitable on the source side and 28.7 percent were profitable on the sink side, but only 8.3 percent were profitable on both the source and sink side.

Table 3-39 Cleared UTC profitability by source and sink point: January through March, 2020 and 2021⁵⁶

(Jan-Mar)	Cleared UTCs	Profitable UTCs	UTC Profitable at Source Bus	UTC Profitable at Sink Bus	UTC Profitable at Source and Sink	Profitable UTC	Profitable Source	Profitable Sink	Profitable at Source and Sink
2020	2,339,677	1,266,098	1,528,029	831,405	157,537	54.1%	65.3%	35.5%	6.7%
2021	1,277,329	597,381	925,643	366,744	105,446	46.8%	72.5%	28.7%	8.3%

Table 3-40 shows the number of cleared INC and DEC transactions and the number of profitable cleared transactions in the first three months of 2020 and 2021. Of cleared INC and DEC transactions in 2020, 71.3 percent of INCs were profitable and 30.4 percent of DECs were profitable.

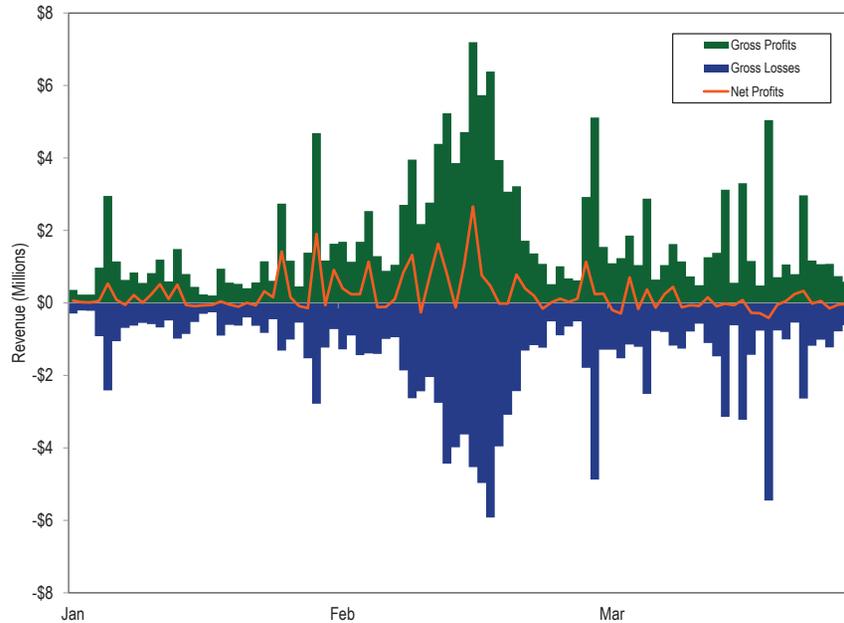
Table 3-40 Cleared INC and DEC profitability: January through March, 2020 and 2021

(Jan-Mar)	Cleared INC	Profitable INC	Profitable INC Percent	Cleared DEC	Profitable DEC	Profitable DEC Percent
2020	548,430	357,950	65.3%	480,129	188,496	39.3%
2021	572,949	408,568	71.3%	616,848	187,705	30.4%

⁵⁶ Calculations exclude PJM administrative charges.

Figure 3-32 shows total UTC daily gross profits, the sum of all positive profit UTC transactions, gross losses, the sum of all negative profit UTC transactions, and net profits and losses in the first three months of 2021.

Figure 3-32 UTC daily gross profits and losses and net profits: January through March, 2021⁵⁷



⁵⁷ Calculations exclude PJM administrative charges.

Figure 3-33 shows the cumulative UTC daily profits for each year from 2013 through the first three months of 2021.

Figure 3-33 Cumulative daily UTC profits: January 2013 through March 2021

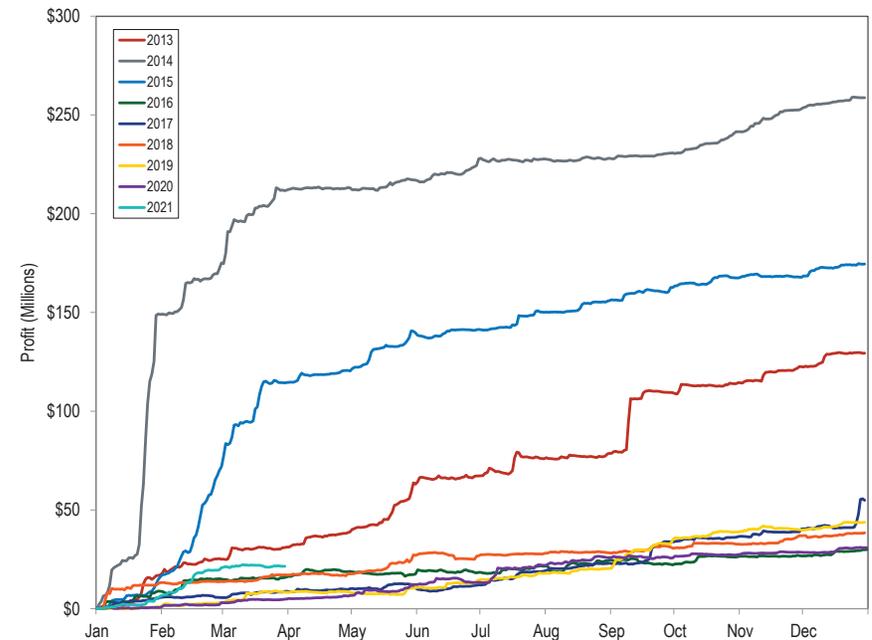


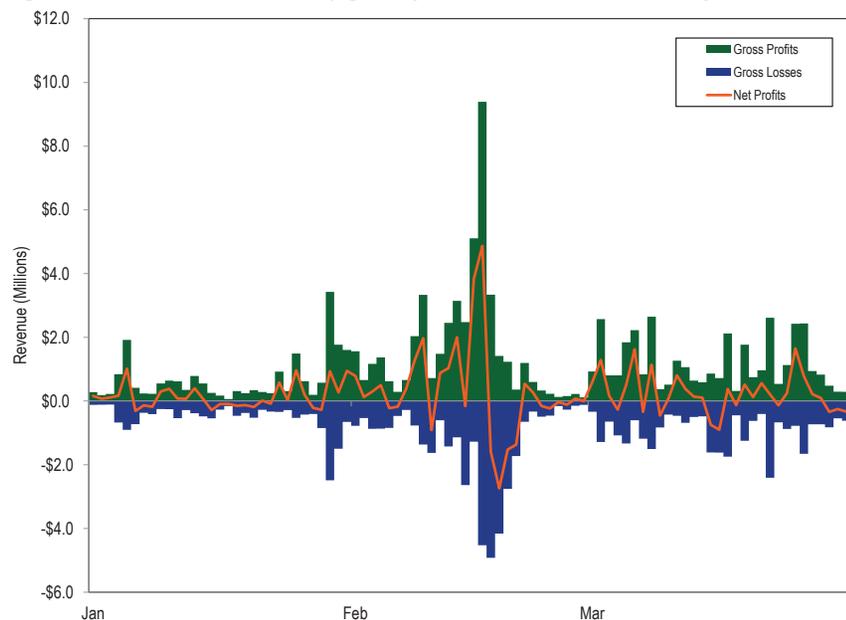
Table 3-41 shows UTC profits by month for January 2013 through March 2021. May 2016, September 2016, February 2017, June 2018 and September 2020 were the only months in this seven year period in which monthly profits were negative.

Table 3-41 UTC profits by month: January 2013 through March 2021

	January	February	March	April	May	June	July	August	September	October	November	December	Total
2013	\$17,048,654	\$8,304,767	\$5,629,392	\$7,560,773	\$25,219,947	\$3,484,372	\$8,781,526	\$2,327,168	\$31,160,618	\$4,393,583	\$8,730,701	\$6,793,990	\$129,435,490
2014	\$148,973,434	\$23,235,621	\$39,448,716	\$1,581,786	\$3,851,636	\$7,353,460	\$3,179,356	\$287,824	\$2,727,763	\$10,889,817	\$11,042,443	\$6,191,101	\$258,762,955
2015	\$16,132,319	\$53,830,098	\$44,309,656	\$6,392,939	\$19,793,475	\$824,817	\$8,879,275	\$5,507,608	\$6,957,012	\$4,852,454	\$392,876	\$6,620,581	\$174,493,110
2016	\$8,874,363	\$6,118,477	\$1,119,457	\$2,768,591	(\$1,333,563)	\$841,706	\$3,128,346	\$3,200,573	(\$2,518,408)	\$4,216,717	\$254,684	\$3,271,368	\$29,942,312
2017	\$5,716,757	(\$17,860)	\$3,083,167	\$944,939	\$1,245,988	\$868,400	\$7,053,390	\$4,002,063	\$10,960,012	\$2,360,817	\$2,716,950	\$15,936,217	\$54,870,839
2018	\$13,184,346	\$506,509	\$3,410,577	\$688,796	\$9,499,735	(\$768,614)	\$1,163,380	\$692,736	\$2,845,649	\$1,452,515	\$4,339,363	\$1,358,446	\$38,373,436
2019	\$574,901	\$2,407,307	\$5,287,985	\$332,036	\$1,833,879	\$3,382,009	\$4,066,461	\$2,442,971	\$12,599,278	\$5,914,042	\$1,171,145	\$3,722,403	\$43,734,418
2020	\$664,972	\$2,497,856	\$1,720,037	\$1,865,139	\$5,508,276	\$1,123,429	\$8,573,276	\$3,957,296	(\$141,240)	\$1,628,186	\$1,170,367	\$2,319,727	\$30,887,320
2021	\$6,421,567	\$13,241,294	\$1,788,961										\$21,451,822

Figure 3-34 shows total INC and DEC daily gross profits, the sum of all positive profit transactions, gross losses, the sum of all negative profit transactions, and net profits and losses in the first three months of 2021.

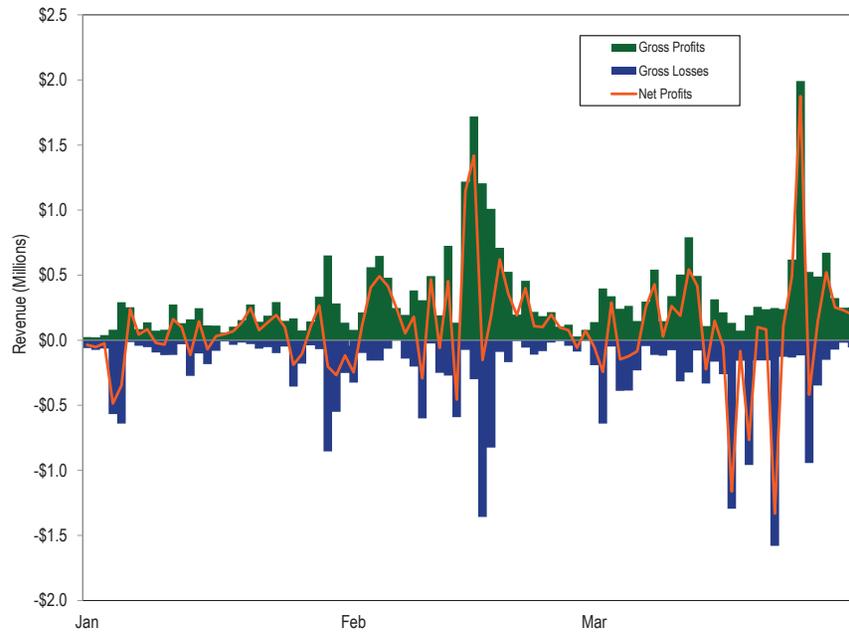
Figure 3-34 INC and DEC daily gross profits and losses and net profits: January through March, 2021⁵⁸



⁵⁸ Calculations exclude PJM administrative charges.

Figure 3-35 shows total INC daily gross profits and losses and net profits and losses in the first three months of 2021.

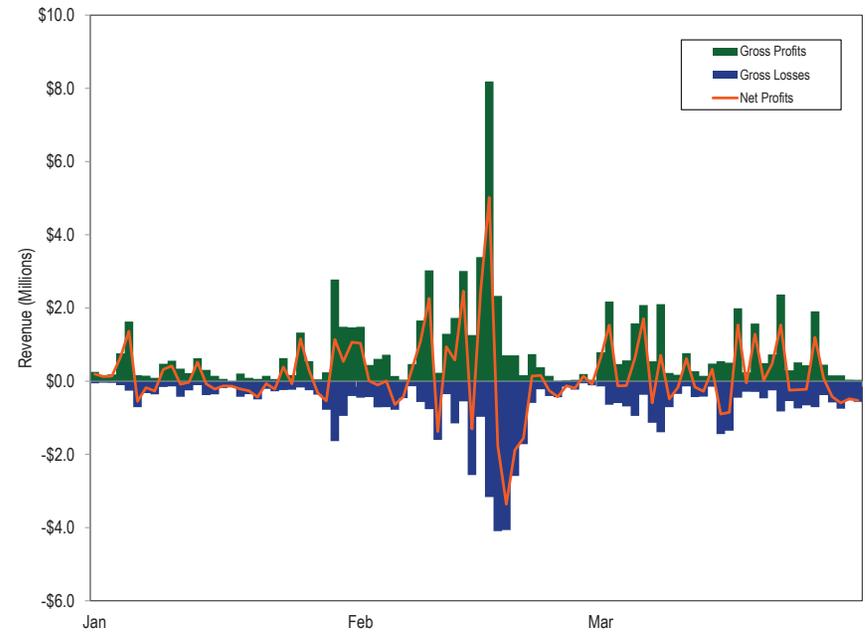
Figure 3-35 INC daily gross profits and losses and net profits: January through March, 2021⁵⁹



⁵⁹ Calculations exclude PJM administrative charges.

Figure 3-36 shows total DEC daily gross profits and losses and net profits and losses in the first three months of 2021.

Figure 3-36 DEC daily gross profits and losses and net profits: January through March, 2021⁶⁰



⁶⁰ Calculations exclude PJM administrative charges.

Figure 3-37 shows the cumulative INC and DEC daily profits for the first three months of 2021.

Figure 3-37 Cumulative daily INC and DEC profits: January through March, 2021

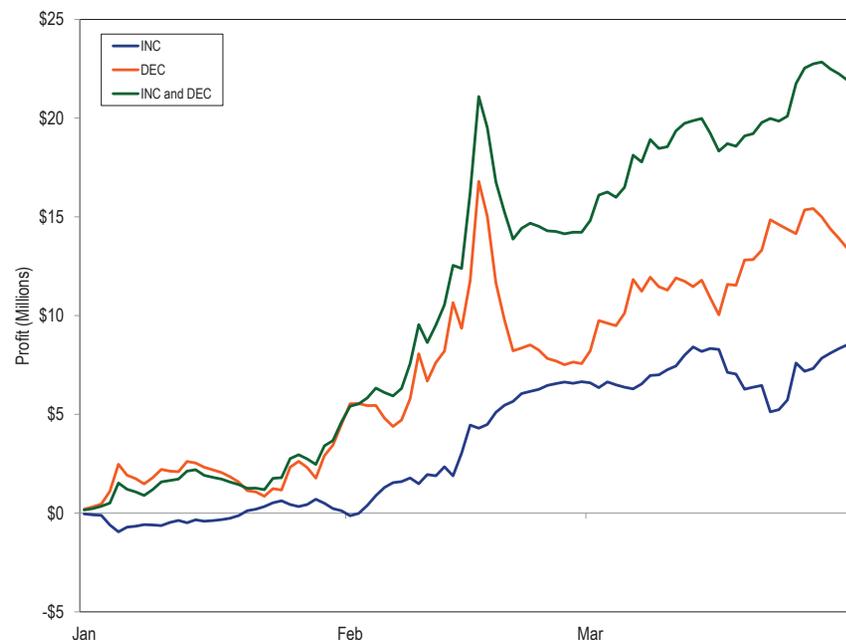


Table 3-42 shows INC and DEC profits by month for the first three months of 2021.

Table 3-42 INC and DEC profits by month: January through March, 2021

	January	February	March	Total
INCs	\$116,313	\$6,534,110	\$1,874,664	\$8,525,087
DECs	\$4,506,985	\$3,060,102	\$5,820,332	\$13,387,419
INCs and DECs	\$4,623,297	\$9,594,212	\$7,694,996	\$21,912,506

There are incentives to use virtual transactions to profit from price differences between the day-ahead and real-time energy markets, but there is no guarantee that such activity will result in price convergence and no data to support that claim. As a general matter, virtual offers and bids are based on expectations about both day-ahead and real-time energy market conditions and reflect the uncertainty about conditions in both markets, about modeling differences and the fact that these conditions change hourly and daily. PJM markets do not provide a mechanism that could result in immediate convergence after a change in system conditions as there is at least a one day lag after any change in system conditions before offers could reflect such changes. PJM markets do not provide a mechanism that could ever result in convergence in the presence of modeling differences.

Substantial virtual trading activity does not guarantee that market power cannot be exercised in the day-ahead energy market. Hourly and daily price differences between the day-ahead and real-time energy markets fluctuate continuously and substantially from positive to negative. There may be substantial, persistent differences between day-ahead and real-time prices even on a monthly basis.

Table 3-43 shows that the difference between the average real-time price and the average day-ahead price was $-\$0.24$ per MWh in the first three months of 2020 and $-\$0.50$ per MWh in the first three months of 2021. The difference between the average peak real-time price and the average peak day-ahead price was $-\$0.18$ per MWh in the first three months of 2020 and $-\$0.89$ per MWh in the first three months of 2021.

Table 3-43 Day-ahead and real-time average LMP (Dollars per MWh): January through March, 2020 and 2021⁶¹

	2020 (Jan-Mar)				2021 (Jan-Mar)			
	Day-Ahead	Real-Time	Difference	Percent of Real Time	Day-Ahead	Real-Time	Difference	Percent of Real Time
Average	\$19.66	\$19.42	(\$0.24)	(1.3%)	\$30.28	\$29.78	(\$0.50)	(1.7%)
Median	\$19.14	\$18.56	(\$0.58)	(3.1%)	\$25.44	\$23.66	(\$1.78)	(7.5%)
Standard deviation	\$4.43	\$6.98	\$2.55	36.6%	\$18.64	\$23.91	\$5.27	22.1%
Peak average	\$21.74	\$21.56	(\$0.18)	(0.8%)	\$34.17	\$33.29	(\$0.89)	(2.7%)
Peak median	\$20.77	\$20.08	(\$0.70)	(3.5%)	\$27.19	\$24.67	(\$2.52)	(10.2%)
Peak standard deviation	\$4.15	\$7.97	\$3.82	47.9%	\$23.09	\$29.72	\$6.63	22.3%
Off peak average	\$17.83	\$17.53	(\$0.30)	(1.7%)	\$26.88	\$26.71	(\$0.17)	(0.6%)
Off peak median	\$17.62	\$17.25	(\$0.37)	(2.2%)	\$23.21	\$22.34	(\$0.87)	(3.9%)
Off peak standard deviation	\$3.81	\$5.30	\$1.48	28.0%	\$12.65	\$16.71	\$4.05	24.3%

The price difference between the real-time and the day-ahead energy markets results in part, from conditions in the real-time energy market that are difficult, or impossible, to anticipate in the day-ahead energy market.

Table 3-44 shows the difference between the real-time load-weighted and the day-ahead load-weighted energy market prices for the first three months of 2001 through 2021.

Table 3-44 Day-ahead load-weighted and real-time load-weighted, average LMP (Dollars per MWh): January through March, 2001 through 2021

(Jan-Mar)	Load-Weighted Average LMP			
	Day-Ahead	Real-Time	Difference	Percent of Real Time
2001	\$36.45	\$33.77	(\$2.68)	(7.3%)
2002	\$22.43	\$22.23	(\$0.20)	(0.9%)
2003	\$51.20	\$49.57	(\$1.63)	(3.2%)
2004	\$45.84	\$46.37	\$0.52	1.1%
2005	\$45.14	\$46.51	\$1.37	3.0%
2006	\$51.23	\$52.98	\$1.75	3.4%
2007	\$52.76	\$55.34	\$2.58	4.9%
2008	\$66.10	\$66.75	\$0.65	1.0%
2009	\$47.41	\$47.29	(\$0.12)	(0.2%)
2010	\$46.13	\$44.13	(\$2.00)	(4.3%)
2011	\$45.60	\$44.76	(\$0.84)	(1.8%)
2012	\$30.82	\$30.38	(\$0.43)	(1.4%)
2013	\$36.46	\$36.33	(\$0.13)	(0.4%)
2014	\$86.52	\$84.04	(\$2.48)	(2.9%)
2015	\$48.62	\$47.39	(\$1.23)	(2.5%)
2016	\$26.90	\$25.60	(\$1.30)	(4.8%)
2017	\$29.59	\$29.39	(\$0.20)	(0.7%)
2018	\$43.59	\$44.65	\$1.07	2.4%
2019	\$29.65	\$29.13	(\$0.52)	(1.7%)
2020	\$19.66	\$19.42	(\$0.24)	(1.2%)
2021	\$30.28	\$29.78	(\$0.50)	(1.7%)

⁶¹ The averages used are the annual average of the hourly average PJM prices for day-ahead and real-time.

Table 3-45 includes frequency distributions of the differences between PJM real-time, load-weighted, hourly LMP and PJM day-ahead, load-weighted, hourly LMP for the first three months of 2020 and 2021.

Table 3-45 Frequency distribution by hours of real-time, load-weighted LMP minus day-ahead, load-weighted LMP (Dollars per MWh): January through March, 2020 and 2021

LMP	2020 (Jan-Mar)		2021 (Jan-Mar)	
	Frequency	Cumulative Percent	Frequency	Cumulative Percent
< (\$200)	0	0.00%	0	0.00%
(\$200) to (\$100)	0	0.00%	0	0.00%
(\$100) to (\$50)	4	0.19%	0	0.00%
(\$50) to \$0	1,535	71.28%	1,428	65.41%
\$0 to \$50	601	99.12%	751	99.82%
\$50 to \$100	12	99.68%	4	100.00%
\$100 to \$200	6	99.95%	0	100.00%
\$200 to \$400	1	100.00%	0	100.00%
\$400 to \$800	0	100.00%	0	100.00%
>= \$800	0	100.00%	0	100.00%

Figure 3-38 shows the hourly differences between day-ahead and real-time hourly LMP in the first three months of 2021.

Figure 3-38 Real-time hourly, LMP minus day-ahead hourly LMP: January through March, 2021

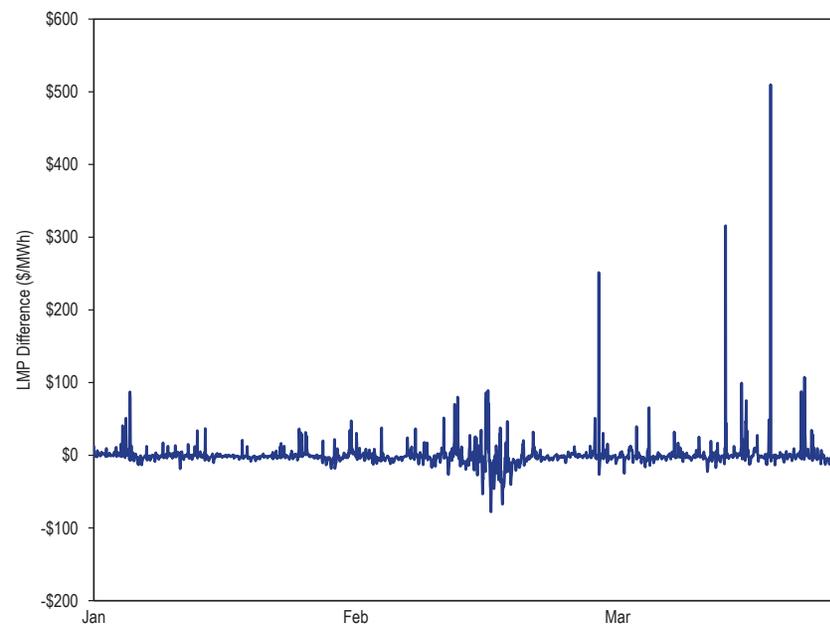
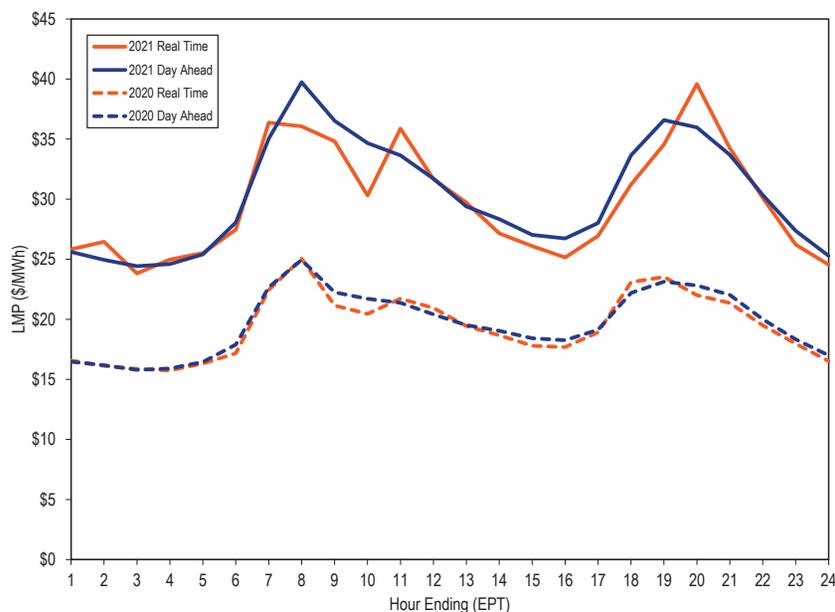


Figure 3-39 shows day-ahead and real-time, load-weighted, average hourly LMP for the first three months of 2020 and 2021.

Figure 3-39 System hourly average LMP: January through March, 2020 and 2021



Zonal LMP and Dispatch

Table 3-46 shows zonal real-time, and real-time, load-weighted, average LMP in the first three months of 2020 and 2021.

Table 3-46 Zonal real-time and real-time, load-weighted, average LMP (Dollars per MWh): January through March, 2020 and 2021

Zone	Real-Time Average LMP			Real-Time, Load-Weighted, Average LMP		
	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change
ACEC	\$18.75	\$26.24	40.0%	\$19.23	\$27.35	42.2%
AEP	\$19.83	\$29.99	51.3%	\$20.23	\$31.07	53.6%
APS	\$19.65	\$29.21	48.7%	\$20.09	\$30.16	50.1%
ATSI	\$19.97	\$28.09	40.7%	\$20.36	\$28.76	41.3%
BGE	\$20.65	\$34.10	65.1%	\$21.30	\$35.61	67.2%
COMED	\$18.40	\$28.26	53.6%	\$18.80	\$29.52	57.1%
DAY	\$20.80	\$31.49	51.4%	\$21.29	\$32.85	54.3%
DUKE	\$20.01	\$30.63	53.1%	\$20.42	\$32.09	57.1%
DUQ	\$19.75	\$31.75	60.8%	\$20.29	\$33.04	62.9%
DOM	\$18.96	\$38.78	104.5%	\$19.54	\$40.22	105.9%
DPL	\$19.84	\$27.88	40.5%	\$20.22	\$28.54	41.2%
EKPC	\$19.92	\$30.74	54.3%	\$20.46	\$33.06	61.6%
JCPLC	\$18.84	\$25.59	35.8%	\$19.34	\$26.44	36.7%
MEC	\$18.91	\$27.43	45.1%	\$19.45	\$28.37	45.9%
OVEC	\$19.53	\$29.16	49.3%	\$19.64	\$29.61	50.7%
PECO	\$18.49	\$25.93	40.3%	\$18.92	\$26.84	41.8%
PE	\$19.07	\$28.36	48.7%	\$19.46	\$29.13	49.7%
PEPCO	\$20.21	\$31.65	56.6%	\$20.86	\$33.06	58.5%
PPL	\$17.70	\$26.14	47.6%	\$18.14	\$27.01	48.9%
PSEG	\$18.92	\$31.24	65.1%	\$19.34	\$32.43	67.7%
RECO	\$18.87	\$36.49	93.4%	\$19.32	\$38.14	97.4%
PJM	\$19.42	\$29.78	53.4%	\$19.85	\$30.84	55.3%

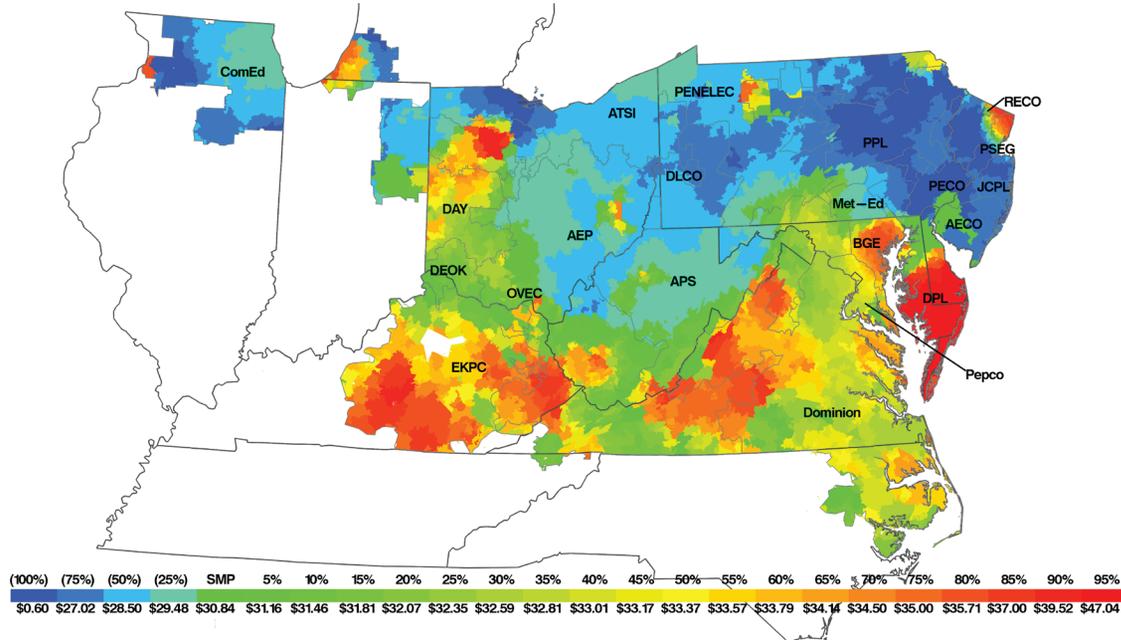
Table 3-47 shows zonal day-ahead, and day-ahead, load-weighted, average LMP in the first three months of 2020 and 2021.

Table 3-47 Zonal day-ahead and day-ahead, load-weighted, average LMP (Dollars per MWh): January through March, 2020 and 2021

Zone	Day-Ahead Average LMP			Day-Ahead, Load-Weighted, Average LMP		
	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change
ACEC	\$18.51	\$27.40	48.0%	\$18.95	\$28.36	49.7%
AEP	\$20.16	\$30.35	50.5%	\$20.56	\$31.72	54.2%
APS	\$19.97	\$30.08	50.6%	\$20.45	\$31.17	52.4%
ATSI	\$20.37	\$30.05	47.5%	\$20.81	\$30.99	48.9%
BGE	\$21.42	\$34.20	59.7%	\$22.18	\$35.61	60.6%
COMED	\$18.72	\$28.52	52.3%	\$19.10	\$29.99	57.1%
DAY	\$21.15	\$32.31	52.7%	\$21.67	\$34.00	56.9%
DUKE	\$20.38	\$31.42	54.1%	\$20.83	\$32.92	58.0%
DUQ	\$20.17	\$31.71	57.2%	\$20.73	\$33.03	59.3%
DOM	\$18.75	\$34.43	83.6%	\$19.40	\$36.10	86.1%
DPL	\$20.25	\$29.27	44.6%	\$20.73	\$30.09	45.2%
EKPC	\$20.19	\$30.58	51.5%	\$20.87	\$33.21	59.1%
JCPLC	\$18.61	\$27.25	46.5%	\$19.12	\$28.09	46.9%
MEC	\$18.89	\$28.62	51.5%	\$19.41	\$29.59	52.4%
OVEC	\$19.83	\$29.58	49.2%	\$20.40	\$32.03	57.0%
PECO	\$18.14	\$27.03	49.0%	\$18.57	\$27.87	50.1%
PE	\$19.46	\$29.72	52.7%	\$20.00	\$30.96	54.8%
PEPCO	\$20.82	\$32.37	55.4%	\$21.57	\$33.88	57.1%
PPL	\$17.82	\$27.43	53.9%	\$18.23	\$28.23	54.8%
PSEG	\$18.69	\$29.81	59.5%	\$19.12	\$30.82	61.2%
RECO	\$18.97	\$33.13	74.6%	\$19.52	\$35.57	82.2%
PJM	\$19.66	\$30.28	54.0%	\$20.12	\$31.58	57.0%

Figure 3-40 is a map of the real-time, load-weighted, average LMP in the first three months of 2021. In the legend, green represents the system marginal price (SMP) and each increment to the right and left of the SMP represents five percent of the pricing nodes above and below the SMP.

Figure 3-40 Real-time, load-weighted, average LMP: January through March, 2021



Transmission Penalty Factors

LMP may, at times, be set by transmission penalty factors. When a transmission constraint is binding and there are no generation alternatives to resolve the constraint, system operators may allow the transmission limit to be violated. When this occurs, the shadow price of the constraint is set by transmission penalty factors. The shadow price directly affects the LMP. Transmission penalty factors are administratively determined and can be thought of as a form of locational scarcity pricing.

Table 3-48 shows the frequency and average shadow price of transmission constraints in PJM. In the first three months of 2021, there were 43,521 transmission constraint intervals in the real-time market with a nonzero shadow price. For nearly eight percent of these transmission constraint intervals, the line limit was violated, meaning that the flow exceeded the facility limit.⁶² In the first three months of 2021, the average shadow price of transmission constraints when the line limit was violated was nearly 12.9 times higher than when the transmission constraint was binding at its limit.

Table 3-48 Frequency and average shadow price of transmission constraints: January through March, 2020 and 2021

Description	Frequency (Constraint Intervals)		Average Shadow Price	
	2020	2021	2020	2021
	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)
PJM Internal Violated Transmission Constraints	386	3,263	\$1,677.98	\$1,919.50
PJM Internal Binding Transmission Constraints	34,071	26,555	\$42.74	\$148.28
Market to Market Transmission Constraints	9,064	10,328	\$153.46	\$558.39
All Transmission Constraints	43,521	40,146	\$80.30	\$397.75

Transmission penalty factors should be applied without discretion. PJM adopted the MMU's recommendation to remove the constraint relaxation logic and allow transmission penalty factors to set prices in the day-ahead and real-time markets for all internal transmission constraints. PJM also revised the tariff to list the conditions under which transmission penalty factors would be changed from their default value of \$2,000 per MWh. The new rules went

⁶² The line limit of a facility associated with a transmission constraint is not necessarily the rated line limit. In PJM, the dispatcher has the discretion to lower the rated line limit.

into effect on February 1, 2019. The Commission approved the PJM and MISO joint filing to remove the constraint relaxation logic for market to market constraints on March 6, 2020. PJM and MISO implemented the changes to their dispatch software in the second half of 2020.

PJM continues the practice of discretionary reductions in line ratings. Table 3-49 shows the frequency of changes to the transmission constraints for binding and violated transmission constraints in the PJM real-time market. In the first three months of 2021, there were 3,189 or 98 percent of 3,263 internal violated transmission constraint intervals in the real-time market with constraint limit less than 100 percent of the actual constraint limit. In the first three months of 2021, among the constraints with reduced constraint limits, the constraint limit was reduced on average by 6.0 percent.

Table 3-49 Frequency of reduction in line ratings (constraint intervals): January through March, 2020 and 2021

Description	Frequency (Constraint Intervals)		Constraints with Reduced Line Limits (Constraint Intervals)		Average Reduction (Percentage)	
	2020	2021	2020	2021	2020	2021
	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)	(Jan - Mar)
PJM Internal Violated Transmission Constraints	386	3,263	377	3,189	21.6%	6.0%
PJM Internal Binding Transmission Constraints	34,071	26,555	33,953	26,178	9.4%	8.1%
Market to Market Transmission Constraints	9,064	10,328	2,242	3,963	7.7%	5.1%
All Transmission Constraints	43,521	40,146	36,572	33,330	9.4%	7.5%

Table 3-50 shows the frequency of changes to the magnitude of transmission penalty factors for binding and violated transmission constraints in the PJM Real-Time Energy Market. In the first three months of 2021, there were 3,098 or 95 percent of internal violated transmission constraint intervals in the real-time market with a transmission penalty factor equal to the default \$2,000 per MWh.

Table 3-50 Frequency of changes to the magnitude of transmission penalty factor (constraint intervals): January through March, 2020 and 2021

Description	2020 (Jan - Mar)			2021 (Jan - Mar)		
	\$2,000 per MWh (Default)	Above \$2,000 per MWh	Below \$2,000 per MWh	\$2,000 per MWh (Default)	Above \$2,000 per MWh	Below \$2,000 per MWh
PJM Internal Violated Transmission Constraints	312	-	74	3,098	-	165
PJM Internal Binding Transmission Constraints	32,759	-	1,312	26,085	-	470
Market to Market Transmission Constraints	362	-	8,702	2,118	-	8,210
All Transmission Constraints	33,433	-	10,088	31,301	-	8,845

Transmission constraint penalty factors frequently set prices when PJM models a surrogate constraint to limit the dispatch of a generator that would experience voltage instability at its full output due to a transmission outage. Changes to the surrogate constraint limit that exceed the unit's ability to reduce output cause constraint violations. Constraint violations also occur when the unit follows the regulation signal or increases its minimum operating parameters above the surrogate constraint limit. Prices set at the \$2,000 per MWh penalty factor are not useful signals to the market under these conditions and create false arbitrage opportunities for virtuals.

PJM uses CT pricing logic to force otherwise uneconomic resources to be marginal and set price in the day-ahead and real-time market solutions. In the event PJM commits a resource that is uneconomic and/or offered with inflexible parameters, PJM uses CT pricing logic to model a constraint with a variable flow limit, paired with an artificial override of the inflexible resource's economic minimum, to force the resource to be marginal in the PJM market solution.⁶³ Frequently, PJM dispatchers also manually override the transmission violation penalty factor of the constraint to match the offer

⁶³ PJM dispatchers generally log the resources paired with a constraint in the CT pricing logic. The data presented is based on PJM dispatcher logs.

price of the resource to artificially control the shadow price of the constraint. Table 3-51 shows the frequency of CT pricing logic used in the PJM Real-Time Energy Market. In the first three months of 2021, there were 2,438 constraint intervals in the real-time market where CT pricing logic was used. In the PJM CT pricing logic, there could be one or multiple resources paired with a constraint.

PJM's use of CT pricing logic is inconsistent with the efficient market dispatch and pricing. For that reason, in 2019 FERC declared CT pricing logic to be unjust and unreasonable.⁶⁴ PJM should discontinue the use of CT pricing logic, regardless of whether the new fast-start pricing process is in place.

Table 3-51 Frequency of CT pricing logic used in the real-time market (constraint intervals): January 2020 through March 2021

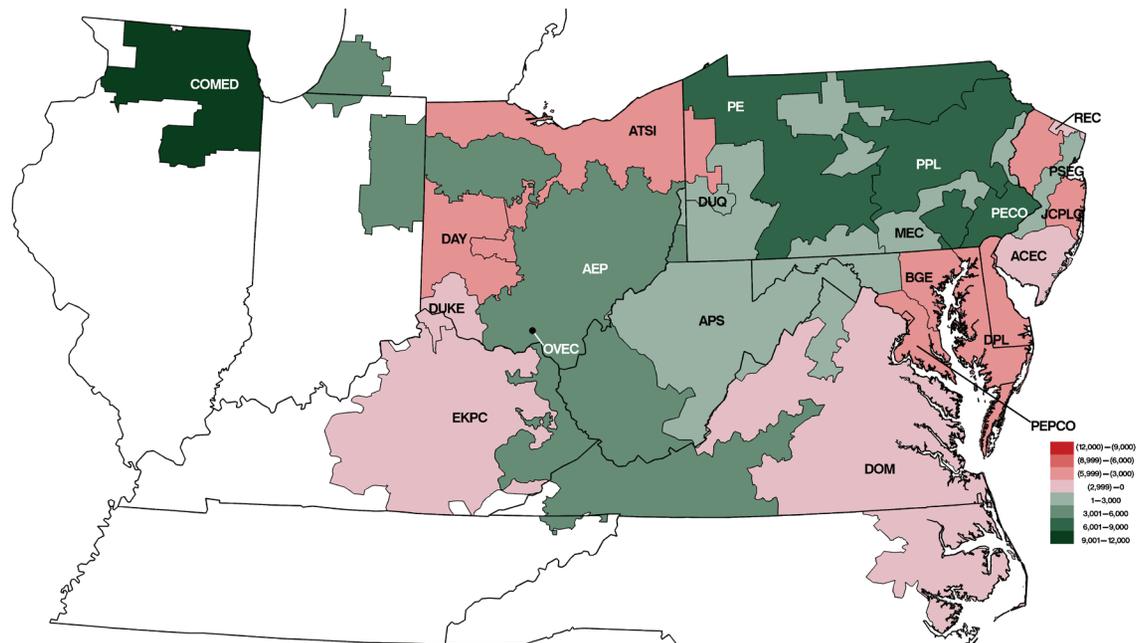
Month	2020	2021
Jan	231	783
Feb	167	469
Mar	122	1,186
Apr	173	-
May	632	-
Jun	825	-
Jul	842	-
Aug	1,189	-
Sep	1,982	-
Oct	2,017	-
Nov	956	-
Dec	1,404	-
Total	10,540	2,438

⁶⁴ 167 FERC ¶ 61,058 at P 69 (2019).

Net Generation by Zone

Figure 3-41 shows the difference between the PJM real-time generation and real-time load by zone in the first three months of 2021. Figure 3-41 is color coded using a scale on which red shades represent zones that have less generation than load and green shades represent zones that have more generation than load, with darker shades meaning greater amounts of net generation or load. Table 3-52 shows the difference between the PJM real-time generation and real-time load by zone in the first three months of 2020 and 2021.

Figure 3-41 Map of real-time generation, less real-time load, by zone: January through March, 2021⁶⁵



⁶⁵ Zonal real-time generation data for the map and corresponding table is based on the zonal designation for every bus listed in the most current PJM LMP bus model, which can be found at <<http://www.pjm.com/markets-and-operations/energy/lmp-model-info.aspx>>.

Table 3-52 Real-time generation less real-time load by zone (GWh): January through March, 2020 and 2021

Zonal Generation and Load (GWh)						
Jan-Mar	2020			2021		
Zone	Generation	Load	Net	Generation	Load	Net
ACEC	880.2	2,119.2	(1,239.0)	328.7	2,219.5	(1,890.8)
AEP	34,767.8	31,499.9	3,267.9	38,142.3	32,359.0	5,783.3
APS	12,110.2	12,342.8	(232.6)	13,920.1	12,843.6	1,076.5
ATSI	9,972.3	15,935.3	(5,963.0)	12,000.5	16,023.8	(4,023.4)
BGE	3,382.5	7,350.7	(3,968.2)	4,232.5	7,770.2	(3,537.7)
COMED	31,997.3	22,534.9	9,462.4	31,974.4	22,508.3	9,466.1
DAY	93.0	4,183.0	(4,090.0)	223.5	4,296.9	(4,073.3)
DUKE	4,565.7	6,350.7	(1,785.0)	4,136.2	6,502.4	(2,366.2)
DUQ	26,936.8	24,211.9	2,725.0	25,009.2	26,820.4	(1,811.2)
DOM	874.6	4,363.1	(3,488.5)	580.6	4,713.7	(4,133.1)
DPL	4,066.0	3,141.2	924.8	4,317.3	3,143.2	1,174.1
EKPC	1,743.5	3,358.5	(1,615.0)	2,668.4	3,691.2	(1,022.8)
JCPLC	1,870.1	4,971.3	(3,101.3)	597.3	5,224.5	(4,627.1)
MEC	5,745.0	3,814.3	1,930.7	4,630.7	3,980.4	650.3
OVEC	2,317.5	34.0	2,283.5	2,977.6	32.1	2,945.5
PECO	19,098.9	9,210.0	9,888.9	17,728.5	9,542.9	8,185.6
PE	10,029.7	4,305.8	5,723.9	12,870.6	4,350.6	8,520.0
PEPCO	2,541.9	6,786.3	(4,244.3)	3,194.0	6,984.5	(3,790.5)
PPL	14,633.4	10,305.1	4,328.3	17,048.4	10,743.9	6,304.5
PSEG	10,316.2	9,754.6	561.6	10,695.0	9,998.3	696.7
RECO	0.0	308.8	(308.8)	0.0	317.3	(317.3)

Net Generation and Load

PJM sums all negative (injections) and positive (withdrawals) load at each designated load bus when calculating net load (accounting load). PJM sums all of the negative (withdrawals) and positive (injections) generation at each generation bus when calculating net generation. Netting withdrawals and injections by bus type (generation or load) affects the measurement of total load and total generation. Energy withdrawn at a generation bus to provide, for example, auxiliary/parasitic power or station power, power to synchronous condenser motors, or power to run pumped storage pumps, is actually load, not negative generation. Energy injected at load buses by behind the meter generation is actually generation, not negative load.

The zonal load-weighted LMP is calculated by weighting the zone's load bus LMPs by the zone's load bus accounting load. The definition of injections and withdrawals of energy as generation or load affects PJM's calculation of zonal load-weighted LMP.

The MMU recommends that during intervals when a generation bus shows a net withdrawal, the energy withdrawal be treated as load, not negative generation, for purposes of calculating load and load-weighted LMP. The MMU also recommends that during intervals when a load bus shows a net injection, the energy injection be treated as generation, not negative load, for purposes of calculating generation and load-weighted LMP.

Fuel Prices, LMP, and Dispatch

Energy Production by Fuel Source

Table 3-53 shows PJM generation by fuel source in GWh for the first three months of 2020 and 2021. In the first three months of 2021, generation from coal units increased 45.6 percent, generation from natural gas units decreased 9.4 percent, and generation from oil increased 24.9 percent compared to the first three months of 2020. Wind and solar output rose by 12.4 percent compared to the first three months of 2020, supplying 4.6 percent of PJM energy in the first three months of 2021.

Table 3-53 Generation (By fuel source (GWh)): January through March, 2020 and 2021^{66 67 68}

	2020 (Jan - Mar)		2021 (Jan - Mar)		Change in Output
	GWh	Percent	GWh	Percent	
Coal	36,129.2	18.0%	52,598.8	25.1%	45.6%
Bituminous	33,412.1	16.7%	47,571.3	22.7%	42.4%
Sub Bituminous	1,259.0	0.6%	3,338.7	1.6%	165.2%
Other Coal	1,458.1	0.7%	1,688.8	0.8%	15.8%
Nuclear	69,142.2	34.5%	68,475.8	32.7%	(1.0%)
Gas	80,158.9	40.0%	72,607.8	34.6%	(9.4%)
Natural Gas CC	77,186.0	38.5%	69,957.1	33.4%	(9.4%)
Natural Gas CT	1,833.0	0.9%	1,758.0	0.8%	(4.1%)
Natural Gas Other Units	586.3	0.3%	434.4	0.2%	(25.9%)
Other Gas	553.6	0.3%	458.4	0.2%	(17.2%)
Hydroelectric	4,522.5	2.3%	4,464.2	2.1%	(1.3%)
Pumped Storage	1,004.8	0.5%	1,064.3	0.5%	5.9%
Run of River	3,224.2	1.6%	3,125.2	1.5%	(3.1%)
Other Hydro	293.4	0.1%	274.7	0.1%	(6.4%)
Wind	7,893.6	3.9%	8,571.3	4.1%	8.6%
Waste	1,054.6	0.5%	1,094.3	0.5%	3.8%
Oil	452.5	0.2%	565.3	0.3%	24.9%
Heavy Oil	0.0	0.0%	0.3	0.0%	NA
Light Oil	19.3	0.0%	166.7	0.1%	764.2%
Diesel	7.9	0.0%	5.4	0.0%	(32.0%)
Other Oil	425.3	0.2%	392.9	0.2%	(7.6%)
Solar, Net Energy Metering	684.6	0.3%	1,071.5	0.5%	56.5%
Battery	8.0	0.0%	9.2	0.0%	15.8%
Biofuel	288.8	0.1%	242.5	0.1%	(16.0%)
Total	200,334.8	100.0%	209,700.7	100.0%	4.7%

66 All generation is total gross generation output and does not net out the MWh withdrawn at a generation bus to provide auxiliary/parasitic power or station power, power to synchronous condenser motors, power to run pumped hydro pumps or power to charge batteries.

67 Net Energy Metering is combined with Solar due to data confidentiality reasons.

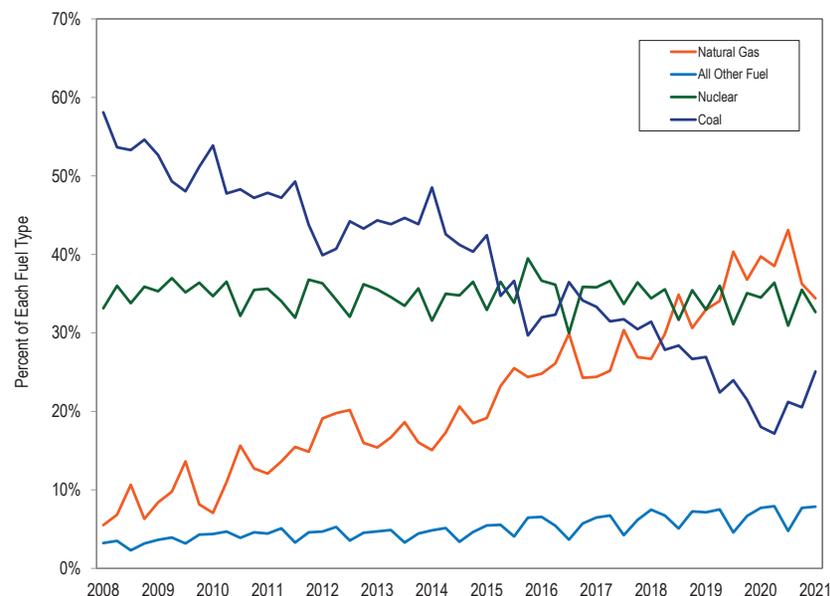
68 Other Gas includes: Landfill, Propane, Butane, Hydrogen, Gasified Coal, and Refinery Gas. Other Coal includes: Lignite, Liquefied Coal, Gasified Coal, and Waste Coal. Other oil includes: Gasoline, Jet Oil, Kerosene, and Petroleum-Other.

Table 3-54 Monthly generation (By fuel source (GWh)): January through March, 2021

	Jan	Feb	Mar	Total
Coal	17,819.1	21,469.5	13,310.2	52,598.8
Bituminous	16,369.6	18,774.2	12,427.5	47,571.3
Sub Bituminous	901.4	2,124.5	312.7	3,338.7
Other Coal	548.1	570.7	570.1	1,688.8
Nuclear	25,133.4	22,125.3	21,217.1	68,475.8
Gas	26,011.2	22,670.8	23,925.7	72,607.8
Natural Gas CC	25,125.8	21,754.9	23,076.4	69,957.1
Natural Gas CT	613.7	577.4	566.9	1,758.0
Natural Gas Other Units	111.3	200.5	122.6	434.4
Other Gas	160.5	138.1	159.8	458.4
Hydroelectric	1,481.8	1,299.8	1,682.7	4,464.2
Pumped Storage	398.4	354.0	311.9	1,064.3
Run of River	994.9	847.5	1,282.8	3,125.2
Other Hydro	88.5	98.3	87.9	274.7
Wind	2,507.3	2,618.9	3,445.2	8,571.3
Waste	386.1	316.6	391.6	1,094.3
Oil	159.7	254.1	151.5	565.3
Heavy Oil	0.0	0.0	0.3	0.3
Light Oil	7.0	136.5	23.2	166.7
Diesel	1.4	2.8	1.2	5.4
Other Oil	151.4	114.8	126.8	392.9
Solar, Net Energy Metering	283.1	255.8	532.7	1,071.5
Battery	2.8	3.3	3.2	9.2
Biofuel	97.4	81.4	63.7	242.5
Total	73,881.8	71,095.4	64,723.4	209,700.7

Figure 3-42 shows generation by natural gas, coal, nuclear and other fuel types in the real-time energy market since 2008.

Figure 3-42 Share of generation by fuel source: January 2008 through March 2021



Fuel Diversity

Figure 3-43 shows the fuel diversity index (FDI_c) for PJM energy generation.⁶⁹ The FDI_c is defined as $1 - \sum_{i=1}^N s_i^2$, where s_i is the share of fuel type i . The minimum possible value for the FDI_c is zero, corresponding to all generation from a single fuel type. The maximum possible value for the FDI_c results when each fuel type has an equal share of total generation. For a generation fleet composed of 10 fuel types, the maximum achievable index is 0.9. The fuel type categories used in the calculation of the FDI_c are the 10 primary fuel sources in Table 3-54 with nonzero generation values. As fuel diversity has increased, seasonality in the FDI_c has decreased and the FDI_c has exhibited less

⁶⁹ Monitoring Analytics developed the FDI to provide an objective metric of fuel diversity. The FDI metric is similar to the HHI used to measure market concentration. The FDI is calculated separately for energy output and for installed capacity.

volatility. Since 2012, the monthly FDI_c has been less volatile as a result of the decline in the share of coal from 51.3 percent prior to 2012 to 33.3 percent from 2012 through March 31, 2021. A significant drop in the FDI_c occurred in the fall of 2004 as a result of the expansion of the PJM market footprint into ComEd, AEP, and Dayton Power & Light Control Zones and the increased shares of coal and nuclear that resulted.⁷⁰ The increasing trend that began in 2008 is a result of decreasing coal generation, increasing gas generation and increasing wind generation. Coal generation as a share of total generation was 54.9 percent for 2008 and 19.3 percent for 2020. Gas generation as a share of total generation was 7.4 percent for 2008 and 39.8 percent for 2020. Wind generation as a share of total generation was 0.5 percent for 2008 and 3.3 percent for 2020.

The FDI_c increased 3.2 percent for the first quarter of 2021 compared to first quarter of 2020. The increase in FDI_c is primarily due to an increase in coal generation in the first quarter of 2021 compared to the first quarter in 2020. The FDI_c was also used to measure the impact on fuel diversity of potential retirements. A total of 4,763 MW of coal, CT, and other capacity were identified as being at risk of retirement.⁷¹ Generation owners that intend to retire a generator are required by the tariff to notify PJM at least 90 days in advance.⁷² There are 4,622.5 MW of generation that have requested retirement after March 31, 2021.⁷³ The at risk units and other generators with deactivation notices generated 6,741.0 GWh in the first quarter of 2021. The dashed line in Figure 3-43 shows a counterfactual result for FDI_c assuming the 6,741.0 GWh of generation from at risk units and other generators with deactivation notices were replaced by gas, wind and solar generation.⁷⁴ The FDI_c for the first quarter of 2021 under the counterfactual assumption would have been 0.4 percent higher than the actual FDI_c.

⁷⁰ See the 2019 State of the Market Report for PJM, Volume 2, Appendix A, "PJM Geography" for an explanation of the expansion of the PJM footprint. The integration of the ComEd Control Area occurred in May 2004 and the integration of the AEP and Dayton control zones occurred in October 2004.

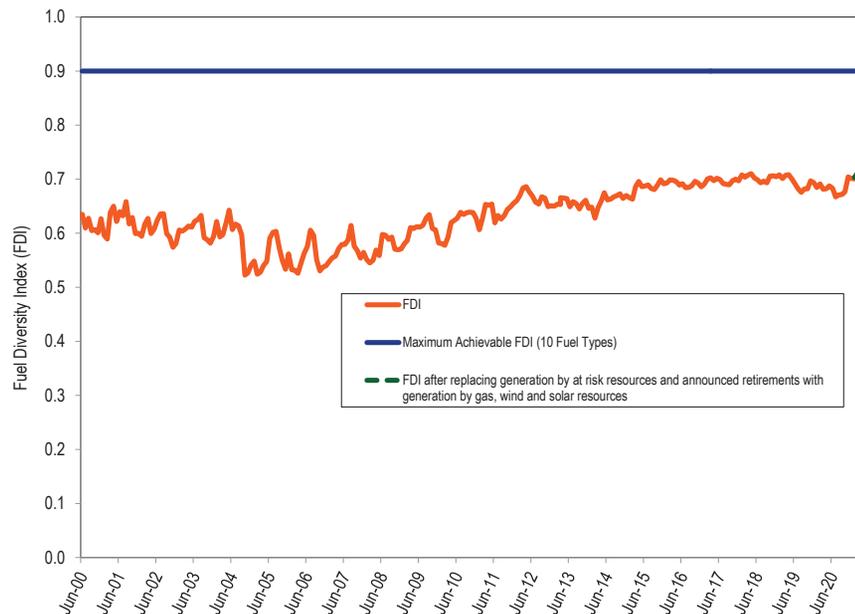
⁷¹ See Table 7-47 in the 2020 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue.

⁷² See PJM. OATT: § V "Generation Deactivation."

⁷³ See 2021 Quarterly State of the Market Report for PJM: January through March, Section 12: Generation and Transmission Planning, Table 12-11.

⁷⁴ It is assumed that 2,295.2 GWh of the replacement energy is from new wind and solar units. This value represents the increase over first quarter 2021 levels in renewable generation that is required by RPS in the first quarter of 2022. The split between solar and wind, 863.7 GWh solar and 1,431.5 GWh wind, is based on queue data.

Figure 3-43 Fuel diversity index for monthly generation: June 2000 through March 2021



Natural Gas Supply Issues

A combination of pipeline transportation and natural gas supplies is needed to deliver natural gas to power plants. A generator could purchase a delivered service in which the seller bundles both the transportation and fuel to make deliveries to the plant. The delivered service could be purchased on either a term contract or a spot basis. A generator could secure pipeline transportation for part or all of the supplies needed to run the plant and purchase commodity natural gas separately with a term supply contract or through daily purchases in the spot market. Other options are also possible.

The increase in natural gas fired capacity in PJM has highlighted issues with the dependence of the PJM system reliability on the fuel transportation arrangements entered into by generators. The risks to the fuel supply for gas

generators, including the risk of interruptible supply on cold days and the ability to get gas on short notice during times of critical pipeline operations, creates risks for the bulk power system. PJM should collect data on each individual generator's fuel supply arrangements, and analyze the associated locational and regional risks to reliability.

In 2019 and 2020, a number of interstate gas pipelines that supply fuel for generators in the PJM service territory issued restriction notices limiting the availability of nonfirm transportation services. These notices include warnings of operational flow orders (OFO) and actual OFOs. These notices may, depending on the nature of the transportation service purchased, permit the pipelines to restrict the provision of gas to 24 hour ratable takes which means that hourly nominations must be the same for each of the 24 hours in the gas day, with penalties for deviating from the nominated quantities. Pipelines may also enforce strict balancing constraints which limit the ability of gas users, depending on the nature of the transportation service purchased, to deviate from the 24 hour ratable take and which may limit the ability of users to have access to unused gas.

Pipeline operators use restrictive and inflexible rules to manage the balance of supply and demand during constrained operating conditions determined by the pipeline. The independent operations of geographically overlapping pipelines during extreme conditions highlights the potential shortcomings of a gas pipeline network that relies on individual pipelines to manage the balancing of supply and demand. The independent operational restrictions imposed by pipelines and the impact on electric generators during extreme conditions demonstrates the potential benefits to creating a separate gas ISO/RTO structure to coordinate the supply of gas across pipelines and with the electric RTOs and to facilitate the interoperability of the pipelines in an explicit network.

Types of Marginal Resources

LMPs result from the operation of a market based on security-constrained, least-cost dispatch in which marginal resources determine system LMPs, based on their offers. Marginal resource designation is not limited to physical resources in the day-ahead energy market. INC offers, DEC bids and up to congestion transactions are dispatchable injections and withdrawals in the day-ahead energy market that can set price via their offers and bids.

Table 3-55 shows the type of fuel used and technology by marginal resources in the real-time energy market. There can be more than one marginal resource in any given interval as a result of transmission constraints. In the first three months of 2021, coal units were 18.0 percent and natural gas units were 69.4 percent of marginal resources. In the first three months of 2021, natural gas combined cycle units were 65.5 percent of marginal resources. In the first three months of 2020, coal units were 17.5 percent and natural gas units were 73.4 percent of the total marginal resources. In the first three months of 2020, natural gas combined cycle units were 71.5 percent of the total marginal resources. In the first three months of 2021, 87.1 percent of the wind marginal units had negative offer prices, 11.9 percent had zero offer prices and 1.0 percent of the wind marginal units had positive offer prices. In the first three months of 2020, 98.9 percent of the wind marginal units had negative offer prices, 1.1 percent had zero offer prices and none had positive offer prices.

The proportion of marginal nuclear units decreased from 1.48 percent in the first three months of 2020 to 0.55 percent in the first three months of 2021. Most nuclear units are offered as fixed generation in the PJM market. A small number of nuclear units were offered with a dispatchable range since 2015. The dispatchable nuclear units do not always respond to dispatch instructions.

Table 3-55 Type of fuel used and technology (By real-time marginal units): January through March, 2017 through 2021⁷⁵

Fuel	Technology	(Jan – Mar)				
		2017	2018	2019	2020	2021
Gas	CC	45.37%	51.77%	62.13%	71.55%	65.49%
Coal	Steam	34.23%	30.40%	24.37%	17.51%	17.95%
Wind	Wind	7.05%	4.54%	3.81%	7.17%	10.36%
Gas	CT	2.79%	4.36%	5.97%	1.03%	3.25%
Oil	CT	5.89%	4.26%	0.49%	0.02%	0.85%
Uranium	Steam	0.78%	0.44%	1.31%	1.48%	0.55%
Other	Solar	0.11%	0.01%	0.07%	0.33%	0.48%
Gas	Steam	2.63%	1.45%	1.29%	0.60%	0.45%
Gas	RICE	0.00%	0.00%	0.37%	0.24%	0.25%
Oil	RICE	0.00%	0.00%	0.05%	0.05%	0.12%
Other	Steam	0.14%	0.20%	0.06%	0.02%	0.10%
Oil	CC	0.00%	0.52%	0.01%	0.00%	0.06%
Oil	Steam	0.00%	1.13%	0.03%	0.00%	0.05%
Municipal Waste	Steam	0.02%	0.03%	0.02%	0.00%	0.02%
Landfill Gas	CT	0.00%	0.00%	0.01%	0.00%	0.01%
Coal	CT	0.00%	0.00%	0.00%	0.00%	0.00%
Municipal Waste	RICE	0.00%	0.00%	0.01%	0.00%	0.00%
Gas	Fuel Cell	0.01%	0.00%	0.00%	0.00%	0.00%
Municipal Waste	RICE	0.00%	0.01%	0.00%	0.00%	0.00%
Municipal Waste	CT	0.00%	0.04%	0.00%	0.00%	0.00%

⁷⁵ The unit type RICE refers to Reciprocating Internal Combustion Engines.

Figure 3-44 shows the type of fuel used by marginal resources in the real-time energy market since 2004. The role of coal as a marginal resource has declined while the role of gas as a marginal resource has increased.

Figure 3-44 Type of fuel used (By real-time marginal units): January through March, 2004 through 2021

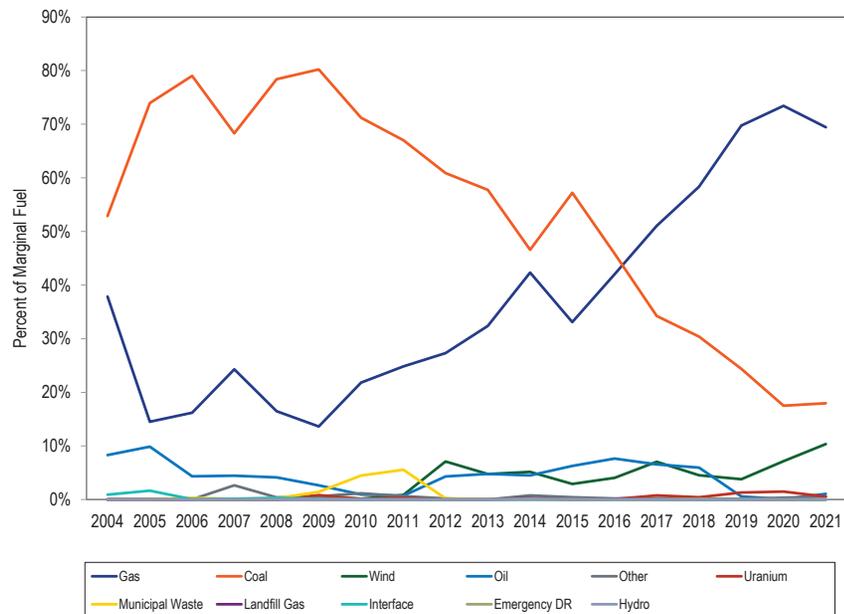


Table 3-56 shows the type of fuel used and technology where relevant, of marginal resources in the day-ahead energy market. In the first three months of 2021, up to congestion transactions were 37.74 percent of marginal resources. Up to congestion transactions were 48.54 percent of marginal resources in the first three months of 2020.

Table 3-56 Day-ahead marginal resources by type/fuel used and technology: January through March, 2017 through 2021

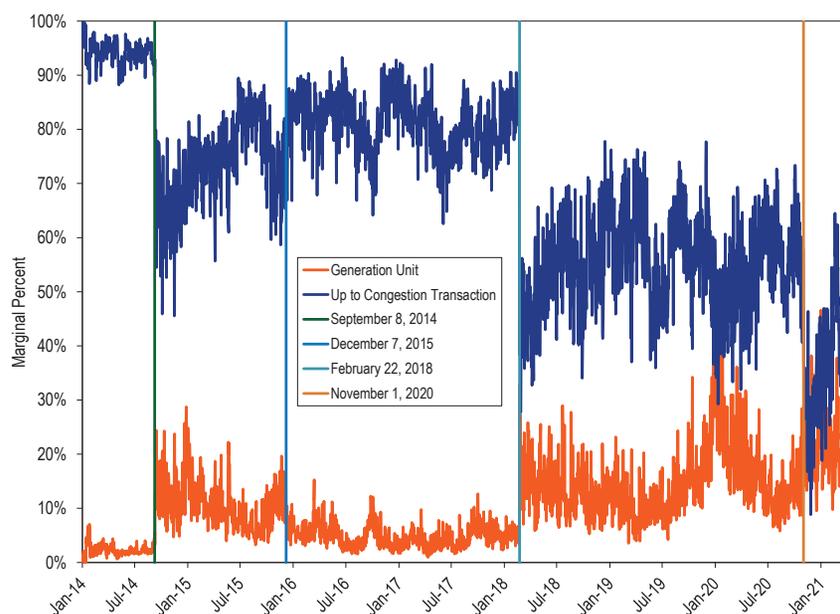
		(Jan - Mar)				
Type/Fuel	Technology	2017	2018	2019	2020	2021
Up to Congestion Transaction	NA	83.14%	76.13%	59.89%	48.54%	37.74%
DEC	NA	7.57%	10.12%	16.67%	12.63%	24.82%
INC	NA	4.54%	6.15%	11.88%	16.21%	16.72%
Gas	CC	1.98%	3.67%	6.32%	15.68%	12.60%
Coal	Steam	1.74%	3.12%	4.68%	5.94%	6.57%
Wind	Wind	0.16%	0.17%	0.11%	0.35%	0.70%
Dispatchable Transaction	NA	0.04%	0.12%	0.16%	0.08%	0.21%
Gas	Steam	0.39%	0.13%	0.09%	0.16%	0.18%
Gas	RICE	0.01%	0.04%	0.06%	0.02%	0.09%
Gas	CT	0.03%	0.16%	0.10%	0.10%	0.07%
Uranium	Steam	0.02%	0.01%	0.00%	0.24%	0.07%
Price Sensitive Demand	NA	0.00%	0.02%	0.01%	0.00%	0.05%
Municipal Waste	RICE	0.00%	0.01%	0.02%	0.01%	0.04%
Other	Steam	0.00%	0.01%	0.01%	0.01%	0.04%
Other	Solar	0.00%	0.00%	0.00%	0.01%	0.03%
Oil	CT	0.34%	0.01%	0.00%	0.03%	0.03%
Oil	RICE	0.04%	0.00%	0.00%	0.00%	0.02%
Oil	CC	0.00%	0.05%	0.00%	0.00%	0.02%
Oil	Steam	0.00%	0.08%	0.00%	0.00%	0.01%
Water	Hydro	0.00%	0.00%	0.00%	0.00%	0.00%
Total		100.00%	100.00%	100.00%	100.00%	100.00%

Figure 3-45 shows, for the day-ahead energy market from January 2014 through March 2021, the daily proportion of marginal resources that were up to congestion transactions and/or generation units. The UTC share decreased from 48.54 percent in the first three months of 2020 to 37.74 percent in the first three months of 2021.

Up to congestion transaction volumes decreased following the allocation of uplift charges on November 1, 2020.⁷⁶

⁷⁶ 172 FERC ¶ 61,046 (2020).

Figure 3-45 Day-ahead marginal up to congestion transaction and generation units: January 2014 through March 2021



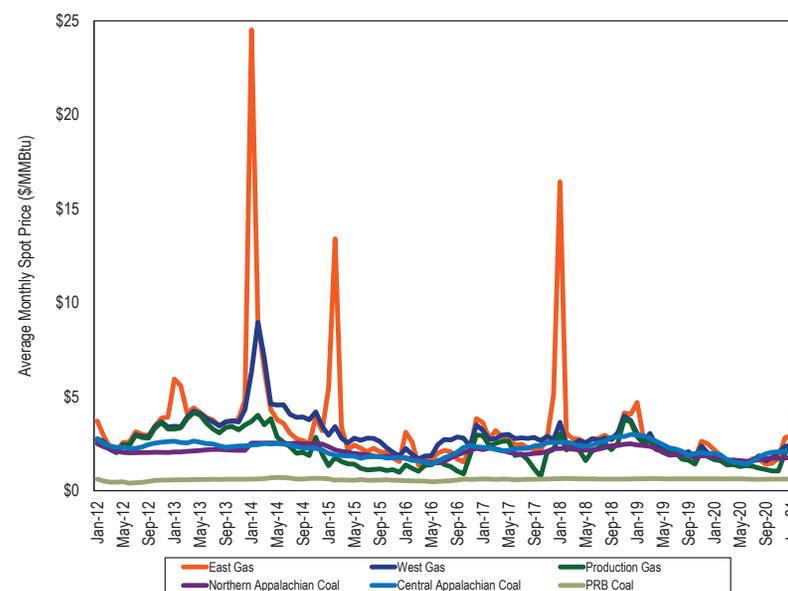
Fuel Price Trends and LMP

In a competitive market, changes in LMP follow changes in the marginal costs of marginal units, the units setting LMP. In general, fuel costs make up between 80 percent and 90 percent of short run marginal cost depending on generating technology, unit efficiency, unit age and other factors. The impact of fuel cost on marginal cost and on LMP depends on the fuel burned by marginal units and changes in fuel costs. Changes in emission allowance costs also contribute to changes in the marginal cost of marginal units.

Figure 3-46 shows fuel prices in PJM for 2012 through March 2021. Natural gas prices increased in the first three months of 2021 compared to the first three months of 2020, as a result of very high gas prices in mid February. Gas price volatility increased and gas price differences among regions increased. Western PJM gas prices were much higher in mid February than eastern PJM

gas prices although both increased significantly. Coal prices were relatively unchanged for the entire time period and across PJM. The price of natural gas in the Marcellus Shale production area is lower than in other areas of PJM. A number of new combined cycle plants have located in the production area since 2016. In the first three months of 2021, the price of production gas was 63.0 percent higher than in the first three months of 2020, the price of eastern natural gas was 84.9 percent higher and the price of western natural gas was 259.2 percent higher. The price of Northern Appalachian coal was 4.5 percent higher; the price of Central Appalachian coal was 15.7 percent higher; and the price of Powder River Basin coal was 1.9 percent lower.⁷⁷ The price of ULSD NY Harbor Barge was 75.8 percent higher.

Figure 3-46 Spot average fuel price comparison: 2012 through March 2021⁷⁸ (\$/MMBtu)



⁷⁷ Eastern natural gas consists of the average of Texas M3, Transco Zone 6 non-NY, Transco Zone 6 NY and Transco Zone 5 daily indices. Western natural gas prices are the average of Columbia Appalachia and Chicago Citygate daily indices. Production gas prices are the average of Dominion South Point, Tennessee Zone 4, and Transco Leidy Line receipts daily indices. Coal prices are the average of daily fuel prices for Central Appalachian coal, Northern Appalachian coal, and Powder River Basin coal. All fuel prices are from Platts.

⁷⁸ This figure is modified from the corresponding figure in the *2020 Quarterly State of the Market Report for PJM: January through June*, which included an error.

Table 3-57 compares the PJM real-time fuel-cost adjusted, load-weighted, average LMP in the first three months of 2021 to the load-weighted, average LMP in the first three months of 2020.⁷⁹ The real-time, load-weighted average LMP in the first three months of 2021 increased by \$10.99 or 55.3 percent from the real-time load-weighted, average LMP in the first three months of 2020. The real-time load-weighted, average LMP for the first three months of 2021 was 51.9 percent higher than the real-time, fuel-cost adjusted, load-weighted average LMP for the first three months of 2021. The real-time, fuel-cost adjusted, load-weighted, average LMP for the first three months of 2021 was 2.2 percent higher than the real-time, load-weighted, average LMP for the first three months of 2020. If fuel and emissions costs in the first three months of 2021 had been the same as in the first three months of 2020, holding the market dispatch constant, the real-time, load-weighted, average LMP in the first three months of 2021 would have been lower, \$20.30 per MWh, than the observed \$30.84 per MWh. Almost all, 95.9 percent of the increase in real-time, load-weighted, average LMP, \$10.54 per MWh out of \$10.99 per MWh, is directly attributable to fuel costs. Contributors to the other \$0.45 per MWh are increased load, adjusted dispatch, including adjustments to dispatch due to changes in relative fuel costs among units, and lower markups.

Table 3-57 Real-time, fuel-cost adjusted, load-weighted average LMP (Dollars per MWh): January through March, 2020 and 2021

	2021 Fuel-Cost Adjusted, Load-Weighted LMP	2021 Load-Weighted LMP	Change	Percent Change
Average	\$20.30	\$30.84	\$10.54	51.9%
	2020 Load-Weighted LMP	2021 Fuel-Cost Adjusted, Load-Weighted LMP	Change	Percent Change
Average	\$19.85	\$20.30	\$0.45	2.2%
	2020 Load-Weighted LMP	2021 Load-Weighted LMP	Change	Change
Average	\$19.85	\$30.84	\$10.99	55.3%

⁷⁹ The fuel-cost adjusted LMP reflects both the fuel and emissions where applicable, including NO_x, CO₂ and SO_x costs.

Table 3-58 shows the impact of each fuel type on the difference between the fuel-cost adjusted, load-weighted, average LMP and the load-weighted, LMP in the first three months of 2021. Table 3-58 shows that lower natural gas prices explain 95.7 percent of the fuel-cost related decrease in the real-time annual, load-weighted, average LMP in the first three months of 2021 from 2020.

Table 3-58 Share of change in fuel-cost adjusted LMP (\$/MWh) by fuel type: January through March, 2021 adjusted to 2020 fuel prices

Fuel Type	Share of Change in Fuel Cost Adjusted,	
	Load Weighted LMP	Percent
Gas	\$10.08	95.7%
Coal	\$0.41	3.8%
Oil	\$0.05	0.5%
Uranium	\$0.00	0.0%
Municipal Waste	\$0.00	0.0%
Other	\$0.00	0.0%
NA	\$0.00	0.0%
Wind	\$0.00	0.0%
Total	\$10.54	100.0%

Components of LMP

Components of Real-Time, Load-Weighted, LMP

LMPs result from the operation of a market based on security-constrained, economic (least cost) dispatch (SCED) in which marginal units determine system LMPs, based on their offers and up to fourteen minute ahead forecasts of system conditions. Those offers can be decomposed into components including fuel costs, emission costs, variable operation and maintenance (VOM) costs, markup, FMU adder and the 10 percent cost adder. As a result, it is possible to decompose LMP by the components of unit offers.

Cost offers of marginal units are separated into their component parts. The fuel related component is based on unit specific heat rates and spot fuel prices. Emission costs are calculated using spot prices for NO_x, SO₂ and CO₂ emission credits, emission rates for NO_x, emission rates for SO₂ and emission rates for CO₂. The CO₂ emission costs are applicable to PJM units in the PJM states

that participate in RGGI: Delaware, Maryland, New Jersey, and Virginia.⁸⁰ The FMU adder is the calculated contribution of the FMU and AU adders to LMP that results when units with FMU or AU adders are marginal.

Since the implementation of scarcity pricing on October 1, 2012, PJM jointly optimizes the commitment and dispatch of energy and reserves. In periods of scarcity when generators providing energy have to be dispatched down from their economic operating level to meet reserve requirements, the joint optimization of energy and reserves takes into account the opportunity cost of the reduced generation and the associated incremental cost to maintain reserves. If a unit incurring such opportunity costs is a marginal resource in the energy market, this opportunity cost will contribute to LMP. In addition, in periods when the SCED solution does not meet the reserve requirements, PJM should invoke shortage pricing. During shortage conditions, the LMPs of marginal generators reflect the cost of not meeting the reserve requirements, the scarcity adder, which is defined by the operating reserve demand curve.

The components of LMP are shown in Table 3-59, including markup using unadjusted cost-based offers.⁸¹ Table 3-59 shows that in the first three months of 2021, 14.0 percent of the load-weighted LMP was the result of coal costs, 56.0 percent was the result of gas costs and 2.8 percent was the result of the cost of carbon emission allowances. Using unadjusted cost-based offers, negative markup was -6.5 percent of the load-weighted LMP. Using unadjusted cost-based offers, positive markup was 5.5 percent of the load weighted LMP. The fuel-related components of LMP reflect the degree to which the cost of the identified fuel affects LMP and does not reflect the other components of the offers of units burning that fuel. The component NA is the unexplained portion of load-weighted LMP. For several intervals, PJM failed to provide all the data needed to accurately calculate generator sensitivity factors. As a result, the LMP for those intervals cannot be decomposed into component costs. The NA component is the cumulative effect of excluding those five minute intervals. The percent column is the difference (in percentage points)

in the proportion of LMP represented by each component in the first three months of 2021 and 2020.

Table 3-59 Components of real-time (Unadjusted), load-weighted, average LMP: January through March, 2020 and 2021

Element	2020 (Jan - Mar)		2021 (Jan - Mar)		Change Percent
	Contribution to LMP	Percent	Contribution to LMP	Percent	
Gas	\$7.95	40.0%	\$17.27	56.0%	16.0%
Coal	\$5.83	29.4%	\$4.33	14.0%	(15.3%)
Constraint Violation Adder	\$0.32	1.6%	\$2.64	8.6%	7.0%
Ten Percent Adder	\$1.65	8.3%	\$2.15	7.0%	(1.3%)
Positive Markup	\$1.67	8.4%	\$1.68	5.5%	(3.0%)
Variable Maintenance	\$1.52	7.7%	\$1.12	3.6%	(4.0%)
NA	\$0.88	4.4%	\$0.88	2.8%	(1.6%)
CO ₂ Cost	\$0.35	1.7%	\$0.87	2.8%	1.1%
Variable Operations	\$0.85	4.3%	\$0.79	2.6%	(1.7%)
Oil	\$0.00	0.0%	\$0.39	1.2%	1.2%
Scarcity Adder	\$0.00	0.0%	\$0.31	1.0%	1.0%
Ancillary Service Redispatch Cost	\$0.02	0.1%	\$0.18	0.6%	0.5%
LPA-SCED Differential	\$0.01	0.1%	\$0.10	0.3%	0.3%
Increase Generation Adder	\$0.06	0.3%	\$0.07	0.2%	(0.1%)
LPA Rounding Difference	\$0.34	1.7%	\$0.06	0.2%	(1.5%)
Opportunity Cost Adder	\$0.02	0.1%	\$0.02	0.1%	(0.0%)
Landfill Gas	(\$0.03)	(0.1%)	\$0.01	0.0%	0.2%
Market-to-Market Adder	\$0.00	0.0%	\$0.01	0.0%	0.0%
Other	\$0.00	0.0%	\$0.00	0.0%	0.0%
SO ₂ Cost	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
NO _x Cost	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Uranium	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Renewable Energy Credits	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Decrease Generation Adder	(\$0.03)	(0.1%)	(\$0.02)	(0.1%)	0.1%
Negative Markup	(\$1.57)	(7.9%)	(\$2.01)	(6.5%)	1.4%
Total	\$19.85	100.0%	\$30.84	100.0%	0.0%

⁸⁰ New Jersey withdrew from RGGI, effective January 1, 2012, and rejoined RGGI effective January 1, 2020. Virginia joined RGGI effective January 1, 2021.

⁸¹ These components are explained in the *Technical Reference for PJM Markets*, at p 27 "Calculation and Use of Generator Sensitivity/Unit Participation Factors," <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

In order to accurately assess the markup behavior of market participants, real-time and day-ahead LMPs are decomposed using two different approaches. In the first approach (Table 3-59 and Table 3-62) markup is the difference between the price offer and the cost-based offer (unadjusted markup). In the second approach (Table 3-60 and Table 3-63), the 10 percent markup is removed from the cost-based offers of coal, gas, and oil units (adjusted markup).

The components of LMP are shown in Table 3-60, including markup using adjusted cost-based offers.

Table 3-60 Components of real-time (Adjusted), load-weighted, average LMP: January through March, 2020 and 2021

Element	2020 (Jan - Mar)		2021 (Jan - Mar)		Change Percent
	Contribution to LMP	Percent	Contribution to LMP	Percent	
Gas	\$7.95	40.0%	\$17.27	56.0%	16.0%
Coal	\$5.83	29.4%	\$4.33	14.0%	(15.3%)
Positive Markup	\$2.55	12.8%	\$2.76	8.9%	(3.9%)
Constraint Violation Adder	\$0.32	1.6%	\$2.64	8.6%	7.0%
Variable Maintenance	\$1.52	7.7%	\$1.12	3.6%	(4.0%)
NA	\$0.88	4.4%	\$0.88	2.8%	(1.6%)
CO ₂ Cost	\$0.35	1.7%	\$0.87	2.8%	1.1%
Variable Operations	\$0.85	4.3%	\$0.79	2.6%	(1.7%)
Oil	\$0.00	0.0%	\$0.39	1.2%	1.2%
Scarcity Adder	\$0.00	0.0%	\$0.31	1.0%	1.0%
Ancillary Service Redispatch Cost	\$0.02	0.1%	\$0.18	0.6%	0.5%
LPA-SCED Differential	\$0.01	0.1%	\$0.10	0.3%	0.3%
Increase Generation Adder	\$0.06	0.3%	\$0.07	0.2%	(0.1%)
LPA Rounding Difference	\$0.34	1.7%	\$0.06	0.2%	(1.5%)
Opportunity Cost Adder	\$0.02	0.1%	\$0.02	0.1%	(0.0%)
Landfill Gas	(\$0.03)	(0.1%)	\$0.01	0.0%	0.2%
Market-to-Market Adder	\$0.00	0.0%	\$0.01	0.0%	0.0%
Other	\$0.00	0.0%	\$0.00	0.0%	0.0%
Ten Percent Adder	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
SO ₂ Cost	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
NO _x Cost	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Uranium	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Renewable Energy Credits	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
Decrease Generation Adder	(\$0.03)	(0.1%)	(\$0.02)	(0.1%)	0.1%
Negative Markup	(\$0.80)	(4.0%)	(\$0.94)	(3.0%)	1.0%
Total	\$19.85	100.0%	\$30.84	100.0%	0.0%

Table 3-61 shows the components of the load weighted LMP, using unadjusted cost based offers, for the seven days between February 13, 2021 and February 18, 2021, when gas prices were high in the PJM region. Table 3-61 shows that in the seven days of 2021 with high gas prices, 13.6 percent of the load-weighted LMP was the result of coal costs and 66.3 percent was the result of gas costs. Using unadjusted cost-based offers, negative markup was -7.5 percent of the load-weighted LMP.

Table 3-61 Components of real-time (Unadjusted), load-weighted, average LMP: February 13, 2021 through February 18, 2021

	13 February - 18 February	
	Contribution to LMP	Percent
Gas	\$50.83	66.3%
Constraint Violation Adder	\$10.42	13.6%
Positive Markup	\$5.64	7.4%
Ten Percent Adder	\$5.07	6.6%
Oil	\$4.73	6.2%
Coal	\$1.43	1.9%
Variable Maintenance	\$1.09	1.4%
CO ₂ Cost	\$1.03	1.3%
Variable Operations	\$0.62	0.8%
NA	\$0.43	0.6%
Ancillary Service Redispatch Cost	\$0.42	0.6%
LPA Rounding Difference	\$0.27	0.3%
LPA-SCED Differential	\$0.15	0.2%
Opportunity Cost Adder	\$0.15	0.2%
Increase Generation Adder	\$0.14	0.2%
Market-to-Market Adder	\$0.03	0.0%
NO _x Cost	\$0.00	0.0%
SO ₂ Cost	\$0.00	0.0%
Decrease Generation Adder	(\$0.03)	(0.0%)
Negative Markup	(\$5.72)	(7.5%)
Total	\$76.61	100.0%

Components of Day-Ahead, Load-Weighted LMP

LMPs result from the operation of a market based on security-constrained, least-cost dispatch in which marginal resources determine system LMPs, based on their offers. For physical units, those offers can be decomposed into their components including fuel costs, emission costs, variable operation and maintenance costs, markup, day-ahead scheduling reserve (DASR)

adder and the 10 percent cost offer adder. INC offers, DEC bids and up to congestion transactions are dispatchable injections and withdrawals in the day-ahead energy market with an offer price that cannot be decomposed. Using identified marginal resource offers and the components of unit offers, it is possible to decompose PJM system LMP using the components of unit offers and sensitivity factors.

Table 3-62 shows the components of the PJM day-ahead, annual, load-weighted, average LMP. In the first three months of 2021, 33.4 percent of the load-weighted LMP was the result of gas costs, 14.0 percent of the load-weighted LMP was the result of coal costs, 24.4 percent was the result of DEC bid costs, 11.2 percent was the result of INC bid costs and 1.5 percent was the result of the up to congestion transaction costs.

Table 3-62 Components of day-ahead, (unadjusted), load-weighted, average LMP (Dollars per MWh): January through March, 2020 and 2021

Element	2020 (Jan - Mar)		2021 (Jan - Mar)		Change Percent
	Contribution to LMP	Percent	Contribution to LMP	Percent	
Gas	\$4.08	20.3%	\$10.56	33.4%	13.1%
DEC	\$2.90	14.4%	\$7.71	24.4%	10.0%
Coal	\$6.42	31.9%	\$4.44	14.0%	(17.9%)
INC	\$2.66	13.2%	\$3.53	11.2%	(2.1%)
Ten Percent Cost Adder	\$1.26	6.3%	\$1.73	5.5%	(0.8%)
CO ₂	\$0.19	0.9%	\$0.78	2.5%	1.5%
Variable Operating Cost	\$0.79	3.9%	\$0.74	2.3%	(1.6%)
Variable Maintenance Cost	\$1.10	5.5%	\$0.66	2.1%	(3.4%)
Up to Congestion Transaction	\$0.53	2.6%	\$0.48	1.5%	(1.1%)
Dispatchable Transaction	\$0.11	0.5%	\$0.46	1.5%	0.9%
Price Sensitive Demand	\$0.00	0.0%	\$0.27	0.8%	0.8%
Municipal Waste	(\$0.00)	(0.0%)	\$0.19	0.6%	0.6%
Oil	\$0.00	0.0%	\$0.07	0.2%	0.2%
NO _x	\$0.00	0.0%	\$0.01	0.0%	0.0%
Other	\$0.00	0.0%	\$0.00	0.0%	0.0%
SO ₂	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
DASR LOC Adder	\$0.00	0.0%	\$0.00	0.0%	0.0%
DASR Offer Adder	\$0.00	0.0%	\$0.00	0.0%	0.0%
Constrained Off	\$0.08	0.4%	(\$0.00)	(0.0%)	(0.4%)
Markup	(\$0.15)	(0.8%)	(\$0.07)	(0.2%)	0.5%
Wind	(\$0.00)	(0.0%)	(\$0.13)	(0.4%)	(0.4%)
Uranium	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
NA	\$0.13	0.7%	\$0.17	0.5%	(0.1%)
Total	\$20.12	100.0%	\$31.58	100.0%	(0.0%)

Table 3-63 shows the components of the PJM day-ahead, annual, load-weighted, average LMP including the adjusted markup calculated by excluding the 10 percent adder from the coal, gas or oil units.

Table 3-63 Components of day-ahead, (adjusted), load-weighted, average LMP (Dollars per MWh): January through March, 2020 and 2021

Element	2020 (Jan - Mar)		2021 (Jan - Mar)		Change Percent
	Contribution to LMP	Percent	Contribution to LMP	Percent	
Gas	\$4.08	20.3%	\$10.56	33.4%	13.1%
DEC	\$2.90	14.4%	\$7.71	24.4%	10.0%
Coal	\$6.42	31.9%	\$4.44	14.0%	(17.9%)
INC	\$2.66	13.2%	\$3.53	11.2%	(2.1%)
Markup	\$1.11	5.5%	\$1.64	5.2%	(0.3%)
CO ₂	\$0.19	0.9%	\$0.78	2.5%	1.5%
Variable Operating Cost	\$0.79	3.9%	\$0.74	2.3%	(1.6%)
Variable Maintenance Cost	\$1.10	5.5%	\$0.66	2.1%	(3.4%)
Up to Congestion Transaction	\$0.53	2.6%	\$0.48	1.5%	(1.1%)
Dispatchable Transaction	\$0.11	0.5%	\$0.46	1.5%	0.9%
Price Sensitive Demand	\$0.00	0.0%	\$0.27	0.8%	0.8%
Municipal Waste	(\$0.00)	(0.0%)	\$0.19	0.6%	0.6%
Oil	\$0.00	0.0%	\$0.07	0.2%	0.2%
Ten Percent Cost Adder	(\$0.00)	(0.0%)	\$0.02	0.1%	0.1%
NO _x	\$0.00	0.0%	\$0.01	0.0%	0.0%
Other	\$0.00	0.0%	\$0.00	0.0%	0.0%
SO ₂	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
DASR LOC Adder	\$0.00	0.0%	\$0.00	0.0%	0.0%
DASR Offer Adder	\$0.00	0.0%	\$0.00	0.0%	0.0%
Constrained Off	\$0.08	0.4%	(\$0.00)	(0.0%)	(0.4%)
Wind	(\$0.00)	(0.0%)	(\$0.13)	(0.4%)	(0.4%)
Uranium	\$0.00	0.0%	\$0.00	0.0%	(0.0%)
NA	\$0.13	0.7%	\$0.17	0.5%	(0.1%)
Total	\$20.12	100.0%	\$31.58	100.0%	0.0%

Shortage

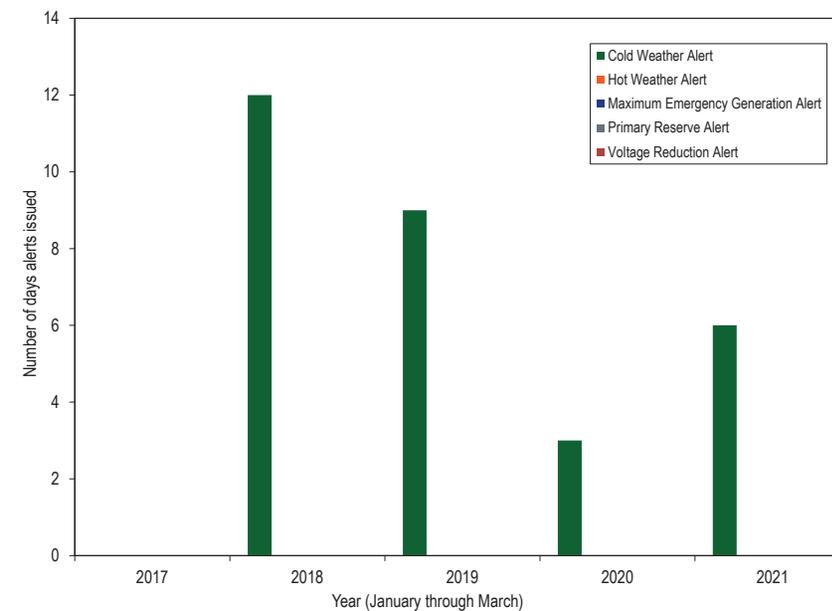
PJM's energy market experienced five minute shortage pricing for four 5 minute intervals on three days in the first three months of 2021. Table 3-64 shows a summary of the number of days emergency alerts, warnings and actions were declared in PJM in the first three months of 2020 and 2021. In the first three months of 2021, there were no emergency actions that triggered a Performance Assessment Interval (PAI). The days with shortage pricing intervals did not correspond to the days with emergency alerts.

Table 3-64 Summary of emergency events declared: January through March, 2020 and 2021

Event Type	Number of days events declared	
	2020 (Jan - Mar)	2021 (Jan - Mar)
Cold Weather Alert	3	6
Hot Weather Alert	0	0
Maximum Emergency Generation Alert	0	0
Primary Reserve Alert	0	0
Voltage Reduction Alert	0	0
Primary Reserve Warning	0	0
Voltage Reduction Warning	0	0
Pre Emergency Mandatory Load Management Reduction Action	0	0
Emergency Mandatory Load Management Reduction Action (30, 60 or 120 minute lead time)	0	0
Maximum Emergency Action	0	0
Emergency Energy Bids Requested	0	0
Voltage Reduction Action	0	0
Shortage Pricing	0	3
Energy export recalls from PJM capacity resources	0	0

Figure 3-47 shows the number of days that weather and capacity emergency alerts were issued in PJM in the first three months of 2017 through 2021.

Figure 3-47 Declared emergency alerts: January through March, 2017 through 2021



Emergency Procedures

PJM declares alerts at least a day prior to the operating day to warn members of possible emergency actions that could be taken during the operating day. In real time, on the operating day, PJM issues warnings notifying members of system conditions that could result in emergency actions during the operating day.

Table 3-65 provides a description of PJM declared emergency procedures.^{82 83 84 85}

Table 3-65 Description of emergency procedures

Emergency Procedure	Purpose
Cold Weather Alert	To prepare personnel and facilities for extreme cold weather conditions, generally when forecast weather conditions approach minimum or temperatures fall below ten degrees Fahrenheit.
Hot Weather Alert	To prepare personnel and facilities for extreme hot and/or humid weather conditions, generally when forecast temperatures exceed 90 degrees with high humidity.
Maximum Emergency Generation Alert	To provide an early alert at least one day prior to the operating day that system conditions may require the use of the PJM emergency procedures and resources must be able to increase generation above the maximum economic level of their offers.
Primary Reserve Alert	To alert members of a projected shortage of primary reserve for a future period. It is implemented when estimated primary reserve is less than the forecast requirement.
Voltage Reduction Alert	To alert members that a voltage reduction may be required during a future critical period. It is implemented when estimated reserve capacity is less than forecasted synchronized reserve requirement.
Pre-Emergency Load Management Reduction Action	To request load reductions from customers registered in the PJM Demand Response program that need 30, 60, or 120 minute lead time before declaring emergency load management reductions
Emergency Mandatory Load Management Reduction Action	To request load reductions from customers registered in the PJM Demand Response program that need 30, 60, or 120 minute lead time to provide additional load relief, generally declared simultaneously with NERC Energy Emergency Alert Level 2 (EEA2)
Primary Reserve Warning	To warn members that available primary reserve is less than required and present operations are becoming critical. It is implemented when available primary reserve is less than the primary reserve requirement but greater than the synchronized reserve requirement.
Maximum Emergency Generation Action	To provide real time notice to increase generation above the maximum economic level. It is implemented whenever generation is needed that is greater than the maximum economic level.
Voltage Reduction Warning & Reduction of Non-Critical Plant Load	To warn members that actual synchronized reserves are less than the synchronized reserve requirement and that voltage reduction may be required.
Deploy All Resources Action	For emergency events that do not evolve over time, but rather develop rapidly and without prior warning, PJM issues this action to instruct all generation resources to be online immediately and to all load management resources to reduce load immediately.
Manual Load Dump Warning	To warn members of the critical condition of present operations that may require manually dumping load. Issued when available primary reserve capacity is less than the largest operating generator or the loss of a transmission facility jeopardizes reliable operations after all other possible measures are taken to increase reserve.
Voltage Reduction Action	To reduce load to provide sufficient reserve capacity to maintain tie flow schedules and preserve limited energy sources. It is implemented when load relief is needed to maintain tie schedules.
Manual Load Dump Action	To provide load relief when all other possible means of supplying internal PJM RTO load have been used to prevent a catastrophe within the PJM RTO or to maintain tie schedules so as not to jeopardize the reliability of the other interconnected regions.

82 See PJM. "Manual 13: Emergency Operations," Rev. 77 (Jan. 1, 2021), Section 3.3 Cold Weather Alert.

83 See PJM. "Manual 13: Emergency Operations," Rev. 77 (Jan. 1, 2021), Section 3.4 Hot Weather Alert.

84 See PJM. "Manual 13: Emergency Operations," Rev. 77 (Jan. 1, 2021), Section 2.3.1 Advanced Notice Emergency Procedures: Alerts.

85 See PJM. "Manual 13: Emergency Operations," Rev. 77 (Jan. 1, 2021), Section 2.3.2 Real-Time Emergency Procedures (Warnings and Actions).

Table 3-66 shows the dates when emergency alerts and warnings were declared and when emergency actions were implemented in the first three months of 2021.

Table 3-66 Declared emergency alerts, warnings and actions: January through March, 2021

Date	Cold Weather Alert	Hot Weather Alert	Maximum Emergency Generation Alert	Primary Reserve Alert	Voltage Reduction Alert	Primary Reserve Warning	Voltage Reduction Warning and Reduction of Non-Critical Plant Load	Maximum Emergency Generation Action	Pre-Emergency Mandatory Load Management Reduction	Emergency Mandatory Load Management Reduction	Voltage Reduction	Manual Load Dump Warning	Manual Load Dump Action	Load Shed Directive
2/7/2021	Western except EKPC													
2/8/2021	Western except EKPC													
2/9/2021	COMED													
2/10/2021	COMED													
2/14/2021	COMED													
2/15/2021	Western													

Power Balance Constraint Violation

On October 1, 2019, the power balance constraint was violated in 11 approved RT SCED solutions. On February 16, 2020, the power balance constraint was violated in one approved RT SCED solution which was used to set prices for three five minute intervals. On March 22, 2021, the power balance constraint was violated in one approved RT SCED solution. In the RT SCED optimization, the power balance constraint enforces the requirement that total dispatched generation (supply) equals the sum total of forecasted load, losses and net interchange (demand). The power balance constraint is violated when supply is less than demand. In some cases, the power balance constraint is violated while the reserve requirements are satisfied.

The current process for meeting energy and reserve requirements in real time, and pricing the system conditions when RT SCED forecasts that energy supply is less than the demand for energy and reserves, is opaque and not defined in the PJM governing documents. It is unclear whether and how PJM would convert reserves to energy before violating power balance. It is unclear whether and when PJM would use its authority under the tariff to curtail exports from PJM capacity resources to meet the power balance constraint.

It is unclear whether PJM would maintain a minimum level of synchronized reserves even if that would result in a controlled load shed. The current RT SCED does not have a mechanism to convert inflexible reserves procured by ASO to energy to satisfy the power balance constraint.⁸⁶ SCED solutions from October 1, 2019, February 16, 2020, and April 21, 2020, indicate that

the currently defined logic meets transmission constraint limits and reserve requirements but violates the power balance constraint, and does not reflect this constraint violation in prices. This logic, if correctly described, is not consistent with basic economics. The overall solution is complex and must be integrated with the approach to shortage pricing.

The MMU recommends that PJM clarify, modify and document its process for dispatching reserves and energy when SCED indicates that supply is less than total demand including forecasted load and reserve requirements. The modifications should define: a SCED process to economically convert reserves to energy; a process for the recall of energy from capacity resources; and the minimum level of synchronized reserves that would trigger load shedding.

Table 3-67 shows the number of five minute intervals for which the RT SCED solutions used to set prices did not balance demand and supply. PJM reran the RT SCED with artificially increased supply to satisfy the power balance constraint. In the first three months of 2021, there was one 5 minute interval using an RT SCED solution with a violated power balance constraint. The average energy component of LMP in that 5 minute interval with artificially

⁸⁶ Inflexible reserves are those reserves that clear in the hour ahead Ancillary Service Optimizer (ASO) but cannot be dispatched in the real time dispatch tool, RT SCED.

increased supply to satisfy the power balance constraint was \$3,685.20 per MWh.⁸⁷

Table 3-67 Number of five minute intervals using RT SCED solutions with violated power balance constraint by year

Year	Number of five minute intervals	Average Energy Component of LMP (\$/MWh)
2013	-	\$0.00
2014	655	\$36.29
2015	71	(\$0.76)
2016	42	\$93.06
2017	31	\$279.86
2018	16	\$268.21
2019	36	\$845.48
2020	5	\$351.56
2021 (Jan - Mar)	1	\$3,685.20

Balancing Ratio for Local Emergency Events

The balancing ratio is theoretically defined as the ratio of actual load and reserve requirements in an area during an emergency event to the total committed capacity in the area. In the case of the PAIs declared in 2018 that were triggered due to transmission outages in limited locations, if the area is defined as the location where the load was shed, the balancing ratio is undefined because there were no committed resources in the area, other than less than 1.0 MW of demand response.⁸⁸ It is not appropriate or correct to calculate a balancing ratio as a measure of capacity needed during these events by defining a wider area to include committed capacity. It is also not appropriate to use a balancing ratio defined in that way in defining the capacity market offer cap. PJM calculated the balancing ratio for the localized load shed that occurred in the AEP Edison area in 2018 and used the average balancing ratio during the event to calculate the capacity market seller offer cap for all LDAs for the 2022/2023 Delivery Year.⁸⁹ These events occurred in a very small local area where no capacity resources were held to CP performance requirements. Assessing nonperformance to resources located in the wider area would not be

⁸⁷ The energy component of LMP, or the shadow price of the power balance constraint, is the incremental cost of meeting a one MWh increase in the system load.

⁸⁸ See 2018 State of the Market Report for PJM, Volume II, Section 3: Energy Market, at Scarcity, pp. 201 – 202.

⁸⁹ See PJM, "Capacity Market Seller Offer Cap Values," (March 15, 2019), which can be accessed at <<https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2022-2023/2022-2023-cp-market-seller-offer-cap-values.ashx?la=en?>>.

appropriate because their performance would not have helped, and may have even exacerbated the transmission issues identified during these events. These events also do not reflect the type of events that are modeled to define the target installed reserve margin in the capacity market. The MMU recommends, if the capacity market seller offer cap were to be calculated using the historical average balancing ratio, that PJM not include the balancing ratios calculated for localized Performance Assessment Intervals (PAIs), and only include those events that trigger emergencies at a defined zonal or higher level.

Performance Assessment Intervals

PJM currently triggers a PAI any time it declares a pre-emergency load management reduction action, or a more severe emergency action.⁹⁰ PJM's trigger for PAI is subjective, and it should be based on a quantifiable, transparent metric of the need for capacity in the PJM system. For example, in ISO New England, under the Pay for Performance design, resources are assessed for performance during Capacity Scarcity Conditions ("CSCs") that occur when the system or local area is short on ten and thirty minute nonspinning reserves.⁹¹ Reserve shortages are determined based on a predefined reserve requirement, and the reserve calculation that is embedded in the real-time dispatch tool.

The October 2, 2019, PAI provided actual data and evidence on the issues with PJM's triggers, and PJM's treatment of excused MW. The PAI on October 2, 2019, was triggered when PJM declared a pre-emergency load management reduction action in the AEP, BGE, Dominion and Pepco zones based on anticipated high load relative to the available supply. The actual load was significantly lower than forecasted.⁹²

On October 1, 2019, the day before the PAI, PJM did experience high load relative to the available supply. The system conditions were reflected in the market outcomes with multiple intervals of high prices, and reserve shortages.⁹³

⁹⁰ OATT Definitions at "Emergency Action".

⁹¹ ISO New England Inc. Internal Market Monitor, "2018 Annual Markets Report," (May 23, 2019) at 156 (§ 6.2.2 (Pay-for-Performance Outcomes)).

⁹² In a report reviewing the PAI, PJM stated: "The most striking anomaly was load levels in the AEP and Mid-Atlantic zones that came in significantly below forecast." See PJM, "A Review of the October 2019 Performance Assessment Event," (2019) at 1, which can be accessed at <<https://www.pjm.com/-/media/markets-ops/rpm/review-of-october-2019-performance-assessment-event.ashx?>>.

⁹³ See Monitoring Analytics, LLC, 2019 State of the Market Report for PJM, Section 3 Energy Market at 176 – 180 (Analysis of October 1 Events).

The decision to declare a pre-emergency load management reduction action on October 2, 2019, was based on an expectation of the repetition of the events on October 1, 2019, which did not materialize. This illustrates the shortcomings of triggering PAIs based on PJM operator declared emergency actions or pre-emergency load management reduction, instead of using a quantitative metric that is readily available to PJM, such as reserves.⁹⁴ Given this implementation, it can no longer be assumed that PAI would occur when the PJM region, or a subset of zones in the PJM region are experiencing capacity shortage conditions.

Shortage and Shortage Pricing

In electricity markets, shortage means that demand, including reserve requirements, is nearing the limits of the currently available capacity of the system. Shortage pricing is a mechanism for signaling scarcity conditions through high energy prices. Under the PJM rules that were in place through September 30, 2012, shortage pricing resulted from the exercise of aggregate market power by individual generation owners for specific units when the system was close to its available capacity. But this was not an efficient way to manage shortage pricing and made it difficult to distinguish between market power and shortage pricing. Shortage pricing is an administrative pricing mechanism in which PJM sets a high energy price at a predetermined level when the system operates with less real-time reserves than required.

In the first three months of 2021, there were four 5 minute intervals with shortage pricing that occurred on three days in PJM.

With Order No. 825, the Commission required each RTO/ISO to trigger shortage pricing for any dispatch and pricing interval in which a shortage of energy or operating reserves is indicated by the RTO/ISO's software.⁹⁵ Prior to May 11, 2017, if the dispatch tools (Intermediate-Term SCED and Real-Time SCED) reflected a shortage of reserves (primary or synchronized) for a time period shorter than a defined threshold (30 minutes), it was considered a transient shortage, a shortage event was not declared, and shortage pricing was not

⁹⁴ There are existing issues with the accuracy of reserve measurement in PJM, and they should also be resolved by improving generator modeling in the energy market.

⁹⁵ 155 FERC ¶ 61,276 ("Order No. 825") at P 162.

implemented. As of May 11, 2017, the rule requires PJM to trigger shortage pricing for any five minute interval for which the Real-Time SCED (Security Constrained Economic Dispatch) indicates a shortage of synchronized reserves or primary reserves. PJM did not implement the rule as intended in Order No. 825, because RT SCED can indicate a shortage that PJM does not use in pricing. In January 2019, PJM updated its business rules in Manual 11 to describe PJM's implementation of the five minute shortage pricing process. PJM Manual 11 states that shortage pricing is triggered when an approved RT SCED case that was used in the Locational Pricing Calculator (LPC) indicates a shortage of reserves. Beginning February 24, 2020, PJM changed the RT SCED automatic execution frequency to once every four minutes, from the previous three minutes. On June 22, 2020, PJM reduced the frequency of automatic RT SCED executions to match the frequency of pricing at five minutes, which reduced the frequency of unpriced shortage solutions.

Voltage reduction actions and manual load dump actions are also triggers for shortage pricing, reflecting the fact that when operators need to take these emergency actions to maintain reliability, the system is short reserves and prices should reflect that condition, even if the data do not show a shortage of reserves.⁹⁶

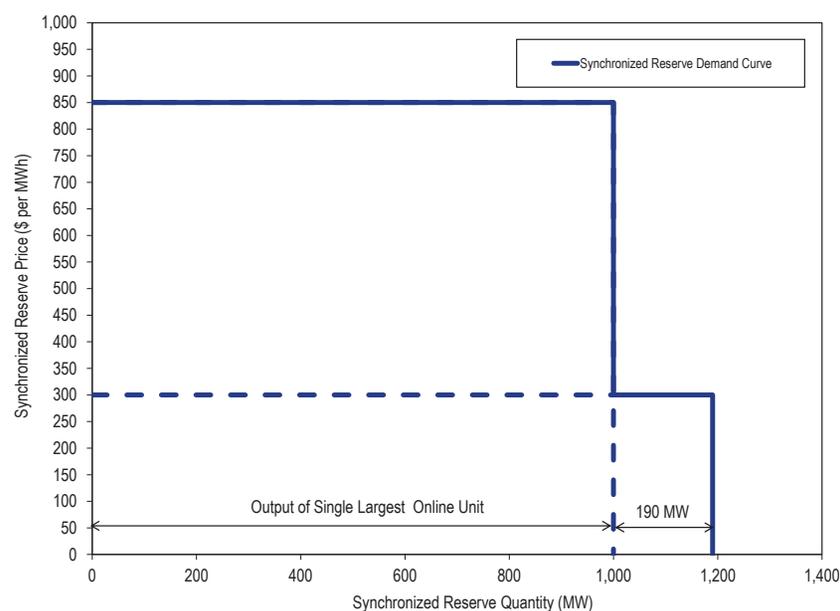
Operating Reserve Demand Curves

Since July 12, 2017, the PJM synchronized reserve requirement in a reserve zone or a subzone is the actual output of the single largest online unit in that reserve zone or subzone. The primary reserve requirement in a reserve zone or a subzone is 150 percent of the actual output of the single largest online unit in that reserve zone or subzone. The first step of the demand curves for primary and synchronized reserves are set at the primary and synchronized reserve requirement. Since the primary and synchronized reserve requirements are based on the actual output of the largest resource, the MW value of the first step changes in real time based on the real-time dispatch solution. The first step is priced at \$850 per MWh. The second step of the primary and synchronized reserve demand curves extends the primary and

⁹⁶ See, e.g., Scarcity and Shortage Pricing, Offer Mitigation and Offer Caps Workshop, Docket No. AD14-14-000, Transcript 29:21-30:14 (Oct. 28, 2014).

synchronized reserve requirements. The extended primary and synchronized reserve requirements are defined as the primary and synchronized reserve requirements, plus 190 MW. This 190 MW second step is priced at \$300 per MWh. Figure 3-48 shows an example of the updated synchronized reserve demand curve when the output of the single largest unit in the region equals 1,000 MW.

Figure 3-48 Synchronized reserve demand curve showing the permanent second step



Shortage Pricing and Energy Price Formation

The current operating reserve demand curves (ORDC) in PJM define an administrative price for estimated reserves (primary and synchronized reserves) up to the extended reserve requirement quantities. The demand curve shown in Figure 3-48 drops to a zero price for quantities above the extended reserve requirement. The price for reserve quantities less than the

reserve requirement is \$850 per MWh, and the price for reserve quantities above the reserve requirement to 190 MW above the reserve requirement is \$300 per MWh.

The shortage prices set by the ORDC are added to LMP during shortages. When multiple reserve products are short or when reserves are short in multiple zones, the ORDC prices are additive. Currently, the highest possible shortage penalty in LMP is \$3,400 per MWh, which is the \$850 per MWh price times four, for two reserve products (synchronized reserve and nonsynchronized reserve) times two reserve zones, RTO and MAD. However, PJM caps the system marginal energy price at \$3,750, which is the sum of the highest possible energy offer, the synchronized reserve penalty factor, the primary reserve penalty factor, and a \$50 per MWh threshold. The current market rules cap the additive reserve shortage penalty factors for the MAD synchronized reserve market clearing price to the sum of the synchronized reserve penalty factor and the primary reserve penalty factor, which is \$1,700 per MW.⁹⁷ The \$1,700 per MWh penalty applies any time PJM initiates a manual load dump action or voltage reduction action.⁹⁸

Table 3-68 shows six example scenarios, under the current ORDCs, with combinations of energy offers, reserve shortage penalty factors and transmission constraint penalty factors that can add up to produce high LMPs at sample nodes in the MAD Reserve Subzone and outside the MAD Reserve Subzone.

In scenario B, there is a reserve shortage for both primary and synchronized reserves in both MAD and RTO Reserve Zones that results in a \$1,700 per MWh reserve shortage penalty in the RTO zone LMP and a \$3,400 per MWh reserve shortage penalty in the MAD zone LMP. The marginal resource for energy is in the RTO zone, and the RTO to MAD reserve transfer constraint is not binding, so the higher MAD reserve penalty does not affect the rest of RTO

⁹⁷ See PJM Operating Agreement, Schedule 1, Section 3.2.3A(d)(ii). The cap on the additive reserve shortage penalty factors in MAD was not reflected in the prior report and the maximum in MAD was therefore overstated. See: *2020 Quarterly State of the Market Report for PJM: January through September*, p. 192.

⁹⁸ See PJM. "Manual 11: Energy & Ancillary Services Market Operations," Rev. 112 (Jan. 5, 2021), 2.8 The Calculation of Locational Marginal Prices (LMPs) During Emergency Procedures.

LMP. In scenario C, there is a reserve shortage for both primary and synchronized reserves in both MAD and RTO Reserve Zones and a violated transmission constraint that affects the congestion costs in the system marginal price.

In scenario C, the sum of the reserve and transmission constraint penalty factors equals \$5,450 per MWh, which exceeds \$3,750 per MWh, so SMP capping is triggered whether the marginal unit for energy is in the MAD or RTO zone.

In scenario D, with a \$1,000 per MWh offer price for the marginal unit for energy, violation of all four reserve penalty factors only triggers SMP capping if the marginal unit for energy can serve the MAD reserve requirement. Scenario E and F show that LMPs can exceed \$3,750 per MWh if there is a violated transmission constraint that is not exacerbated by an increase in load at the load weighted reference pricing node, which determines the SMP.⁹⁹

In Scenario F, the energy component of LMP is at its highest level, \$2,000 per MWh and there is a reserve shortage for both primary and synchronized reserves in both MAD and RTO Reserve Zones that results in the \$1,700 per MWh scarcity adder, and a violated transmission constraint with \$2,000 per MWh penalty factor that results in a \$5,700 per MWh LMP. The LMPs in Scenario F are not the highest possible LMPs in the PJM energy market under the current rules. If there are multiple violated transmission constraints, the congestion costs contributing to the LMP at a pnode can exceed \$2,000 per MWh resulting in LMPs higher than \$5,700 per MWh. The extent to which each violated transmission penalty factor affects the LMP at a pnode is directly proportional to the pnode's distribution factor (dfax) with respect to that constraint.

Table 3-68 Additive penalty factors under reserve shortage and transmission constraint violations: Status Quo

Scenario	Marginal Unit Offer Price	Synchronized Reserve Penalty Factor		Primary Reserve Penalty Factor		Congestion Cost in SMP	System Marginal Price		Congestion Cost in CLMP	Total LMP	
		RTO	MAD	RTO	MAD		MAD Marginal	RTO Marginal		MAD Marginal	RTO Marginal
A	\$50	\$850	\$0	\$0	\$0	\$0	\$900	\$900	\$0	\$900	\$900
B	\$50	\$850	\$850	\$850	\$850	\$0	\$3,450	\$1,750	\$0	\$3,450	\$1,750
C	\$50	\$850	\$850	\$850	\$850	\$2,000	\$3,750	\$3,750	\$0	\$3,750	\$3,750
D	\$1,000	\$850	\$850	\$850	\$850	\$0	\$3,750	\$2,700	\$0	\$3,750	\$2,700
E	\$1,000	\$850	\$850	\$850	\$850	\$2,000	\$3,750	\$3,750	\$2,000	\$5,750	\$5,750
F	\$2,000	\$850	\$850	\$850	\$850	\$2,000	\$3,750	\$3,750	\$2,000	\$5,750	\$5,750

Changes to the ORDC, approved by FERC and planned for implementation in 2022, will increase the price for reserve quantities less than the reserve requirement to \$2,000 per MWh.¹⁰⁰ For each reserve quantity greater than the reserve requirement, PJM will multiply an assumed probability of a reserve shortage, based on historic forecast error, by \$2,000 per MWh, creating an extended downward sloping ORDC. The extended ORDC is an administratively determined reserve price that will be added to LMP, as a scarcity pricing adder, when no shortage exists. The \$2,000 per MWh price is unjustified because the highest possible energy offer under most circumstances is only \$1,000 per MWh. Only in the unusual circumstance when short run marginal costs exceed \$1,000 per MWh is a higher ORDC price justified. When energy offers exceed \$1,000 per MWh, they have to be verified and pre-approved by PJM and cannot exceed \$2,000 per MWh, to be eligible to set LMP in the PJM energy market.

⁹⁹ The impact of the transmission constraint penalty factor at a pnode depends on its distribution factor (dfax) with respect to the constraint. The scenarios here assume a single violated transmission constraint with dfax of 1.0. If there are multiple violated transmission constraints, the total impact at a pnode is the sum of the product of transmission constraint penalty factors and distribution factors.

¹⁰⁰ See 171 FERC ¶ 61,153 (2020), *order on reh'g*, 173 FERC ¶ 61,123 (2020).

The highest possible scarcity adder increases under the planned changes to the ORDC. The highest possible scarcity adder will be \$10,000 per MWh, which is the \$2,000 per MWh price times five. The five products are the synchronized and nonsynchronized reserve products for RTO and MAD Zones plus a new secondary 30 minute reserve product for the RTO Zone.

Table 3-69 shows example scenarios, under the ORDCs planned for implementation in 2022, with combinations of energy offers, reserve shortage penalty factors and transmission constraint penalty factors that can add up to produce LMPs at sample pnodes in the MAD Reserve Subzone and outside the MAD Reserve Subzone. In scenario B, there is a reserve shortage for both primary and synchronized reserves in both the MAD and RTO Reserve Zones and reserve shortage for secondary reserve in the RTO Zone that results in the \$10,000 per MWh scarcity adder in MAD. The \$10,000 per MWh scarcity adder applies any time PJM initiates a manual load dump action or voltage reduction action. In scenario C, there is a reserve shortage for both primary and synchronized reserves in both the MAD and RTO Reserve Zones, a reserve shortage for secondary reserve in the RTO Zone, that results in the \$10,000 per MWh scarcity adder, and a violated transmission constraint with a \$2,000 per MWh penalty factor that results in a \$12,050 per MWh LMP at a pnode in MAD.¹⁰¹

In Scenario E, the Energy Component of LMP is at its highest level, \$2,000 per MWh and there is a reserve shortage for both primary and synchronized reserves in both MAD and RTO Reserve Zones and a secondary reserve shortage, resulting in the \$10,000 per MWh scarcity adder, and a violated transmission constraint with a \$2,000 per MWh penalty factor that results in a \$14,000 per MWh LMP at a pnode in MAD. The LMPs in Scenario E are not the highest possible LMPs in the PJM energy market under the ORDCs planned for implementation in 2022. If there are multiple violated transmission constraints, the transmission constraint penalty factors' contribution to the LMP at a pnode can exceed \$2,000 per MWh resulting in LMPs higher than \$14,000 per MWh. The extent to which each violated transmission penalty factor affects the LMP at a pnode is directly proportional to the pnode's distribution factor (dfax) with respect to that constraint.

Table 3-69 Additive penalty factors under shortage conditions and transmission constraint violation

Scenario	Energy Component of LMP	Synchronized Reserve Penalty Factor		Primary Reserve Penalty Factor		Secondary Reserve Penalty Factor	Transmission Constraint Penalty Factor	Total LMP in MAD	Total LMP outside MAD
		RTO	MAD	RTO	MAD	RTO			
A	\$50	\$2,000	\$200	\$200	\$200	\$0	\$0	\$2,650	\$2,250
B	\$50	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$0	\$10,050	\$6,050
C	\$50	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$12,050	\$8,050
D	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$13,000	\$9,000
E	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$14,000	\$10,000

¹⁰¹ The impact of the transmission constraint penalty factor at a pnode depends on its distribution factor (dfax) with respect to the constraint. The scenarios here assume a single violated transmission constraint with dfax of 1.0. If there are multiple violated transmission constraints, the total impact at a pnode is sum of the product of transmission constraint penalty factors and distribution factors.

Operator Actions

Actions taken by PJM operators to maintain reliability, such as committing more reserves than required, may suppress reserve prices. The need to commit more reserves could instead be directly reflected in the ORDC when operational issues arise, allowing the market to efficiently account for the reliability commitment in the energy and reserves markets. Instead, the new ORDC will be inflated at all times based on average historical forecast error that may or may not have resulted in operator actions to commit additional reserves.

Locational Reserve Requirements

In addition to the construction of the operating reserve demand curves to reflect the value of maintaining reserves and avoiding a loss of load event, the modeling of reserve requirements should reflect locational needs and should price operator actions to, for example, commit more reserves when specific needs arise.

The current operating reserve demand curves are modeled for reserve requirements for the RTO level (RTO Reserve Zone) and for the Mid-Atlantic and Dominion region (MAD Subzone). This was a result of historical congestion patterns where limits to transmission capacity to deliver power from outside the MAD Subzone into the MAD Subzone necessitated maintaining reserves in the MAD area to respond to disturbances within the subzone. On most days, the MAD Subzone is no longer relevant. PJM may need to maintain or operate resources in other local areas to maintain local reliability. Currently, these units are committed out of market for reliability reasons, or the reserve need is modeled as an artificial closed loop interface with limited deliverability modeled inside the closed loop from resources located outside. The value of operating these resources, including generators that are manually committed for reliability and demand resources that may be dispatched inside a closed loop, is not correctly reflected in prices. A more efficient way to reflect these requirements would be to have locational reserve requirements that are adjusted based on PJM forecasts and reliability studies.

Reserve Shortages in 2021

Reserve Shortage in Real-Time SCED

The MMU analyzed the RT SCED solutions to determine how many of the RT SCED solutions indicated a shortage of any of the reserve products (synchronized reserve and primary reserve at RTO Reserve Zone and MAD Reserve Subzone), how many of these solutions were approved by PJM, and how many of these were used in LPC to calculate prices. Reserves are considered short if the quantity (MW) of reserves dispatched by RT SCED for a five minute interval was less than the extended reserve requirement. Table 3-70 shows the number and percent of RT SCED solutions that indicated a shortage of any of the four reserve products (RTO synchronized reserve, RTO primary reserve, MAD synchronized reserve, and MAD primary reserve), the number and percent of the RT SCED solutions with shortage that were approved by PJM, and the number and percent of the RT SCED solutions with shortage that were used in LPC to calculate real-time prices.

Table 3-70 shows that, in the first three months of 2021, PJM operators approved four RT SCED solutions that indicated a shortage of reserves, from a total of 567 RT SCED solutions that indicated shortage. All of the four approved RT SCED solutions with reserve shortage were used in LPC for LMPs and reserve clearing prices. In the first three months of 2020, PJM operators approved zero solutions that indicated a shortage of reserves, from a total of 805 RT SCED solutions that indicated shortage. It is unclear what criteria PJM operators use to approve the RT SCED solutions to send dispatch signals to resources. In the first three months of 2021, the frequency with which RT SCED solutions are approved has improved to one solution per five minute interval. This approval frequency has improved the proportion of approved SCED solutions that are reflected in LMPs. However, the process of selecting the SCED solution to approve, among the solutions available to PJM operators, is subjective, and is not based on clearly defined criteria. The criteria are especially important when only a subset of the SCED solutions reflects shortage pricing, and the rest of the solutions do not.

Table 3–70 RT SCED cases with reserve shortage: January through March, 2021

Month (2021)	Number of RT SCED Solutions	Number of RT SCED Solutions With Reserve Shortage	Number of Approved RT SCED Solutions With Reserve Shortage	Number of Approved RT SCED Solutions With Reserve Shortage Used in LPC	Solutions With Reserve Shortage as Percent of Total RT SCED Solutions	Approved RT SCED Solutions With Reserve Shortage as Percent of RT SCED Solutions With Shortage	RT SCED Solutions With Shortage Used in LPC as Percent of RT SCED Solutions With Shortage
Jan	31,395	146	0	0	0.5%	0.0%	0.0%
Feb	30,489	148	0	0	0.5%	0.0%	0.0%
Mar	32,456	273	4	4	0.8%	1.5%	1.5%
Total	94,340	567	4	4	0.6%	0.7%	0.7%

While there were 567 RT SCED solutions that indicated shortage, the number of RT SCED target times for which RT SCED indicated shortage was only 420. PJM generally solves one RT SCED case with three solutions per case, for each five minute target time.^{102 103}

The MMU analyzed the target times for which one or more RT SCED case solutions indicated a shortage of one or more reserve products. Table 3-71 shows, for each month of 2020 and the first three months of 2021, the total number of target times, the number of target times for which at least one RT SCED solution showed a shortage of reserves, the number of target times for which more than one RT SCED solution showed a shortage of reserves, and the number of five minute pricing intervals for which the LPC solution showed a shortage of reserves. Table 3-71 shows that 420 target times, or 1.6 percent of all five minute target times in the first three months of 2021, had at least one RT SCED solution showing a shortage of reserves, and 96 target times, or 0.4 percent of all five minute target times in the first three months of 2021, had more than one RT SCED solution showing a shortage of reserves.

Table 3–71 Five minute SCED target times and pricing intervals with shortage: January 2020 through March 2021

Year, Month	Number of Five Minute Intervals	Number of Target Times With At Least One SCED Solution Short of Reserves	Percent Target Times With At Least One SCED Solution Short of Reserves	Number of Target Times With Multiple SCED Solutions Short of Reserves	Percent Target Times With Multiple SCED Solutions Short of Reserves	Number of Five Minute Intervals With Shortage Prices in LPC	Percent RT SCED Target Times With Reserve Shortage With Shortage Prices in LPC
2020 Jan	8,928	172	1.9%	89	1.0%	0	0.0%
2020 Feb	8,352	94	1.1%	44	0.5%	0	0.0%
2020 Mar	8,916	173	1.9%	66	0.7%	0	0.0%
2020 Apr	8,640	208	2.4%	99	1.1%	2	1.0%
2020 May	8,928	113	1.3%	36	0.4%	0	0.0%
2020 Jun	8,640	114	1.3%	30	0.3%	0	0.0%
2020 Jul	8,928	110	1.2%	17	0.2%	0	0.0%
2020 Aug	8,928	95	1.1%	14	0.2%	0	0.0%
2020 Sep	8,640	64	0.7%	21	0.2%	0	0.0%
2020 Oct	8,928	327	3.7%	91	1.0%	3	0.9%
2020 Nov	8,652	181	2.1%	44	0.5%	3	1.7%
2020 Dec	8,928	168	1.9%	41	0.5%	1	0.6%
2020 Total	105,408	1,819	1.7%	592	0.6%	9	0.5%
2021 Jan	8,928	114	1.3%	22	0.2%	0	0.0%
2021 Feb	8,064	108	1.3%	28	0.3%	0	0.0%
2021 Mar	8,916	198	2.2%	46	0.5%	4	2.0%
2021 Total	25,908	420	1.6%	96	0.4%	4	1.0%

¹⁰² A case is executed when it begins to solve. Most but not all cases are solved. RT SCED cases take about one to two minutes to solve.

¹⁰³ PJM updated the RT SCED execution frequency to solve one case for each five minute target time beginning June 22, 2020. PJM dispatchers may solve additional cases at their discretion.

While a single RT SCED solution indicating a shortage for a target time among multiple RT SCED solutions that solved for that target time could be the result of operator load bias or erroneous inputs, it is less likely that a target time with multiple RT SCED solutions indicating shortage was the result of an error. There were four 5 minute intervals with shortage pricing that occurred in the first three months of 2021, while there were 96 five minute target times for which multiple RT SCED solutions showed a shortage of reserves. In the first three months of 2020, out of 439 target times for which one or more RT SCED solutions indicated a shortage of reserves, there were zero five minute intervals in LPC, or 0.0 percent, with shortage pricing. In the first three months of 2021, out of 420 target times for which one or more RT SCED solutions indicated a shortage of reserves, there were four 5 minute intervals in LPC, or 1.0 percent, with shortage pricing.

The PJM Real-Time Energy Market produces an efficient outcome only when prices are allowed to reflect the fundamental supply and demand conditions in the market in real time. While it is appropriate for operators to ensure that cases use data that reflect the actual state of the system, it is essential that operator discretion not extend beyond what is necessary and that operator discretion not prevent shortage pricing when there are shortage conditions. This is a critical issue now that PJM settles all real-time energy transactions on a five minute basis using the prices calculated by LPC. The MMU recommends that PJM clearly define the criteria for operator approval of RT SCED cases used to send dispatch signals to resources, and for pricing, to minimize operator discretion and implement a rule based approach.

Shortage Pricing Intervals in LPC

There were four 5 minute intervals with shortage pricing in the first three months of 2021, compared to zero intervals in the first three months of 2020, in PJM. Table 3-72 shows the extended synchronized reserve requirement, the total synchronized reserves, the synchronized reserve shortage, and the synchronized reserve clearing prices for the RTO Reserve Zone during the nine intervals with shortage pricing due to synchronized reserve shortage. Table 3-73 shows the extended synchronized reserve requirement, the total synchronized reserves, the synchronized reserve shortage, and the

synchronized reserve clearing prices for the MAD Reserve Subzone during the seven intervals with shortage pricing due to synchronized reserve shortage. Table 3-74 shows the extended primary reserve requirement, the total primary reserves, the primary reserve shortage, and the primary reserve clearing prices for the RTO Reserve Zone during the one interval with shortage pricing due to primary reserve shortage. Table 3-75 shows the extended primary reserve requirement, the total primary reserves, the primary reserve shortage, and the primary reserve clearing prices for the MAD Reserve Subzone during the one interval with shortage pricing due to primary reserve shortage.

PJM enforces an RTO wide reserve requirement and a supplemental reserve requirement for the MAD region. The MAD Reserve Subzone is nested within the RTO Reserve Zone. Resources located in the MAD Reserve Subzone can simultaneously satisfy the synchronized reserve requirement of the RTO Reserve Zone and the synchronized reserve requirement of the MAD Reserve Subzone. Resources located outside the MAD Reserve Subzone can satisfy the synchronized reserve requirement of the RTO Reserve Zone, and subject to transfer limits defined by transmission constraints, satisfy the reserve requirement of the MAD Subzone. The synchronized reserve clearing price of the RTO Reserve Zone is set by the shadow price of the binding reserve requirement constraint of the RTO Reserve Zone.¹⁰⁴ The synchronized reserve clearing price of the MAD Reserve Subzone, nested within the RTO Reserve Zone, is set by the sum of the shadow prices of the binding reserve requirement constraint of the RTO Reserve Zone and the shadow price of the binding reserve requirement constraint of the MAD Reserve Subzone.

In all four intervals in the first three months of 2021 with shortage pricing, both the RTO Zone and the MAD Subzone cleared with synchronized reserves less than their extended requirement. In all four intervals, the synchronized reserves in the RTO Zone were short of the minimum reserve requirement, resulting in an \$850 per MWh penalty factor. The clearing price for synchronized reserves in the RTO Zone is the sum of the shadow prices of the synchronized reserve constraint for the RTO Zone and the primary reserve constraint for the RTO Zone. The clearing price for synchronized reserves in

¹⁰⁴ If the reserve requirement cannot be met by the resources located within the reserve zone, the shadow price of the reserve requirement is set by the applicable operating reserve demand curve.

the MAD Subzone is the sum of the shadow prices of the synchronized reserve constraints for the RTO Zone and MAD Subzone and the shadow prices of the primary reserve constraints in the RTO and MAD Subzone.

Table 3-72 RTO synchronized reserve shortage intervals: January through March, 2021

Interval (EPT)	RTO Extended Synchronized Reserve Requirement (MW)	Total RTO Synchronized Reserves (MW)	RTO Synchronized Reserve Shortage (MW)	RTO Synchronized Reserve Clearing Price (\$/MWh)
02-Mar-21 06:30	1,835.0	1,305.6	529.4	\$1,700.0
17-Mar-21 10:10	1,859.0	1,452.1	406.9	\$1,150.0
22-Mar-21 19:45	1,786.0	1,256.5	529.5	\$1,700.0
22-Mar-21 19:50	1,783.0	1,422.9	360.1	\$1,150.0

Table 3-73 MAD synchronized reserve shortage intervals: January through March, 2021

Interval (EPT)	MAD Extended Synchronized Reserve Requirement (MW)	Total MAD Synchronized Reserves (MW)	MAD Synchronized Reserve Shortage (MW)	MAD Synchronized Reserve Clearing Price (\$/MWh)
02-Mar-21 06:30	1,835.0	1,557.5	277.5	\$1,700.0
17-Mar-21 10:10	1,859.0	1,452.1	406.9	\$1,700.0
22-Mar-21 19:45	1,786.0	1,256.5	529.5	\$1,700.0
22-Mar-21 19:50	1,783.0	1,422.9	360.1	\$1,700.0

Table 3-74 RTO primary reserve shortage intervals: January through March, 2021

Interval (EPT)	RTO Extended Primary Reserve Requirement (MW)	Total RTO Primary Reserves (MW)	RTO Primary Reserve Shortage (MW)	RTO Primary Reserve Clearing Price (\$/MWh)
02-Mar-21 06:30	2,657.5	2,405.6	251.9	\$850.0
17-Mar-21 10:10	2,693.5	2,536.1	157.4	\$300.0
22-Mar-21 19:45	2,584.0	2,357.7	226.3	\$850.0
22-Mar-21 19:50	2,579.5	2,406.9	172.6	\$300.0

Table 3-75 MAD primary reserve shortage intervals: January through March, 2021

Interval (EPT)	MAD Extended Primary Reserve Requirement (MW)	Total MAD Primary Reserves (MW)	MAD Primary Reserve Shortage (MW)	MAD Primary Reserve Clearing Price (\$/MWh)
17-Mar-21 10:10	2,693.5	2,536.1	157.4	\$300.0
22-Mar-21 19:45	2,584.0	2,357.7	226.3	\$850.0
22-Mar-21 19:50	2,579.5	2,406.9	172.6	\$600.0

On March 17, 2021, for the interval beginning 1010 EPT, both the RTO and MAD primary reserves were short of the extended requirements by 157.4 MW. The penalty factor for each reserve constraint violation was \$300 per MWh. On March 22, 2021, for the interval beginning 1945 EPT, both the RTO and MAD primary reserves were short of the extended requirements by 226.3 MW. The penalty factor for each reserve constraint violation was \$850 per MWh. Generally, the market clearing price (MCP) for primary reserves in the MAD Subzone will equal the sum of the penalty factor for the reserve requirement constraint of the RTO Reserve Zone and the penalty factor for the reserve requirement constraint of the MAD Reserve Subzone. Using this logic, the MCPs for primary reserves in the MAD Subzone should have been \$600 per MWh on March 17, 2021, at 1010 EPT, and \$1,700 per MWh on March 22, 2021, at 1945 EPT. However, the MCPs for primary reserves for the MAD subzone were \$300 per MWh and \$850 per MWh. This occurred because the MAD primary reserve requirement constraint was relaxed for both these intervals, resulting in the shadow price for the MAD primary reserve constraint equal to \$0 per MWh. This is a result of the application of PJM's System Marginal Price (SMP) capping logic.

System Marginal Price Cap

In the PJM real time market, the SMP is capped at \$3,750 per MWh. This cap is the result of the Energy Offer Cap (\$2,000 per MWh), the Synchronous Reserve Penalty Factor from the first step on the demand curve (\$850 per MWh), the Primary Reserve Penalty Factor from the first step on the demand curve (\$850 per MWh) and a threshold (\$50 per MWh). The Operating Agreement states that only two reserve penalty factors may be included in the energy price.

If the SMP would otherwise exceed \$3,750 per MWh, PJM solves the SCED optimization by progressively relaxing reserve requirement constraints until the SMP falls below the cap. For instance, if the original SMP is above \$3,750, PJM would solve the SCED optimization by disabling the subzone (MAD) primary reserve requirement constraint. If the SMP from the relaxed SCED optimization is still above \$3,750, PJM would solve the SCED optimization by disabling subzone (MAD) primary and synchronized reserve requirement constraints. If the relaxed SCED optimization is still above \$3,750, PJM would solve the SCED optimization by disabling subzone (MAD) primary and synchronized reserve requirement constraints and the RTO primary reserve constraint.

Since 2018, the SMP has been capped in 95 SCED solutions, of which four SCED solutions were approved and used in the LPC to set the five minute LMPs in the PJM real-time market.

Table 3-76 shows the shadow price, MCP and SMP for all reserve constraints for SCED cases that were solved using PJM's SMP capping logic and set the prices in the PJM real-time market.

Table 3-77 shows the components of SMP for the five minute intervals that used SMP capping logic since 2018. The SMP for the five minute interval beginning at 10:10 on March 17, 2021 was \$3,653.98 per MWh. The MAD primary reserve constraint was disabled for this interval. Of the \$3,653.95 per MWh, the marginal unit's incremental energy cost was \$17.85 per MWh, the congestion cost was \$1,546.98 and reserve opportunity cost was \$2,086.15 per MWh. The remaining \$3.00 is attributed to rounding error.¹⁰⁵ The original SMP, prior to the use of the capping logic would have been at least \$3,965.08 per MWh.¹⁰⁶

The contribution of the transmission penalty factor of a violated transmission constraint to the SMP depends on the location of the marginal units relative to

the location of the load weighted reference bus. If the marginal unit is located such that incremental increase in the load at the load weighted reference bus results in increased flow on the violated transmission constraint, the SMP reflects the positive contribution of the transmission penalty factor. The marginal unit's congestion cost, \$1,546.98, for the five minute interval beginning at 10:10 on March 17, 2021, includes the contribution of transmission constraint penalty factors of two violated transmission constraints.

Table 3-76 Five minute intervals based on approved SCED cases that used SMP capping logic: January 2018 through March 2021

Five Minute Interval	Reserve Constraint	Disabled	Shadowprice (\$/MWh)	MCP (\$/MWh)	SMP (\$/MWh)
01OCT2019:15:00:00	MAD Primary Reserve	No	\$0.00	\$300.00	\$3,651.02
01OCT2019:15:00:00	MAD Synchronized Reserve	Yes	\$0.00	\$1,150.00	\$3,651.02
01OCT2019:15:00:00	RTO Synchronized Reserve	No	\$850.00	\$1,150.00	\$3,651.02
01OCT2019:15:00:00	RTO Primary Reserve	No	\$300.00	\$300.00	\$3,651.02
13NOV2020:18:00:00	MAD Primary Reserve	Yes	\$0.00	\$850.00	\$3,166.28
13NOV2020:18:00:00	MAD Synchronized Reserve	No	\$850.00	\$2,550.00	\$3,166.28
13NOV2020:18:00:00	RTO Primary Reserve	No	\$850.00	\$850.00	\$3,166.28
13NOV2020:18:00:00	RTO Synchronized Reserve	No	\$850.00	\$1,700.00	\$3,166.28
02MAR2021:06:30:00	MAD Synchronized Reserve	Yes	\$0.00	\$2,782.22	\$2,994.68
02MAR2021:06:30:00	MAD Primary Reserve	No	\$149.36	\$999.36	\$2,994.68
02MAR2021:06:30:00	RTO Primary Reserve	No	\$850.00	\$850.00	\$2,994.68
02MAR2021:06:30:00	RTO Synchronized Reserve	No	\$1,782.86	\$2,632.86	\$2,994.68
17MAR2021:10:10:00	MAD Synchronized Reserve	No	\$850.00	\$2,000.00	\$3,653.98
17MAR2021:10:10:00	RTO Primary Reserve	No	\$300.00	\$300.00	\$3,653.98
17MAR2021:10:10:00	RTO Synchronized Reserve	No	\$850.00	\$1,150.00	\$3,653.98
17MAR2021:10:10:00	MAD Primary Reserve	Yes	\$0.00	\$300.00	\$3,653.98

¹⁰⁵ The final SMP does not precisely match the sum of components due to rounded network parameters such as distribution factors and loss penalty factors used for deriving the components of the SMP. This difference is shown as rounding error.

¹⁰⁶ The original SMP shown in the table represents the lower bound of the uncapped SMP. PJM does not report the segment of the disabled reserve constraint. To derive the original SMP, the lowest priced segment that results in the SMP exceeding the cap was used.

Table 3-77 Components of SMP for five minute intervals based on approved SCED cases that used SMP capping logic: January 2018 through March 2021

Five Minute Interval	Lower bound of Original SMP	Components of Final SMP				Rounding Error
		Final SMP	Incremental Cost of Marginal Unit	Congestion Cost	Reserve Opportunity Cost	
October 01,2019 15:00:00	\$3,950.36	\$3,651.02	\$33.88	\$2,436.47	\$1,173.81	\$6.87
November 13,2020 18:00:00	\$4,049.76	\$3,166.28	\$520.20	\$0.00	\$2,645.22	\$0.86
March 02,2021 06:30:00	\$3,891.21	\$2,994.68	\$30.51	\$181.10	\$2,780.81	\$2.26
March 17,2021 10:10:00	\$3,965.08	\$3,653.98	\$17.85	\$1,546.98	\$2,086.15	\$3.00

The MMU recommends that PJM cease the practice of capping the system marginal price in the RT SCED and instead limit the sum of violated reserve constraint shadow prices used in LPC to \$1,700 per MWh.

Accuracy of Reserve Measurement

The definition of a shortage of synchronized and primary reserves is based on the measured and estimated levels of load, generation, interchange, demand response, and reserves from the real-time SCED software. The definition of such shortage also includes discretionary operator inputs to the ASO (Ancillary Service Optimizer) or RT SCED software, such as tier 1 bias or operator load bias. For shortage pricing to be accurate, there must be accurate measurement of real-time reserves. That does not appear to be the case at present in PJM, but there does not appear to be any reason that PJM cannot accurately measure reserves. Without accurate measurement of reserves on a minute by minute basis, system operators cannot know with certainty that there is a shortage condition and a reliable trigger for five minute shortage pricing does not exist. The benefits of five minute shortage pricing are based on the assumption that a shortage can be precisely and transparently defined.¹⁰⁷ PJM cannot accurately measure or price reserves due to the inaccuracy of its generator models. PJM's commitment and dispatch models rely on generator data to properly commit and dispatch generators. Generator data includes offers and parameters. When the models do not properly account for the different generator characteristics, both PJM dispatchers and generators have to make simplifications and assumptions using the tools available. Most of these actions taken by generators and by PJM dispatchers are not transparent.

¹⁰⁷ See Comments of the Independent Market Monitor for PJM, Docket No. RM15-24-000 (December 1, 2015) at 9.

PJM manuals do not provide clarity regarding what actions generators can take when the PJM models and tools do not reflect their operational characteristics and PJM manuals do not provide sufficient clarity regarding the actions PJM dispatchers can take when generators do not follow dispatch.

In the energy and reserve markets, the actions that both generators and PJM dispatchers take have a direct impact on the amount of supply available for energy and reserves and the prices for energy and reserves. These flaws in PJM's models do not allow PJM to accurately calculate the amount of reserves available. PJM does not accurately model discontinuities in generator ramp rates, such as duct burners on combined cycle plants. PJM's generator models do not account for the complexities that may result in generators underperforming their submitted ramp rates. Instead of addressing these complexities through generator modeling improvements, PJM relies on a nontransparent method of adjusting generator parameters, called Degree of Generator Performance (DGP).^{108 109} PJM also fails to accurately model unit starts. The market software does not account for the energy output a resource produces prior to reaching its economic minimum output level, during its soak time.

PJM adjusts ramp rates using DGP, deselects specific units from providing reserves, and overrides the dispatch signal to certain units to set the dispatch signal equal to actual resource output. These manual interventions are, at best, rough approximations of the capability of generators and result in an inaccurate measurement of reserves.

¹⁰⁸ See "PJM Manual 12: Balancing Operations," Rev. 41 (Nov. 19, 2020) Attachment A, P78. "PJM Manual 11: Energy and Ancillary Services Market Operations," does not mention the use of DGP in the market clearing engine.

¹⁰⁹ PJM published a whitepaper that defines DGP and describes its use, which can be accessed at <<http://www.pjm.com/~media/etools/oasis/system-information/generation-performance-monitor-and-degree-of-generator-performance-white-paper.aspx>> (July 2, 2020).

Competitive Assessment

Market Structure

Market Concentration

The Herfindahl-Hirschman Index (HHI) concentration ratio is calculated by summing the squares of the market shares of all firms in a market. Hourly PJM energy market HHIs are based on the real-time energy output of generators adjusted with scheduled imports.

The HHI may not accurately capture market power issues in situations where, for example, there is moderate concentration in all on line resources but there is a high level of concentration in resources needed to meet increases in load. The HHIs for supply curve segments are an indicator of the ownership of incremental resources. But an aggregate pivotal supplier test is required to accurately measure the ability of incremental resources to exercise market power.

Hourly HHIs for the baseload, intermediate and peaking segments of generation supply are based on hourly energy market shares, unadjusted for imports.

FERC's Merger Policy Statement defines levels of concentration by HHI level. The market is unconcentrated if the market HHI is below 1000, the HHI if there were 10 firms with equal market shares. The market is moderately concentrated if the market HHI is between 1000 and 1800. The market is highly concentrated if the market HHI is greater than 1800, the HHI if there were between five and six firms with equal market shares.¹¹⁰

Analysis of supply curve segments of the PJM energy market in the first three months of 2021 indicates low concentration in the base load segment, moderate concentration in the intermediate segment, and high concentration in the peaking segment.¹¹¹ High concentration levels, particularly in the peaking segment, increase the probability that a generation owner will be pivotal in

the aggregate market. The fact that the average HHI is in the unconcentrated range and the maximum hourly HHI is in the moderately concentrated range does not mean that the aggregate market was competitive in all hours. It is possible to have pivotal suppliers in the aggregate market even when the HHI level does not indicate a highly concentrated market structure. Given the low responsiveness of consumers to prices (inelastic demand), it is possible to have high markup even when HHI is low. It is possible to have an exercise of market power even when the HHI level does not indicate a highly concentrated market structure.

When transmission constraints exist, local markets are created with ownership that is typically significantly more concentrated than the overall energy market. PJM offer capping rules that limit the exercise of local market power were generally effective in preventing the exercise of market power in the first three months of 2021, although there are issues with the application of market power mitigation for resources whose owners fail the TPS test that permit local market power to be exercised even when mitigation rules are applied. These issues include the lack of a method for consistently determining the cheaper of the cost and price schedules and the lack of rules requiring that cost-based offers equal short run marginal costs.

¹¹⁰ See *Inquiry Concerning the Commission's Merger Policy under the Federal Power Act: Policy Statement*, 77 FERC ¶ 61,263 mimeo at 80 (1996).

¹¹¹ A unit is classified as base load if it runs for more than 50 percent of hours, as intermediate if it runs for less than 50 percent but greater than 10 percent of hours, and as peak if it runs for less than 10 percent of hours.

PJM HHI Results

Hourly HHIs indicate that by FERC standards, the PJM energy market during the first three months of 2021 was unconcentrated on average (Table 3-78).¹¹²

Table 3-78 Hourly energy market HHI: January through March, 2020 and 2021

By offering supplier	Hourly Market HHI (Jan - Mar, 2020)	Hourly Market HHI (Jan - Mar, 2021)
Average	912	738
Minimum	775	607
Maximum	1140	919
Highest market share (One hour)	25%	24%
Average of the highest hourly market share	19%	18%
# Hours	2,183	2,159
# Hours HHI > 1800	0	0
% Hours HHI > 1800	0%	0%

Table 3-79 includes HHI values by supply curve segment, including base, intermediate and peaking plants for the first three months of 2020 and 2021. On average, ownership in the baseload segment was unconcentrated, in the intermediate segment was moderately concentrated, and in the peaking segment was highly concentrated.

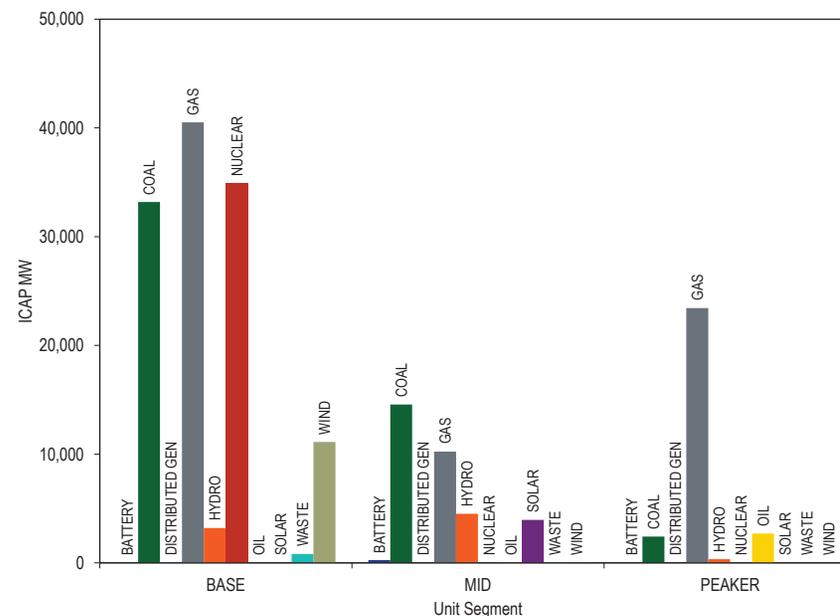
Table 3-79 Generation segment HHI: January through March, 2020 and 2021

By offering supplier	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Base	655	790	1102	643	766	928
Intermediate	738	1686	6726	769	1653	9717
Peak	1072	6113	10000	981	6305	10000

¹¹² The HHI calculations use actual real time settled generation data for each unit in PJM. Each unit's output is assigned to the supplier that is responsible for offering the unit in the energy market.

Figure 3-49 shows the total installed capacity (ICAP) MW of units in the baseload, intermediate and peaking segments by fuel source in the first three months of 2021.¹¹³

Figure 3-49 Fuel source distribution in unit segments: January through March, 2021¹¹⁴



¹¹³ The installed capacity (ICAP) used for wind and solar units here is their nameplate capacity in MW. In PJM's Capacity Market, the ICAP value of wind and solar units is derated from the nameplate capacity to reflect their effective load carrying capability.

¹¹⁴ The units classified as Distributed Gen are buses within Electric Distribution Companies (EDCs) that are modeled as generation buses to accurately reflect net energy injections from distribution level load buses. The modeling change was the outcome of the Net Energy Metering Task Force stakeholder group in July, 2012. See PJM. "Net Energy Metering Senior Task Force (NEMSTF) 1st Read - Final Report and Proposed Manual Revisions," (June 28, 2012) <<http://www.pjm.com/~media/committees-groups/task-forces/nemstf/postings/20120628-first-read-item-04-nemstf-report-and-proposed-manual-revisions.ashx>>.

Figure 3-50 shows the ICAP of coal fired and gas fired units in PJM that are classified as baseload, intermediate and peaking in the first three months from 2017 through 2021. Figure 3-50 shows that the total ICAP of coal fired units in PJM that are classified as baseload has been steadily decreasing and the total ICAP of gas fired units in PJM that are classified as baseload has been steadily increasing, based on operating history for the period consisting of the first three months from 2017 through 2020. In the first three months of 2021, the ICAP of gas fired units classified as baseload is lower compared to the ICAP of gas fired units classified as baseload in the first three months of 2020. In 2019, the ICAP of gas fired units classified as baseload exceeded the ICAP of coal fired units classified as baseload for the first time.

Figure 3-50 Unit segment classification by fuel: January through March, 2017 through 2021

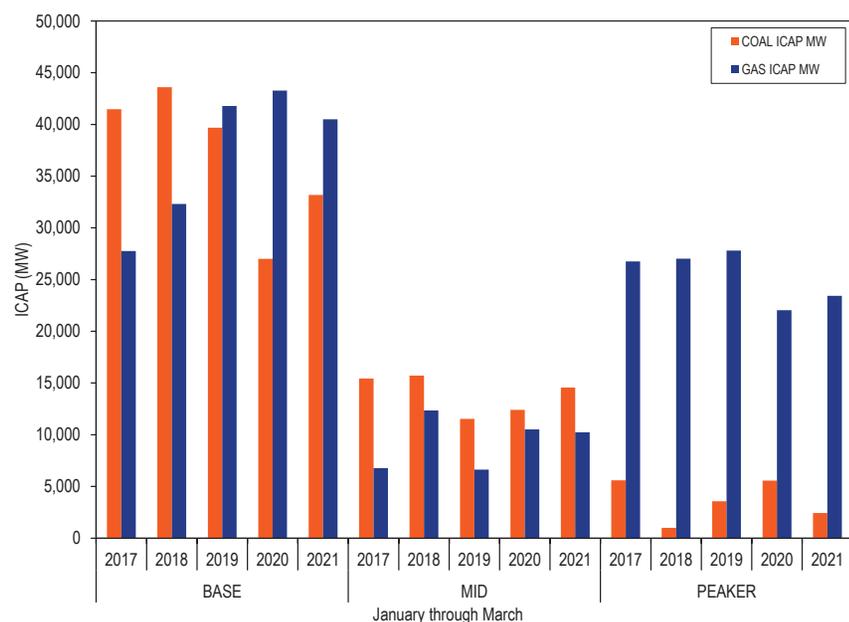
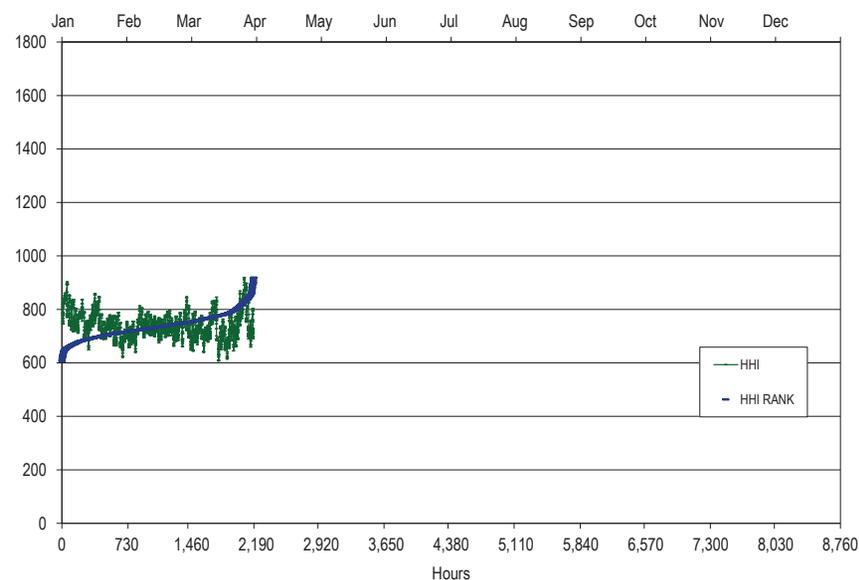


Figure 3-51 presents the hourly HHI values in chronological order and an HHI duration curve for the first three months of 2021.

Figure 3-51 Hourly energy market HHI: January through March, 2021



Market-Based Rates

Participation in the PJM market using offers that exceed costs requires market-based rate approval from FERC, which reviews the market-based rate authority of PJM market sellers on a triennial schedule to ensure that market sellers do not have market power or that market power is appropriately mitigated. The entire PJM Region is included in the Northeast Region for purposes of the triennial review schedule. The most recent triennial review filing period for the December 1, 2017–November 30, 2018 study period for nontransmission owning utilities in the Northeast Region was in June 2020. The next triennial review filing period for the December 1, 2020–November 30, 2021 study period for transmission owners in the Northeast Region will be in December 2022.

With Order No. 861, FERC no longer requires structural market power assessments to determine whether sellers have market power in the PJM markets. Instead, sellers may rely on a rebuttable presumption that market monitoring and market power mitigation are sufficient to ensure competitive market outcomes.¹¹⁵

The MMU has recommended since 2015 that changes to the offer capping process for the energy market are needed to ensure effective market power mitigation of units that fail the TPS test. The MMU has found that the capacity market is not competitive because the default Market Seller Offer Cap (MSOC) is inflated due to the use of an inaccurate estimate for the expected number of Performance Assessment Intervals (PAIs).¹¹⁶ With these results and the supporting evidence, the MMU has challenged the rebuttable presumption of sufficient market power mitigation for the June 2020 triennial review filings by unit generating unit owners in PJM and recommended that conditions limiting sellers to cost-based energy offers and a revised capacity market offer cap be required until improvements are made to the offer capping processes in the energy and capacity markets so that suppliers cannot exercise market power.¹¹⁷

Merger Reviews

FERC reviews contemplated dispositions, consolidations, acquisitions, and changes in control of jurisdictional generating units and transmission facilities under section 203 of the Federal Power Act to determine whether such transactions are “consistent with the public interest.”¹¹⁸

FERC applies tests set forth in the 1996 Merger Policy Statement.^{119 120}

The 1996 Merger Policy Statement provides for review of jurisdictional transactions based on “(1) the effect on competition; (2) the effect on rates; and (3) the effect on regulation.” FERC adopted the 1992 Department of Justice Guidelines and the Federal Trade Commission Horizontal Merger Guideline (1992 Guidelines) to evaluate the effect on competition. Following the 1992 Guidelines, FERC applies a five step framework, which includes: (1) defining the market; (2) analyzing market concentration; (3) analyzing mitigative effects of new entry; (4) assessing efficiency gains; and (5) assessing viability of the parties without a merger. FERC also evaluates a Competitive Analysis Screen.¹²¹

The MMU reviews proposed mergers based on analysis of the impact of the merger or acquisition on market power given actual market conditions. The analysis includes use of the three pivotal supplier test results in the real-time energy market. The MMU’s review ensures that mergers are evaluated based on their impact on local market power in the PJM energy market using actual observed market conditions, actual binding constraints and actual congestion results. This is in contrast to the typical merger filing that uses predefined local markets rather than the actual local markets. The MMU routinely files comments including such analyses.¹²² The MMU has proposed that FERC adopt this approach when evaluating mergers in PJM.¹²³ FERC has considered the MMU’s analysis in reviewing mergers.¹²⁴

The MMU also reviews transactions that involve ownership changes of PJM generation resources that are submitted to the Commission pursuant to section 203 of the Federal Power Act. There were no transactions that involved an entire generation unit that were completed in the first three months of 2021, as reported to the Commission. Table 3-80 shows transactions that involved

¹¹⁵ *Refinements to Horizontal Market Power Analysis for Sellers in Certain Regional Transmission Organization and Independent System Operator Markets*, 168 FERC ¶ 61,040 (“Order No. 861”) (July 18, 2019).

¹¹⁶ See “Complaint of the Independent Market Monitor for PJM”, Docket No. EL19 - 47, (February 21, 2019), which can be accessed at <https://www.monitoringanalytics.com/Filings/2019/IMM_Complaint_Docket_No_EL19-XXX_20190221.pdf>.

¹¹⁷ See, e.g., “Protest of the Independent Market Monitor for PJM,” Docket No. ER10-1556 (August 28, 2020). 118 18 U.S.C. § 824b.

¹¹⁹ See Order No. 592, FERC Stats. & Regs. ¶ 31,044 (1996) [1996 Merger Policy Statement], *reconsideration denied*, Order No. 592-A, 79 FERC ¶ 61,321 (1997). See also FPA Section 203 Supplemental Policy Statement, FERC Stats. & Regs. ¶ 31,253 (2007), *order on clarification and reconsideration*, 122 FERC ¶ 61,157 (2008).

¹²⁰ FERC has an open but inactive docket where the guidelines are under review. See 156 FERC ¶ 61,214 (2016); FERC Docket No. RM16-21-000.

¹²¹ In February 2019, in response to 2017 amendments to Section 203 of the Federal Power Act, the Commission issued Order No. 855, implementing a \$10,000,000 minimum value for transactions requiring the Commission’s review. See 166 FERC ¶ 61,120 (2019).

¹²² See, e.g., Comments of the Independent Market Monitor for PJM, FERC Docket No. EC14-141-000 (Nov. 10, 2014); Comments of the Independent Market Monitor for PJM, FERC Docket No. EC14-96-000 (July 21, 2014) Comments of the Independent Market Monitor for PJM, FERC Docket No. EC11-83-000 (July 21, 2011); Comments of the Independent Market Monitor for PJM, FERC Docket No. EC14-14 (Dec. 9, 2013); Comments of the Independent Market Monitor for PJM, FERC Docket No. EC14-112-000 (Sept. 15, 2014); Comments of the Independent Market Monitor for PJM, FERC Docket No. EC20-49 (June 1, 2020).

¹²³ See Comments of the Independent Market Monitor for PJM, Docket No. RM16-21 (Dec. 12, 2016).

¹²⁴ See *Dynegy Inc., et al.*, 150 FERC ¶ 61, 231 (2015); *Exelon Corporation, Constellation Energy Group, Inc.*, 138 FERC ¶ 61,167 (2012); *NRG Energy Holdings, Inc., Edison Mission Energy*, 146 FERC ¶ 61,196 (2014); see also *Analysis of Horizontal Market Power under the Federal Power Act*, 138 FERC ¶ 61,109 (2012).

transfers of partial unit ownership that were completed in the first three months of 2021, as reported to the Commission.¹²⁵

Table 3–80 Completed transfers of partial ownership of resources: January through March, 202

Generator or Generation Owner Name	From	To	Transaction Completion Date	Docket
Competitive Power Ventures: Fairview (25%), Maryland (25%), Shore (37.5%)	Global Infrastructure Partners	OPC Energy	January 25, 2021	EC21-16
Yards Creek (50%)	JCPL	LS Power Development LLC	March 5, 2021	EC20-65

The MMU has also facilitated settlements for mitigation of market power, in cases where market power concerns have been identified.¹²⁶ Such mitigation is designed to mitigate behavior over the long term, in addition to or instead of imposing short term asset divestiture requirements.

Aggregate Market Pivotal Supplier Results

Notwithstanding the HHI level, a supplier may have the ability to raise energy market prices. If reliably meeting the PJM system load requires energy from a single supplier, that supplier is pivotal and has monopoly power in the aggregate energy market. If a small number of suppliers are jointly required to meet load, those suppliers are jointly pivotal and have oligopoly power. The number of pivotal suppliers in the energy market is a more precise measure of structural market power than the HHI. The HHI is not a definitive measure of structural market power.

The current market power mitigation rules for the PJM energy market rely on the assumption that the aggregate market includes sufficient competing sellers to ensure competitive market outcomes. With sufficient competition, any attempt to economically or physically withhold generation would not result in higher market prices, because another supplier would replace the generation at a similar price. This assumption requires that the total demand for energy can be met without the supply from any individual supplier or without the supply from a small group of suppliers. This assumption is not always correct, as demonstrated by these results. There are pivotal suppliers in the aggregate energy market.

¹²⁵ The transaction completion date is based on the notices of consummation submitted to the Commission.
¹²⁶ See 138 FERC ¶ 61,167 at P 19.

The existing market power mitigation measures do not address aggregate market power.¹²⁷ The MMU is developing an aggregate market power test for the day-ahead and real-time energy markets based on pivotal suppliers and will propose appropriate market power mitigation rules to address aggregate market power.

Day-Ahead Energy Market Aggregate Pivotal Suppliers

To assess the number of pivotal suppliers in the day-ahead energy market, the MMU determined, for each supplier, the MW available for economic commitment that were already running or were available to start between the close of the day-ahead energy market and the peak load hour of the operating day. The available supply is defined as MW offered at a price less than 150 percent of the applicable LMP because supply available at higher prices is not competing to meet the demand for energy.¹²⁸ Generating units, import transactions, economic demand response, and INCs, are included for each supplier. Demand is the total MW required by PJM to meet physical load, cleared load bids, export transactions, and DECs. A supplier is pivotal if PJM would require some portion of the supplier's available economic capacity in the peak hour of the operating day in order to meet demand. Suppliers are jointly pivotal if PJM would require some portion of the joint suppliers' available economic capacity in the peak hour of the operating day in order to meet demand.

Figure 3–52 shows the number of days in 2020 and the first three months of 2021 with one pivotal supplier, two jointly pivotal suppliers, and three jointly pivotal suppliers for the day-ahead energy market. One supplier was singly pivotal on the summer peak days in 2020 and on February 15, 2021. Two suppliers were jointly pivotal on 128 days in 2020 and on 28 days in the first three months of 2021. Three suppliers were jointly pivotal on 301 days in 2020 and on 80 days in the first three months of 2021, despite average HHIs

¹²⁷ One supplier, Exelon, is partially mitigated for aggregate market power through its merger agreement. The agreement is not part of the PJM market rules. See Monitoring Analytics, LLC, Letter attaching Settlement Terms and Conditions, FERC Docket No. EC11-83-000 and Maryland PSC Case No. 9271 (October 11, 2011).

¹²⁸ Each LMP is scaled by 150 percent to determine the relevant supply, resulting in a different price threshold for each LMP value. The analysis does not solve a redispatch of the PJM market.

at persistently unconcentrated levels. In 2020, the highest levels of aggregate market power occurred in the third quarter, PJM's summer peak load season. Outside the summer months, the frequency of pivotal suppliers increased on high demand days in January 2020 and in February 2021.

Figure 3-52 Days with pivotal suppliers and numbers of pivotal suppliers in the day-ahead energy market by quarter

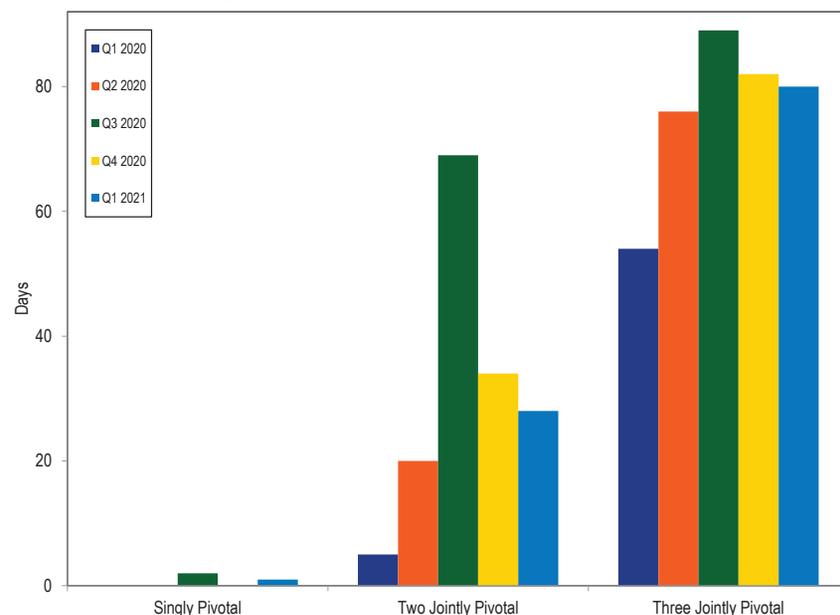


Table 3-81 provides the frequency with which each of the top 10 pivotal suppliers was singly or jointly pivotal for the day-ahead energy market in the first three months of 2021. The largest pivotal supplier was singly pivotal on one day in the first three months of 2021. All of the top 10 suppliers were one of two pivotal suppliers on at least 4 days in the first three months of 2021. All of the top 10 suppliers were one of three pivotal suppliers on at least 47 days in the first three months of 2021.

Table 3-81 Day-ahead market pivotal supplier frequency: January through March, 2021

Pivotal Supplier Rank	Days Singly Pivotal	Percent of Days	Days Jointly Pivotal with One Other Supplier		Days Jointly Pivotal with Two Other Suppliers	
			Days	Percent of Days	Days	Percent of Days
1	1	1.1%	26	28.9%	80	88.9%
2	0	0.0%	26	28.9%	79	87.8%
3	0	0.0%	23	25.6%	80	88.9%
4	0	0.0%	18	20.0%	78	86.7%
5	0	0.0%	8	8.9%	64	71.1%
6	0	0.0%	7	7.8%	65	72.2%
7	0	0.0%	5	5.6%	40	44.4%
8	0	0.0%	4	4.4%	48	53.3%
9	0	0.0%	4	4.4%	48	53.3%
10	0	0.0%	4	4.4%	47	52.2%

Market Behavior

Local Market Power

In the PJM energy market, market power mitigation rules currently apply only for local market power. Local market power exists when transmission constraints or reliability issues create local markets that are structurally noncompetitive. If the owners of the units required to solve the constraint or reliability issue are pivotal or jointly pivotal, they have the ability to set the price. Absent market power mitigation, unit owners that submit noncompetitive offers, or offers with inflexible operating parameters, could exercise market power. This could result in LMPs being set at higher than competitive levels, or could result in noncompetitive uplift payments.

The three pivotal supplier (TPS) test is the test for local market power in the energy market.¹²⁹ If the TPS test is failed, market power mitigation is applied by offer capping the resources of the owners who have been identified as having local market power. Offer capping is designed to set offers at competitive levels. Competitive offers are defined to be cost-based energy offers. In the PJM energy market, units are required to submit cost-based energy offers, defined by fuel cost policies, and have the option to submit market-based or price-based offers. Units are committed and dispatched on price-based offers,

¹²⁹ See the MMU Technical Reference for PJM Markets, at "Three Pivotal Supplier Test" for a more detailed explanation of the three pivotal supplier test. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

if offered, as the default offer. When a unit that submits both cost-based and price-based offers is mitigated to its cost-based offer by PJM, it is considered offer capped. A unit that submits only cost-based offers, or that requests PJM to dispatch it on its cost-based offer, is not considered offer capped.

Local market power mitigation is implemented in both the day-ahead and real-time energy markets. However, the implementation of the TPS test and offer capping differ in the day-ahead and real-time energy markets.

TPS Test Statistics for Local Market Power

The TPS test in the energy market defines whether one, two or three suppliers are jointly pivotal in a defined local market. The TPS test is applied when the system solution indicates that out of merit resources are needed to relieve a transmission constraint. The TPS test result for a constraint for a specific interval indicates whether a supplier failed or passed the test for that constraint for that interval. A failed test indicates that the resource owner has structural market power.

A metric to describe the number of local markets created by transmission constraints and the applicability of the TPS is the number of hours that each transmission constraint was binding in the real-time energy market over a period, by zone.

In the first three months of 2021, the 500 kV system, 12 zones, and MISO experienced congestion resulting from one or more constraints binding for 25 or more hours, or resulting from a binding interface constraint (Table 3-82).¹³⁰ Table 3-82 shows that the 500 kV system, two zones and MISO experienced congestion resulting from one or more constraints binding for 25 or more hours or resulting from a binding interface constraint in every year from January through March, 2009 through 2021. Three Control Zones did not experience congestion resulting from one or more constraints binding for 25 or more hours or resulting from any binding interface constraint in any year from January through March, 2009 through 2021.

¹³⁰ A constraint is mapped to the 500 kV system if its voltage is 500 kV and it is located in one of the control zones including AECO, BGE, DPL, JCPLC, MEC, PECO, PENELEC, PEPCO, PPL and PSEG. All PJM/MISO reciprocally coordinated flowgates (RCF) are mapped to MISO regardless of the location of the flowgates. All PJM/NYISO RCF are mapped to NYISO as location regardless of the location of the flowgates.

Table 3-82 Congestion hours resulting from one or more constraints binding for 25 or more hours or from an interface constraint: January through March, 2009 through 2021

	(Jan - Mar)												
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
500 kV System	1,704	1,457	1,932	228	512	1,368	688	579	144	315	524	1,107	153
AECO	149	0	70	40	32	0	41	252	0	0	112	0	0
AEP	890	157	556	100	447	840	1,405	283	54	517	154	205	1,054
APS	125	165	89	56	38	309	417	72	0	0	30	148	110
ATSI	101	37	0	1	46	428	391	30	349	637	55	200	267
BGE	0	25	0	650	150	29	232	1,418	551	875	133	265	1,263
COMED	325	816	123	525	973	1,233	651	1,426	766	409	278	673	399
DAY	0	0	0	0	0	0	0	0	0	0	0	0	0
DLCO	0	141	0	146	0	211	674	0	0	57	0	0	0
DOM	130	114	73	0	0	124	423	500	52	91	0	236	92
DPL	43	0	28	133	0	297	388	694	389	141	0	0	139
DUKE	0	0	0	33	0	68	0	0	0	25	0	0	93
DUQ	0	0	0	0	0	0	0	0	0	0	0	0	0
EKPC	0	0	0	0	0	0	0	0	0	45	0	0	0
EXT	0	0	0	0	0	0	0	0	348	0	0	51	0
JCPLC	0	0	0	0	0	44	79	0	0	0	0	0	0
MEC	0	0	0	0	70	34	144	0	0	666	182	162	78
MISO	1,728	110	1,306	3,353	5,045	4,877	3,372	2,739	1,805	1,548	1,919	1,376	815
NYISO	0	0	0	0	159	107	174	1,014	332	0	0	0	0
OVEC	0	0	0	0	0	0	0	0	0	0	0	0	0
PE	0	0	58	32	29	179	517	237	578	883	859	1,004	75
PECO	30	0	158	0	77	327	242	287	537	32	80	0	0
PEPCO	0	0	44	66	71	39	0	0	0	0	0	0	0
PPL	0	0	52	0	97	41	0	166	0	432	294	353	0
PSEG	336	344	281	199	1,408	1,445	2,550	55	0	151	285	0	1,502
REC	0	0	0	0	0	0	0	0	0	0	0	0	0

The local market structure in the real-time energy market associated with each of the frequently binding constraints was analyzed using the three pivotal supplier results in 2020.¹³¹ While the real-time constraint hours include constraints that were binding in the five minute real-time pricing solution (LPC), IT SCED may contain different binding constraints because IT SCED looks ahead to target times that are in the near future to solve for constraints that could be binding, using the load forecast for those times. IT SCED solves for target times that occur at 15 minute time increments, unlike RT SCED that solves for every five minute time increment. The TPS statistics shown in this

¹³¹ See the *MMU Technical Reference for PJM Markets*, p. 38 "Three Pivotal Supplier Test" for a more detailed explanation of the three pivotal supplier test. <http://www.monitoringanalytics.com/reports/Technical_References/reference_shtml>.

section present the data from the IT SCED TPS solution. The results of the TPS test are shown for tests that could have resulted in offer capping and tests that resulted in offer capping.

Table 3-83 shows the average constraint relief required on the constraint, the average effective supply available to relieve the constraint, the average number of owners with available relief in the defined market and the average number of owners passing and failing for the transfer interface constraints. Table 3-84 shows the average constraint relief required on the constraint, the average effective supply available to relieve the constraint, the average number of owners with available relief in the defined market and the average number of owners passing and failing for the 10 constraints that were binding for the most hours in the PJM Real-Time Energy Market. Table 3-83 and Table 3-84 include analysis of all the tests for every target time where IT SCED determined that constraint relief was needed for each of the constraints shown. The same target time can be evaluated by multiple IT SCED cases at different look ahead times. Each 15 minute target time is solved by 12 different IT SCED cases at different look ahead times. The set of binding constraints for a target time may be different in 12 look ahead IT SCED solutions.

Table 3-83 Three pivotal supplier test details for interface constraints: January through March, 2021

Constraint	Period	Average Constraint Relief (MW)	Average Effective Supply (MW)	Average Number Owners	Average Number Owners Passing	Average Number Owners Failing
5004/5005 Interface	Peak	328	421	19	5	14
	Off Peak	146	548	21	15	6
AP South	Peak	640	1,064	23	11	11
	Off Peak	453	376	11	6	5
Eastern	Peak	409	468	18	2	16
	Off Peak	NA	NA	NA	NA	NA

Table 3-84 Three pivotal supplier test details for top 10 congested constraints: January through March, 2021

Constraint	Period	Average Constraint Relief (MW)	Average Effective Supply (MW)	Average Number Owners	Average Number Owners Passing	Average Number Owners Failing
Cedar Grove Sub - William	Peak	79	99	6	0	6
	Off Peak	56	93	5	0	5
Bagley - Raphael Road	Peak	87	171	12	6	6
	Off Peak	74	146	11	5	6
Nottingham	Peak	73	106	9	1	8
	Off Peak	53	83	8	1	7
Bagley - Graceton	Peak	105	210	11	6	6
	Off Peak	81	150	10	4	6
East Lima - Haviland	Peak	27	33	1	0	1
	Off Peak	30	29	1	0	1
Haumesser Road - Steward	Peak	23	69	2	0	2
	Off Peak	24	60	2	0	2
Sub 85 - Sub 18	Peak	28	12	2	0	2
	Off Peak	26	9	2	0	2
Harwood - Susquehanna	Peak	21	31	3	0	3
	Off Peak	7	29	3	0	3
Vienna	Peak	37	43	2	0	2
	Off Peak	48	53	2	0	2
Maple St - Chrysler	Peak	10	3	1	0	1
	Off Peak	11	1	1	0	1

The three pivotal supplier test is applied every time the IT SCED solution indicates that incremental relief is needed to relieve a transmission constraint. While every system solution that requires incremental relief to transmission constraints will result in a test, not all tested providers of effective supply are eligible for offer capping. Steam unit offers that are offer capped in the day-ahead energy market continue to be offer capped in the real-time energy market regardless of their inclusion in the TPS test in real time or the outcome of the TPS test in real time. Steam unit offers that are not offer capped in the day-ahead energy market continue to not be offer capped in the real-time energy market regardless of their inclusion in the TPS test in real time or the outcome of the TPS test in real time.¹³² Offline units that are committed to provide relief for a transmission constraint, whose owners fail the TPS test, are committed on the cheaper of their cost or price-based offers. Beginning

¹³² If a steam unit were to lower its cost-based offer in real time, it would become eligible for offer capping based on the online TPS test.

November 1, 2017, with the introduction of hourly offers and intraday offer updates, certain online units whose commitment is extended beyond the day-ahead or real-time commitment, whose owners fail the TPS test, are also switched to the cost-based offer if it is cheaper than the price-based offer.

Units committed in the day-ahead market often fail the TPS test in the real-time market when they are redispatched to provide relief to transmission constraints, even though they did not fail the TPS test in the day-ahead market. These units are able to set prices with a positive markup in the real-time market. Units that cleared the day-ahead market on their price based schedule were evaluated to identify the units whose offers were mitigated in real-time and the units that cleared on price offers in real-time despite failing the real-time TPS test. Table 3-85 shows that 0.7 percent of unit hours that cleared the day-ahead market on their price based offer were switched to cost in real-time. Table 3-85 shows that 7.0 percent of unit hours that cleared the day-ahead market on their price based offer cleared on their price based offer in real-time despite failing the real-time TPS test.

Table 3-85 Day-ahead committed units that cleared real-time: January through March, 2021

Period	Day Ahead Price Based Unit Hours That Cleared Real-Time on Cost	Day Ahead Price Based Unit Hours That Cleared Real-Time on Price	Day Ahead Price Based Unit Hours That Failed Real-Time TPS and Cleared Real-Time on Price	Percent Day Ahead Price Based Unit Hours That Cleared Real-Time on Cost	Percent Day Ahead Price Based Unit Hours That Failed Real-Time TPS and Cleared Real-Time on Price
Jan - Mar, 2021	4,568	635,865	44,845	0.7%	7.0%

The MMU recommends, in order to ensure effective market power mitigation when the TPS test is failed, that offer capping be applied to units that fail the TPS test in the real-time market that were not offer capped at the time of commitment in the day-ahead market or at a prior time in the real-time market.

Table 3-86 and Table 3-87 provide, for the identified constraints, information on total tests applied, the subset of three pivotal supplier tests that could have resulted in offer capping and the portion of those tests that did result in offer capping. Tests where there was at least one offline unit or an online unit eligible for offer capping are considered tests that could have resulted in offer capping. PJM operators also manually commit units for reliability reasons other than providing relief to a binding constraint. Manual commitments are offer capped along with resources that fail the TPS test.

Table 3-86 Summary of three pivotal supplier tests applied for interface constraints: January through March, 2021

Constraint	Period	Total Tests Applied	Total Tests that Could Have Resulted in Offer Capping	Percent Total Tests that Could Have Resulted in Offer Capping	Total Tests Resulted in Offer Capping	Percent Total Tests Resulted in Offer Capping	Tests Resulted in Offer Capping as Percent of Tests that Could Have Resulted in Offer Capping
5004/5005	Peak	223	223	100%	2	1%	1%
	Off Peak	30	30	100%	0	0%	0%
AP South	Peak	27	27	100%	0	0%	0%
	Off Peak	47	31	66%	0	0%	0%
Eastern	Peak	48	48	100%	0	0%	0%
	Off Peak	0	0	NA	0	NA	NA

Table 3-87 Summary of three pivotal supplier tests applied for top 10 congested constraints: January through March, 2021

Constraint	Period	Total Tests Applied	Total Tests that Could Have Resulted in Offer Capping	Percent Total Tests that Could Have Resulted in Offer Capping	Total Tests Resulted in Offer Capping	Percent Total Tests Resulted in Offer Capping	Tests Resulted in Offer Capping as Percent of Tests that Could Have Resulted in Offer Capping
Cedar Grove Sub - William	Peak	10,160	9,357	92%	87	1%	1%
	Off Peak	6,282	5,355	85%	47	1%	1%
Bagley - Raphael Road	Peak	9,007	8,881	99%	27	0%	0%
	Off Peak	5,997	5,936	99%	18	0%	0%
Nottingham	Peak	4,816	4,686	97%	11	0%	0%
	Off Peak	2,904	2,747	95%	35	1%	1%
Bagley - Graceton	Peak	5,178	5,107	99%	34	1%	1%
	Off Peak	4,262	4,219	99%	40	1%	1%
East Lima - Haviland	Peak	4,183	17	0%	0	0%	0%
	Off Peak	3,478	12	0%	0	0%	0%
Haumesser Road - Steward	Peak	2,189	117	5%	0	0%	0%
	Off Peak	1,510	54	4%	0	0%	0%
Sub 85 - Sub 18	Peak	2,667	409	15%	0	0%	0%
	Off Peak	1,729	148	9%	0	0%	0%
Harwood - Susquehanna	Peak	1,535	963	63%	4	0%	0%
	Off Peak	446	119	27%	0	0%	0%
Vienna	Peak	1,993	1,217	61%	24	1%	2%
	Off Peak	2,433	1,608	66%	21	1%	1%
Maple St - Chrysler	Peak	500	235	47%	0	0%	0%
	Off Peak	1,079	241	22%	0	0%	0%

Offer Capping for Local Market Power

In the PJM energy market, offer capping occurs as a result of structurally noncompetitive local markets and noncompetitive offers in the day-ahead and real-time energy markets. PJM also uses offer capping for units that are committed for reliability reasons, specifically for providing black start and reactive service as well as for conservative operations. There are no explicit rules governing market structure or the exercise of market power in the aggregate energy market.

There are some issues with the application of mitigation in the day-ahead energy market and the real-time energy market when market sellers fail the TPS test. There is no tariff or manual language that defines in detail the application of the TPS test and offer capping in the day-ahead energy market and the real-time energy market.

In both the day-ahead and real-time energy markets, generators with market power have the ability to evade mitigation by using varying markups in their price-based offers, offering different operating parameters in their price-based and cost-based offers, and using different fuels in their price-based and cost-based offers. These issues can be resolved by simple rule changes.

When an owner fails the TPS test, the units offered by the owner that are committed to provide relief are committed on the cheaper of cost-based or price-based offers. In the day-ahead energy market, PJM commits a unit on the schedule that results in the lower overall system production cost. This is consistent with the day-ahead energy market objective of clearing resources (including physical and virtual resources) to meet the total demand (including physical and virtual

demand) at the lowest bid production cost for the system over the 24 hour period. In the real-time energy market, PJM uses a dispatch cost formula to compare price-based offers and cost-based offers to select the cheaper offer.¹³³

$$\text{Total Dispatch Cost} = \text{Startup Cost} + \sum_{\text{Min Run}} \text{Hourly Dispatch Cost}$$

where the hourly dispatch cost is calculated for each hour using the offers applicable for that hour as:

$$\text{Hourly Dispatch Cost} = (\text{Incremental Energy Offer@EcoMin} \times \text{EcoMin MW}) + \text{NoLoad Cost}$$

Given the ability to submit offer curves with different markups at different output levels in the price-based offer, unit owners with market power can evade mitigation by using a low markup at low output levels and a high markup at higher output levels. Figure 3-53 shows an example of offers from a unit that has a negative markup at the economic minimum MW level and a positive markup at the economic maximum MW level. The result would be that a unit that failed the TPS test would be committed on its price-based offer that has a lower dispatch cost, even though the price-based offer is higher than cost-based offer at higher output levels and includes positive markups, inconsistent with the explicit goal of local market power mitigation.

Figure 3-53 Offers with varying markups at different MW output levels

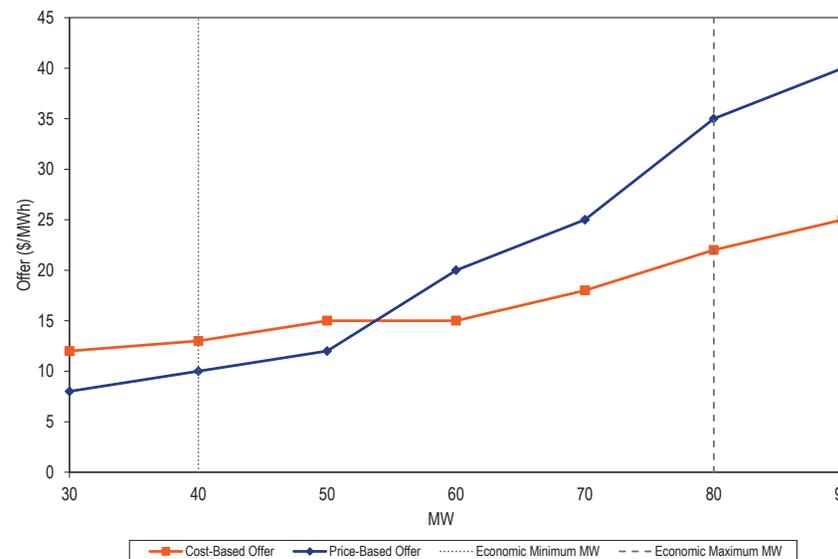


Table 3-88 shows the number and percent of unit schedule hours, by month, when unit offers included crossing curves in the PJM Day-Ahead and Real-Time Energy Markets, in the first three months of 2021. The analysis only includes units that offer both price-based and cost-based offers. Units in PJM are only required to submit cost-based offers, and they may elect to offer price-based offers, but are not required to do so.

Table 3-88 Units offered with crossing curves in the day-ahead and real-time energy markets: January through March, 2021

	Day-Ahead			Real-Time		
	Number of Schedule Hours with Crossing Curves	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Crossing Curves	Number of Schedule Hours with Crossing Curves	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Crossing Curves
2021						
Jan	75,695	838,152	9.0%	74,261	779,014	9.5%
Feb	70,614	750,072	9.4%	64,570	687,184	9.4%
Mar	70,110	844,732	8.3%	58,436	722,456	8.1%
Total	216,419	2,432,956	8.9%	197,267	2,188,654	9.0%

133 See PJM Operating Agreement Schedule 1 § 6.4.1(g).

Offering a different economic minimum MW level, different minimum run times, or different start up and notification times in the cost-based and price-based offers can also be used to evade mitigation. For example, a unit may offer its price-based offer with a positive markup, but have a shorter minimum run time (MRT) in the price-based offer resulting in a lower dispatch cost for the price-based offer but setting prices at a level that includes a positive markup. Table 3-89 shows the number and percent of unit schedule hours when units offered lower minimum run times in price-based offers than in cost-based offers while having a positive markup in the price based offer.

Table 3-89 Units offered with lower minimum run time on price compared to cost but with positive markup in the day-ahead and real-time energy markets: January through March, 2021

	Day-Ahead			Real-Time		
	Number of Schedule Hours with Lower Min Run Time in Price Compared to Cost	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Lower Min Run Time in Price Compared to Cost	Number of Schedule Hours with Lower Min Run Time in Price Compared to Cost	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Lower Min Run Time in Price Compared to Cost
2021						
Jan	38,688	838,152	4.6%	29,049	779,014	3.7%
Feb	36,275	750,072	4.8%	27,248	687,184	4.0%
Mar	38,612	844,732	4.6%	31,868	722,456	4.4%
Total	113,575	2,432,956	4.7%	88,165	2,188,654	4.0%

A unit may offer a lower economic minimum MW level on the price-based offer than the cost-based offer. Such a unit may appear to be cheaper to commit on the price-based offer even with a positive markup. A unit with a positive markup can have lower dispatch cost with the price-based offer with a lower economic minimum level compared to cost-based offer. Figure 3-54 shows an example of offers from a unit that has a positive markup and a price-based offer with a lower economic minimum MW than the cost-based offer. Keeping the startup cost, Minimum Run Time and no load cost constant between the price-based offer and cost-based offer, the dispatch cost for this unit is lower on the price-based offer than on the cost-based offer. However, the price-based offer includes a positive markup and could result in setting the market price at a noncompetitive level even after the resource owner fails the TPS test.

Figure 3-54 Offers with a positive markup but different economic minimum MW

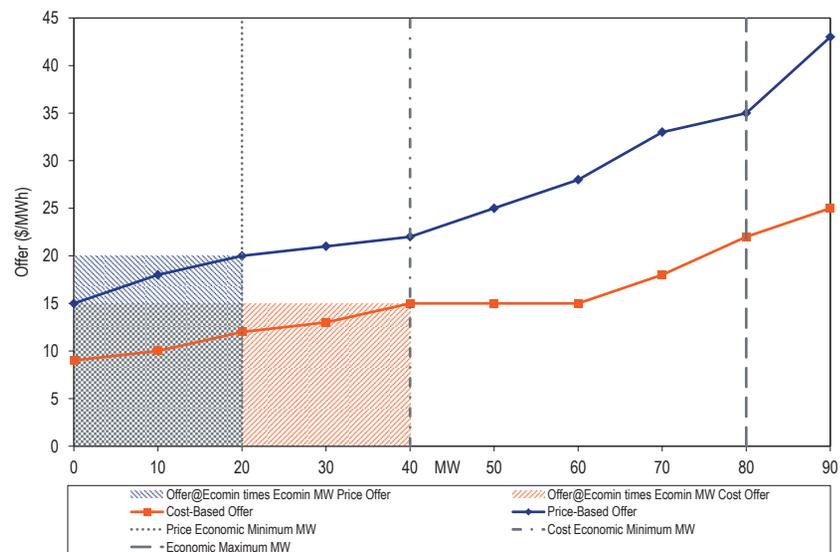


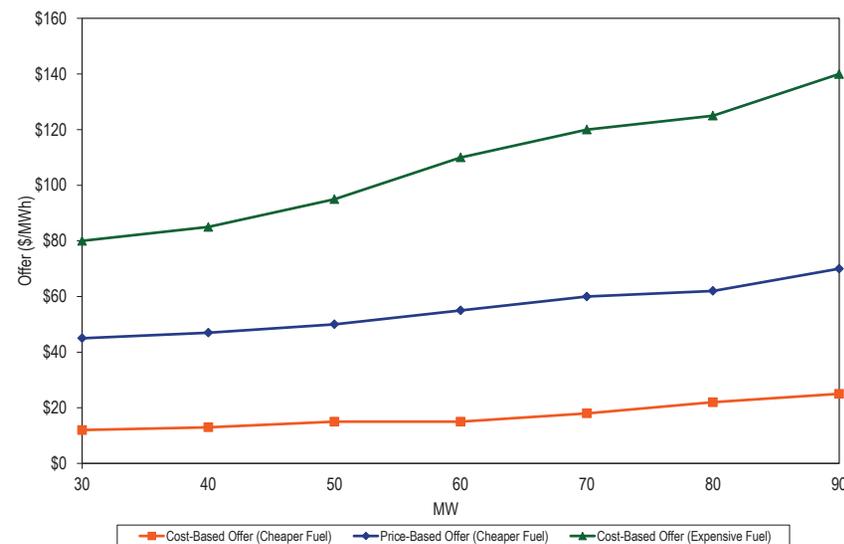
Table 3-90 shows the number and percent of unit schedule hours when units offered lower economic minimum MW in price-based offers than in cost-based offers while having a positive markup in the price-based offer.

Table 3-90 Units offered with lower economic minimum MW on price compared to cost but with positive markup in the day-ahead and real-time energy markets: January through March, 2021

	Day-Ahead			Real-Time		
	Number of Schedule Hours with Lower Economic Minimum MW in Price Compared to Cost	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Lower Economic Minimum MW in Price Compared to Cost	Number of Schedule Hours with Lower Economic Minimum MW in Price Compared to Cost	Total Number of Cost Schedule Hours Offered by Price Based Units	Percent of Schedule Hours with Lower Economic Minimum MW in Price Compared to Cost
2021	480	838,152	0.1%	415	779,014	0.1%
Jan	1,200	750,072	0.2%	523	687,184	0.1%
Feb	1,755	844,732	0.2%	1,257	722,456	0.2%
Mar	3,435	2,432,956	0.1%	2,195	2,188,654	0.1%

In case of dual fuel units, if the price-based offer uses a cheaper fuel and the cost-based offer uses a more expensive fuel, the price-based offer will appear to be lower cost even when it includes a markup. Figure 3-55 shows an example of offers by a dual fuel unit, where the active cost-based offer uses a more expensive fuel and the price-based offer uses a cheaper fuel and includes a markup.

Figure 3-55 Dual fuel unit offers



These issues can be solved by simple rule changes.¹³⁴ The MMU recommends that markup of price-based offers over cost-based offers be constant across the offer curve, that there be at least one cost-based offer using the same fuel as the available price-based offer, and that operating parameters on parameter limited schedules (PLS) be at least as flexible as price-based non-PLS offers.

Levels of offer capping have historically been low in PJM, as shown in Table 3-92. But offer capping remains a critical element of PJM market rules because it is designed to prevent the exercise of local market power. While overall offer capping levels have been low, there are a significant number of units with persistent structural local market power that would have a significant impact on prices in the absence of local market power mitigation. Until November 1, 2017, only uncommitted resources, started to relieve a transmission constraint, were subject to offer capping. Beginning November 1, 2017, under certain circumstances, online resources that are committed beyond their original commitment (day-ahead or real-time) can be offer capped if the owner fails the TPS test, and the latest available cost-based offer is determined to be lower than the price-based offer.¹³⁵ Units running in real time as part of their original commitment on the price-based offer on economics, and that can provide incremental relief to a constraint, cannot be switched to their cost-based offer.

The offer capping percentages shown in Table 3-91 include units that are committed to provide constraint relief whose owners failed the TPS test in the energy market excluding units that were committed for reliability reasons, providing black start and providing reactive support. Offer capped unit run hours and offer capped generation (in MWh) are shown as a percentage of the total run hours and the total generation (MWh) from all the units in the PJM energy market.¹³⁶ Beginning November 1, 2017, with the introduction of hourly offers, certain online units, whose owners fail the TPS test in the real-time energy market for providing constraint relief, can be offer capped and

¹³⁴ The MMU proposed these offer rule changes as part of a broader reform to address generator offer flexibility and associated impact on market power mitigation rules in the Generator Offer Flexibility Senior Task Force (GOFSTF) and subsequently in the MMU's protest in the hourly offers proceeding in Docket No. ER16-372-000, filed December 14, 2015.

¹³⁵ See OATT Attachment K Appendix § 6.4.1.

¹³⁶ Prior to the 2018 *Quarterly State of the Market Report for PJM: January through June*, these tables presented the offer cap percentages based on total bid unit hours and total load MWh. Beginning with the quarterly report for January through June, 2018, the statistics have been updated with percentages based on run hours and total generation MWh from units modeled in the energy market.

dispatched on their cost-based offer subsequent to a real-time hourly offer update. This is reflected in the slightly higher rate of offer capping in the real-time energy market in since 2017.

Table 3-91 Offer capping statistics – energy only: January through March, 2017 to 2021

(Jan-Mar)	Real-Time		Day-Ahead	
	Unit Hours Capped	MW Capped	Unit Hours Capped	MW Capped
2017	0.2%	0.1%	0.0%	0.1%
2018	1.0%	0.4%	0.1%	0.1%
2019	0.6%	0.5%	0.2%	0.2%
2020	0.7%	1.1%	0.8%	0.8%
2021	1.2%	0.9%	0.9%	0.7%

Table 3-92 shows the offer capping percentages including units committed to provide constraint relief and units committed for reliability reasons. Reliability reasons include reactive support or local voltage support. PJM creates closed loop interfaces to, in some cases, model reactive constraints. The result was higher LMPs in the closed loop interfaces, which increased economic dispatch, which contributed to the reduction in units offer capped for reactive support over time in Table 3-93. In instances where units are committed and offer capped for the modeled closed loop interface constraints, they are considered offer capped for providing constraint relief, and not for reliability. They are included in the offer capping percentages in Table 3-91. Prior to closed loop interfaces, these units were considered as committed for reactive support, and were included in the offer capping statistics for reliability in Table 3-93.

Table 3-92 Offer capping statistics for energy and reliability: January through March, 2017 to 2021

(Jan-Mar)	Real-Time		Day-Ahead	
	Unit Hours Capped	MW Capped	Unit Hours Capped	MW Capped
2017	0.4%	0.7%	0.3%	0.6%
2018	1.1%	0.5%	0.1%	0.1%
2019	0.6%	0.5%	0.2%	0.2%
2020	0.7%	1.1%	0.8%	0.8%
2021	1.2%	0.9%	1.0%	0.7%

Table 3-93 shows the offer capping percentages for units committed for reliability reasons, including units committed for reactive support. The low offer cap percentages do not mean that units manually committed for reliability reasons do not have market power. All units manually committed for reliability have market power and all are treated as if they had market power. These units are not capped to their cost-based offers because they tend to offer with a negative markup in their price-based offers, particularly at the economic minimum level, which means that PJM's offer capping process results in the use of the price-based offer for commitment. However, the price-based offers have inflexible parameters such as longer minimum run times that may lead to higher total commitment cost if the unit was only needed for a shorter period that is less than its inflexible minimum run time.

Table 3-93 Offer capping statistics for reliability: January through March, 2017 to 2021

(Jan-Mar)	Real-Time		Day-Ahead	
	Unit Hours Capped	MW Capped	Unit Hours Capped	MW Capped
2017	0.20%	0.56%	0.24%	0.51%
2018	0.07%	0.14%	0.02%	0.04%
2019	0.00%	0.00%	0.00%	0.00%
2020	0.00%	0.00%	0.00%	0.00%
2021	0.03%	0.01%	0.03%	0.01%

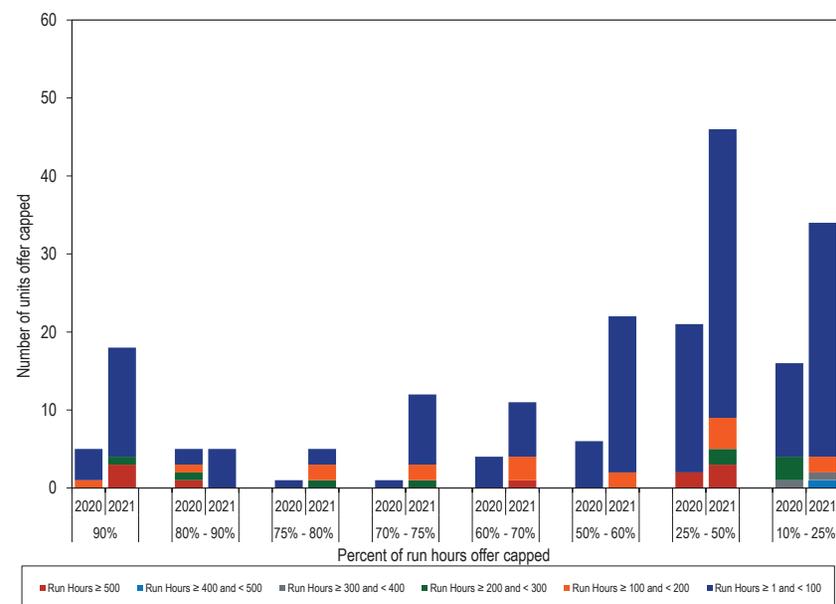
Table 3-94 presents data on the frequency with which units were offer capped in the first three months of 2020 and 2021 as a result of failing the TPS test to provide energy for constraint relief in the real-time energy market and for reliability reasons. Table 3-94 shows that 14 units were offer capped for 90 percent or more of their run hours in the first three months of 2021 compared to four units in the first three months of 2020.

Table 3-94 Real-time offer capped unit statistics: January through March, 2020 and 2021

Run Hours Offer-Capped, Percent Greater Than Or Equal To:	Jan - Mar	Offer-Capped Hours					
		Hours ≥ 500	Hours ≥ 400 and < 500	Hours ≥ 300 and < 400	Hours ≥ 200 and < 300	Hours ≥ 100 and < 200	Hours ≥ 1 and < 100
90%	2020	0	0	0	0	1	4
	2021	3	0	0	1	0	14
80% and < 90%	2020	1	0	0	1	1	2
	2021	0	0	0	0	0	5
75% and < 80%	2020	0	0	0	0	0	1
	2021	0	0	0	1	2	2
70% and < 75%	2020	0	0	0	0	0	1
	2021	0	0	0	1	2	9
60% and < 70%	2020	0	0	0	0	0	4
	2021	1	0	0	0	3	7
50% and < 60%	2020	0	0	0	0	0	6
	2021	0	0	0	0	2	20
25% and < 50%	2020	2	0	0	0	0	19
	2021	3	0	0	2	4	37
10% and < 25%	2020	0	0	1	3	0	12
	2021	0	1	1	0	2	30

Figure 3-56 shows the frequency with which units were offer capped in the first three months of 2020 and 2021 for failing the TPS test to provide energy for constraint relief in the real-time energy market and for reliability reasons.

Figure 3-56 Real-time offer capped unit statistics: January through March, 2020 and 2021



Markup Index

Markup is a summary measure of participant offer behavior or conduct for individual units. When a seller responds competitively to a market price, markup is zero. When a seller exercises market power in its pricing, markup is positive. The degree of markup increases with the degree of market power. The markup index for each marginal unit is calculated as $(\text{Price} - \text{Cost})/\text{Price}$.¹³⁷ The markup index is normalized and can vary from -1.00 when the offer price is less than the cost-based offer price, to 1.00 when the offer price is

¹³⁷ In order to normalize the index results (i.e., bound the results between +1.00 and -1.00) for comparison across both low and high cost units, the index is calculated as $(\text{Price} - \text{Cost})/\text{Price}$ when price is greater than cost, and $(\text{Price} - \text{Cost})/\text{Cost}$ when price is less than cost.

higher than the cost-based offer price. The markup index does not measure the impact of unit markup on total LMP. The dollar markup for a unit is the difference between price and cost.

Real-Time Markup Index

Table 3-95 shows the average markup index of marginal units in the real-time energy market, by offer price category using unadjusted cost-based offers. Table 3-96 shows the average markup index of marginal units in the real-time energy market, by offer price category using adjusted cost-based offers. The unadjusted markup is the difference between the price-based offer and the cost-based offer including the 10 percent adder in the cost-based offer. The adjusted markup is the difference between the price-based offer and the cost-based offer excluding the 10 percent adder from the cost-based offer. The adjusted markup is calculated for coal, gas and oil units because these units have consistently had price-based offers less than cost-based offers.¹³⁸ The markup is negative if the cost-based offer of the marginal unit exceeds its price-based offer at its operating point.

All generating units are allowed to add an additional 10 percent to their cost-based offer. The 10 percent adder was included prior to the implementation of PJM markets in 1999, based on the uncertainty of calculating the hourly operating costs of CTs under changing ambient conditions. The owners of coal units, facing competition, typically exclude the additional 10 percent from their actual offers. The owners of many gas fired and oil fired units have also begun to exclude the 10 percent adder. The introduction of hourly offers and intraday offer updates in November 2017 allows gas and oil generators to directly incorporate the impact of ambient temperature changes in fuel consumption in offers.

Even the adjusted markup overestimates the negative markup because units facing increased competitive pressure have excluded both the 10 percent and components of operating and maintenance costs that are not short run marginal costs. The PJM Market rules permit the 10 percent adder and maintenance costs, which are not short run marginal costs, under the definition of cost-

¹³⁸ The MMU will calculate adjusted markup for gas units also in future reports because gas units also more consistently have price-based offers less than cost-based offers.

based offers. Actual market behavior reflects the fact that neither is part of a competitive offer and neither is a short run marginal cost.¹³⁹

In the first three months of 2021, the average markup index in the real-time market was -0.2. The average dollar markups of units with offer prices less than \$10 was negative (-\$8.67 per MWh) when using unadjusted cost-based offers. The average dollar markups of units with offer prices between \$10 and \$15 was negative (-\$1.10 per MWh) when using unadjusted cost-based offers. Negative markup means the unit is offering to run at a price less than its cost-based offer, revealing a short run marginal cost that is less than the maximum allowable cost-based offer under the PJM Market Rules.

Some marginal units did have substantial markups. Among the units that were marginal in the first three months of 2021, none had offer prices above \$400 per MWh. Among the units that were marginal in the first three months of 2020, none had offer prices greater than \$400 per MWh. Using the unadjusted cost-based offers, the highest markup for any marginal unit in the first three months of 2021 was more than \$200, and the highest markup in the first three months of 2020 was more than \$150.

Table 3-95 Average, real-time marginal unit markup index (By offer price category unadjusted): January through March, 2020 and 2021

Offer Price Category	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Average Markup Index	Average Dollar Markup	Frequency	Average Markup Index	Average Dollar Markup	Frequency
< \$10	(0.06)	(\$0.95)	8.7%	(0.05)	(\$8.67)	7.6%
\$10 to \$15	0.07	\$0.82	44.4%	(0.06)	(\$1.10)	6.3%
\$15 to \$20	0.00	(\$0.37)	32.8%	(0.04)	(\$0.92)	31.3%
\$20 to \$25	0.04	\$0.71	11.5%	(0.02)	(\$0.82)	29.2%
\$25 to \$50	0.14	\$4.56	2.1%	(0.01)	(\$0.82)	20.8%
\$50 to \$75	0.57	\$33.63	0.2%	0.10	\$2.09	2.0%
\$75 to \$100	0.77	\$71.01	0.0%	0.09	\$7.27	0.8%
\$100 to \$125	0.79	\$88.32	0.0%	0.02	\$0.89	0.6%
\$125 to \$150	0.39	\$49.93	0.0%	0.16	\$20.75	0.2%
\$150 to \$400	0.30	\$56.38	0.1%	0.05	\$10.68	1.1%
All Offers	0.04	\$0.59	100.0%	(0.02)	(\$1.04)	100.0%

¹³⁹ See PJM, "Manual 15: Cost Development Guidelines," Rev. 37 (Dec. 9, 2020).

Table 3-96 Average, real-time marginal unit markup index (By offer price category adjusted): January through March, 2020 and 2021

Offer Price Category	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Average Markup Index	Average Dollar Markup	Frequency	Average Markup Index	Average Dollar Markup	Frequency
< \$10	(0.03)	(\$0.68)	8.7%	(0.05)	(\$8.64)	7.6%
\$10 to \$15	0.15	\$1.96	44.4%	0.01	(\$0.01)	6.3%
\$15 to \$20	0.09	\$1.25	32.8%	0.03	\$0.50	31.3%
\$20 to \$25	0.13	\$2.62	11.5%	0.06	\$1.08	29.2%
\$25 to \$50	0.22	\$6.83	2.1%	0.06	\$1.87	20.8%
\$50 to \$75	0.61	\$35.82	0.2%	0.16	\$6.47	2.0%
\$75 to \$100	0.79	\$72.93	0.0%	0.16	\$13.32	0.8%
\$100 to \$125	0.81	\$90.45	0.0%	0.10	\$10.23	0.6%
\$125 to \$150	0.45	\$57.35	0.0%	0.23	\$30.35	0.2%
\$150 to \$400	0.37	\$66.60	0.1%	0.14	\$24.96	1.1%
All Offers	0.12	\$1.97	100.0%	0.05	\$0.98	100.0%

Table 3-97 shows the percentage of marginal units that had markups, calculated using unadjusted cost-based offers, below, above and equal to zero for coal, gas and oil fuel types.¹⁴⁰ Table 3-98 shows the percentage of marginal units that had markups, calculated using adjusted cost-based offers, below, above and equal to zero for coal, gas and oil fuel types. In the first three months of 2021, using unadjusted cost-based offers for coal units, 53.37 percent of marginal coal units had negative markups. In the first three months of 2021, using adjusted cost-based offers for coal units, 31.71 percent of marginal coal units had negative markups. The share of marginal gas units with negative markups at the dispatch point on their offer curve increased from 32.05 percent in the first three months of 2020 to 49.57 percent in the first three months of 2021 when using unadjusted cost based offers. Most marginal combined cycle units had significant negative markups, particularly during the periods of high natural gas prices in February 2021. Cost-based offers for gas fired units are frequently based on the current spot price of fuel while price-based offers may reflect a range of factors including sellers' fuel purchase prices and power sales prices.

¹⁴⁰ Other fuel types were excluded based on data confidentiality rules.

Table 3-97 Percent of marginal units with markup below, above and equal to zero (By fuel type with unadjusted offers): January through March, 2020 and 2021

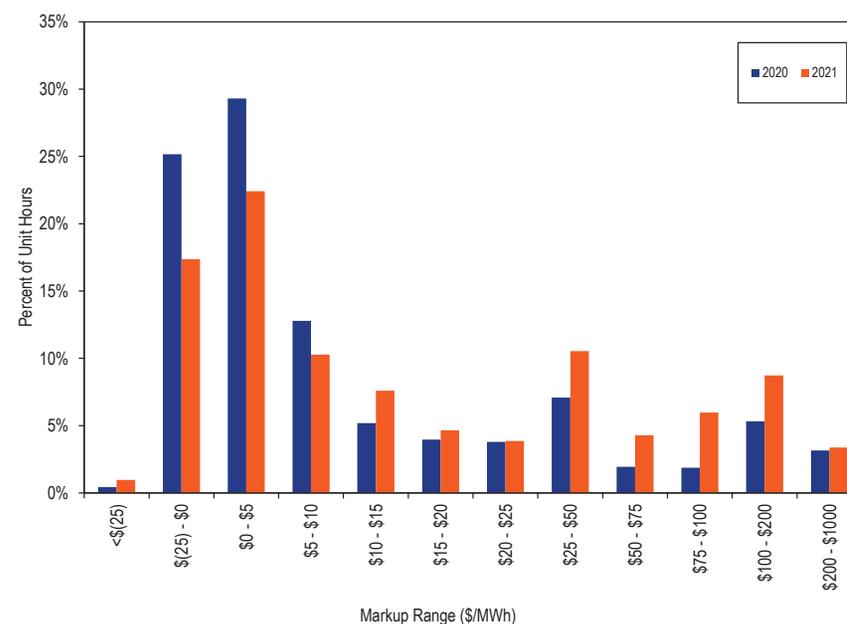
Type/Fuel	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Negative	Zero	Positive	Negative	Zero	Positive
Coal	55.03%	26.87%	18.10%	53.37%	23.20%	23.43%
Gas	32.05%	2.62%	65.33%	49.57%	18.43%	32.00%
Oil	0.00%	100.00%	0.00%	13.45%	82.50%	4.05%

Table 3-98 Percent of marginal units with markup below, above and equal to zero (By fuel type with adjusted offers): January through March, 2020 and 2021

Type/Fuel	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Negative	Zero	Positive	Negative	Zero	Positive
Coal	35.22%	20.17%	44.61%	31.71%	16.44%	51.85%
Gas	18.21%	1.40%	80.40%	30.31%	4.25%	65.43%
Oil	0.00%	70.45%	29.55%	0.81%	79.58%	19.61%

Figure 3-57 shows the frequency distribution of hourly markups for all gas units offered in the first three months of 2020 and the first three months of 2021 using unadjusted cost-based offers. The highest markup within the economic operating range of the unit's offer curve was used in the frequency distributions.¹⁴¹ Of the gas units offered in the PJM market in the first three months of 2021, 18.3 percent of gas unit-hours had a maximum markup that was negative and 12.1 percent of gas fired unit-hours had a maximum markup above \$100 per MWh. The share of offered gas units with maximum markup that was negative decreased in the first three months of 2021 compared to the first three months of 2020 while the share of marginal gas units with negative markups increased.

Figure 3-57 Frequency distribution of highest markup of gas units offered using unadjusted cost offers: January through March, 2020 and 2021



¹⁴¹ The categories in the frequency distribution were chosen so as to maintain data confidentiality.

Figure 3-58 shows the frequency distribution of hourly markups for all coal units offered in the first three months of 2020 and the first three months of 2021 using unadjusted cost-based offers. Of the coal units offered in the PJM market in the first three months of 2021, 42.3 percent of coal unit-hours had a maximum markup that was negative or equal to zero, decreasing from 51.2 in the first three months of 2020. The share of offered coal units with maximum markup that was negative and the share of marginal coal units with negative markups decreased in the first three months of 2021 compared to the first three months of 2020.

Figure 3-58 Frequency distribution of highest markup of coal units offered using unadjusted cost offers: January through March, 2020 and 2021

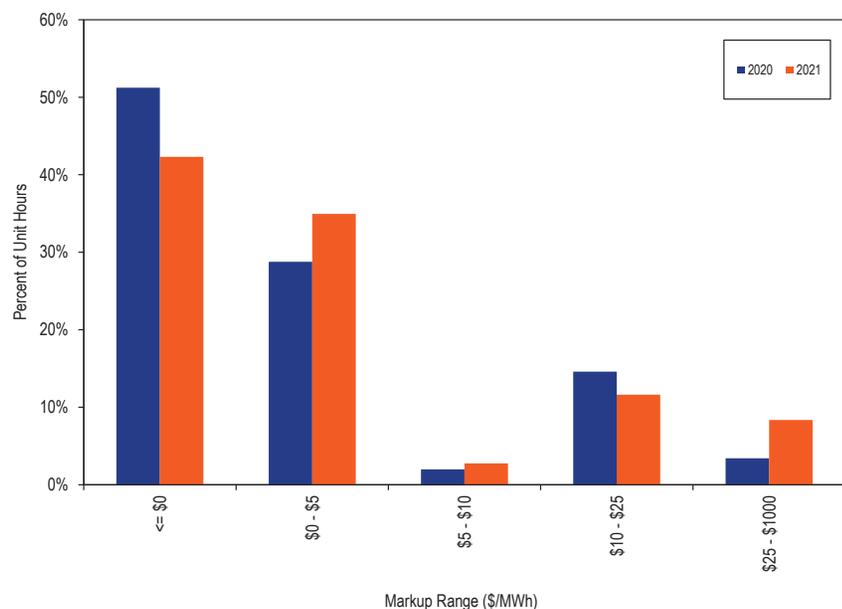
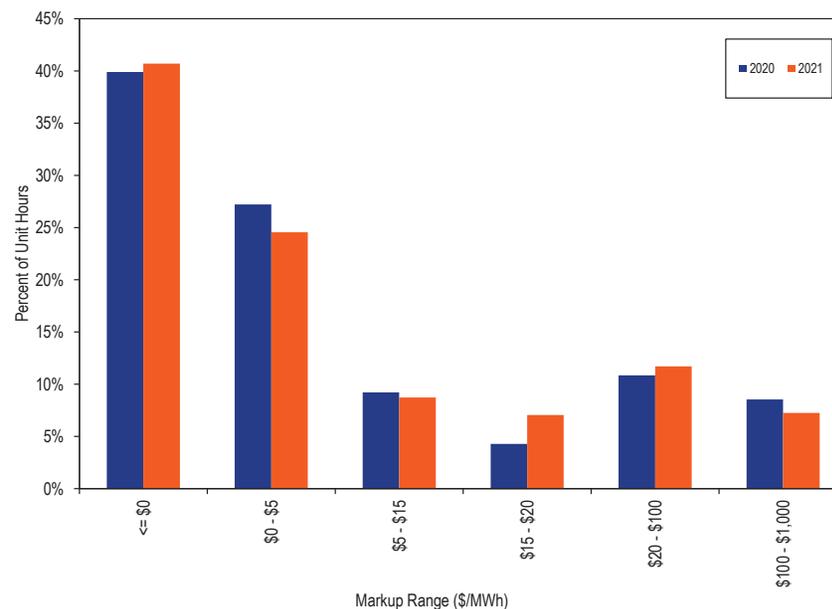


Figure 3-59 shows the frequency distribution of hourly markups for all offered oil units in the first three months of 2020 and the first three months of 2021 using unadjusted cost-based offers. Of the oil units offered in the PJM market in the first three months of 2021, 39.9 percent of oil unit-hours had a maximum markup that was negative or equal to zero. More than 8.5 percent of oil fired unit-hours had a maximum markup above \$100 per MWh.

Figure 3-59 Frequency distribution of highest markup of oil units offered using unadjusted cost offers: January through March, 2020 and 2021

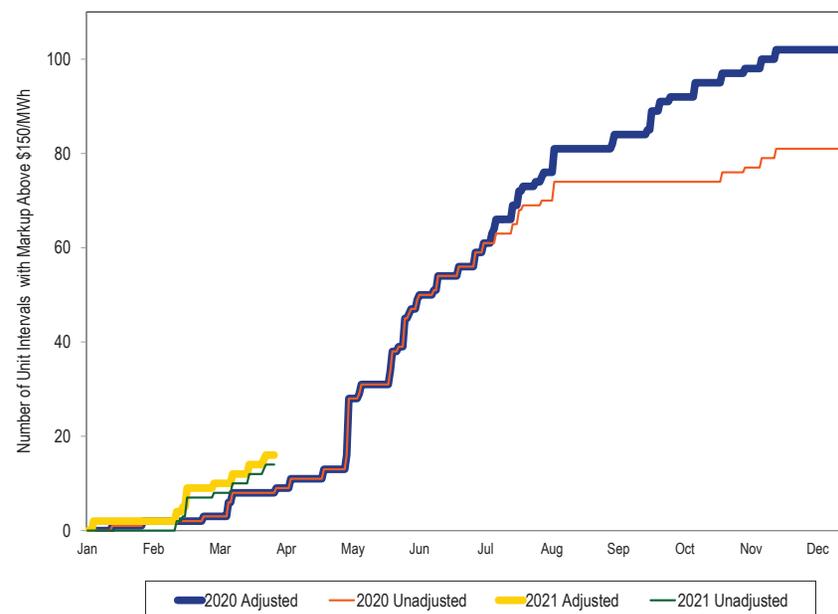


The markup frequency distributions show that a significant proportion of units make price-based offers less than the cost-based offers permitted under the PJM market rules. This behavior means that competitive price-based offers reveal actual unit marginal costs and that PJM market rules permit the inclusion of costs in cost-based offers that are not short run marginal costs.

The markup behavior shown in the markup frequency distributions also shows that a substantial number of units were offered with high markups, consistent with the exercise of market power.

Figure 3-60 shows the number of marginal unit intervals in the first three months of 2021 and the first three months of 2020 with markup above \$150 per MWh. For several of the marginal unit intervals with markups above \$150 per MWh, the units failed the TPS test for the hour. These exercises of market power are a result of PJM's failure to address the issues with the offer capping process identified by the MMU. If PJM adopted the MMU's recommendations, these exercises of market power would not occur.

Figure 3-60 Cumulative number of unit intervals with markups above \$150 per MWh: January through March, 2020 and 2021



Day-Ahead Markup Index

Table 3-99 shows the average markup index of marginal generating units in the day-ahead energy market, by offer price category using unadjusted cost-based offers. The majority of marginal units are virtual transactions, which do not have markup. The average dollar markups of units with offer prices less than \$10 was negative (-\$6.09 per MWh) when using unadjusted cost-based offers. The average dollar markups of units with offer prices between \$10 and \$15 was positive (\$0.69 per MWh) when using unadjusted cost-based offers.

Some marginal units did have substantial markups. Among the units that were marginal in the day-ahead market in January through March, 2021, none had offer prices above \$400 per MWh. Using the unadjusted cost-based offers, the highest markup for any marginal unit in the day-ahead market in the first three months of 2021 was more than \$80 per MWh while the highest markup in the first three months of 2020 was more than \$30 per MWh.

Table 3-99 Average day-ahead marginal unit markup index (By offer price category, unadjusted): January through March, 2020 and 2021

Offer Price Category	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Average Markup Index	Average Dollar Markup	Frequency	Average Markup Index	Average Dollar Markup	Frequency
< \$10	0.02	(\$2.31)	4.7%	(0.03)	(\$6.09)	3.8%
\$10 to \$15	0.08	\$1.04	30.3%	0.07	\$0.69	2.5%
\$15 to \$20	0.23	\$3.37	48.4%	0.05	\$0.69	24.3%
\$20 to \$25	0.01	\$0.03	14.2%	(0.00)	(\$0.40)	34.1%
\$25 to \$50	0.02	\$0.26	2.3%	0.01	(\$31.18)	3.8%
\$50 to \$75	0.00	\$0.00	0.0%	0.15	\$12.63	0.7%
\$75 to \$100	0.00	\$0.00	0.0%	0.04	(\$1.86)	0.8%
\$100 to \$125	0.00	\$0.00	0.1%	0.01	\$1.70	0.3%
>= \$150	0.15	\$25.35	0.0%	0.03	\$4.94	0.5%

Table 3-100 shows the average markup index of marginal generating units in the day-ahead energy market, by offer price category using adjusted cost-based offers. In the first three months of 2021, 24.3 percent of marginal generating units had offers between \$15 and \$20 per MWh, and the average dollar markup and the average markup index were both positive. The average markup index decreased from 0.08 in the first three months of 2020, to -0.00 in the first three months of 2021 in the offer price category less than \$10.

Table 3-100 Average day-ahead marginal unit markup index (By offer price category, adjusted): January through March, 2020 and 2021

Offer Price Category	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Average Markup Index	Average Dollar Markup	Frequency	Average Markup Index	Average Dollar Markup	Frequency
< \$10	0.08	(\$1.93)	4.7%	(0.00)	(\$6.00)	3.8%
\$10 to \$15	0.16	\$2.15	30.3%	0.15	\$1.92	2.5%
\$15 to \$20	0.29	\$4.61	48.4%	0.13	\$2.25	24.3%
\$20 to \$25	0.10	\$2.00	14.2%	0.08	\$1.66	34.1%
\$25 to \$50	0.11	\$2.84	2.3%	0.09	\$2.22	29.1%
\$50 to \$75	0.00	\$0.00	0.0%	0.09	(\$23.16)	3.8%
\$75 to \$100	0.00	\$0.00	0.0%	0.22	\$18.35	0.7%
\$100 to \$125	0.00	\$0.00	0.0%	0.10	\$7.25	0.8%
\$125 to \$150	0.09	\$12.16	0.1%	0.06	\$8.37	0.3%
>= \$150	0.15	\$25.35	0.0%	0.11	\$17.76	0.5%

No Load and Start Cost Markup

Generator energy offers in PJM are comprised of three parts, an incremental energy offer curve, no load cost and start cost. In cost-based offers, all three parts are capped at the level allowed by Schedule 2 of the Operating Agreement, the Cost Development Guidelines (Manual 15) and fuel cost policies approved by PJM. In price-based offers, the incremental energy offer curve is capped at \$1,000 per MWh (unless the verified cost-based offer exceeds \$1,000 per MWh, but cannot exceed \$2,000 per MWh). Generators are allowed to choose whether to use price-based or cost-based no load cost and start costs twice a year. If price-based is selected, the no load and start costs do not have a cap, but the offers cannot be changed for six months (April through September and October through March). If cost-based is selected, the cap is the same as the cap of the no load and start costs in the cost-based offers, and the offers

can be updated daily or hourly. Table 3-101 shows the caps on the three parts of cost-based and price-based offers.

Table 3-101 Cost-based and price-based offer caps

Offer Type	No Load and Start Cost Option	Incremental Offer Curve Cap	No Load Cost Cap	Start Cost Cap
Cost-Based	Cost-Based	Based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies	Based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies	Based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies
Price-Based	Cost-Based	\$1,000/MWh or based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies if verified cost-based offer exceeds \$1,000/MWh but no more than \$2,000/MWh.	Based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies	Based on OA Schedule 2, Cost Development Guidelines (Manual 15) and Fuel Cost Policies
	Price-Based		No cap but can only be changed twice a year.	No cap but can only be changed twice a year.

Table 3-102 shows the number of units that chose the cost-based option and the price-based option. In the first three months of 2021, 92 percent of all generators that submitted no load or start costs chose to have cost-based no load and start costs in their price-based offers, three percentage points higher than in the first three months of 2020.

Table 3-102 Number of units selecting cost-based and price-based no load and start costs: January through March, 2020 and 2021

No Load and Start Cost Option	2020		2021	
	Number of units	Percent	Number of units	Percent
Cost-Based	541	89%	542	92%
Price-Based	66	11%	47	8%
Total	607	100%	589	100%

Generators can have positive or negative markups in their no load and start costs under the price-based option. Generators cannot have positive markups in no load and start costs when they select the cost-based option. Table 3-103 shows the average markup in the no load and start costs in the first three months of 2020 and 2021. Generators that selected the cost-based start and no load option offered on average with a negative markup on the no load cost and a negative markup on the start costs. The price-based offers were actually lower than the cost-based offers. Generators that selected the price-based start and no load option offered on average with a negative markup on the no load cost but with very large positive markups on the start costs.

Table 3-103 No load and start cost markup: January through March, 2020 and 2021

Period	No Load and Start		Intermediate		
	Cost Option	No Load Cost	Cold Start Cost	Start Cost	Hot Start Cost
2020	Cost-Based	(10%)	(8%)	(7%)	(6%)
	Price-Based	(15%)	524%	616%	640%
2021	Cost-Based	(8%)	(9%)	(9%)	(9%)
	Price-Based	(72%)	302%	338%	416%

Energy Market Cost-Based Offers

The application of market power mitigation rules in the day-ahead energy market and the real-time energy market helps ensure competitive market outcomes even in the presence of structural market power.

Cost-based offers in PJM affect all aspects of the PJM energy market. Cost-based offers affect prices when units are committed and dispatched on their cost-based offers. In the first three months of 2021, 8.8 percent of the marginal units set prices based on cost-based offers, 1.2 percentage points higher than in the first three months of 2020.

The efficacy of market power mitigation rules depends on the definition of a competitive offer. A competitive offer is equal to short run marginal costs. The enforcement of market power mitigation rules is undermined if the definition of a competitive offer is not correct. The significance of competition metrics like markup is also undermined if the definition of a competitive offer is not

correct. The definition of a competitive offer in the PJM market rules is not correct. Some unit owners include costs that are not short run marginal costs in offers, including maintenance costs. This issue can be resolved by simple changes to the PJM market rules to incorporate a clear and accurate definition of short run marginal costs.

The efficacy of market power mitigation rules also depends on the accuracy of cost-based offers. Some unit owners use fuel cost policies that are not algorithmic, verifiable, and systematic. These inadequate fuel cost policies permit overstated fuel costs in cost-based offers. FERC's decision to permit maintenance costs in cost-based offers that are not short run marginal costs also results in overstated cost-based offers.

When market power mitigation is not effective due to inaccurate cost-based offers that exceed short run marginal costs, market power causes increases in market prices above the competitive level.

Short Run Marginal Costs

Short run marginal costs are the only costs relevant to competitive offers in the energy market. Specifically, the competitive energy offer level is the short run marginal cost of production. The current PJM market rules distinguish costs includable in cost-based energy offers from costs includable in cost-based capacity market offers based on whether costs are directly related to energy production. The rules do not provide a clear standard. Energy production is the sole purpose of a power plant. Therefore, all costs, including the sunk costs, are directly related to energy production. This current ambiguous criterion is incorrect and, in addition, allows for multiple interpretations, which could lead to tariff violations. The incorrect rules will lead to higher energy market prices and higher uplift.

There are three types of costs identified under PJM rules as of April 15, 2019: variable costs, avoidable costs, and fixed costs. The criterion for whether a generator may include a cost in an energy market cost-based offer, a variable cost, is that the cost is "directly related to electric production."¹⁴²

¹⁴² See 167 FERC ¶ 61,030 (2019).

Variable costs are comprised of short run marginal costs and avoidable costs that are directly related to electric production. Short run marginal costs are the cost of inputs consumed or converted to produce energy, and the costs associated with byproducts that result from consuming or converting materials to produce energy, net of any revenues from the sale of those byproducts. The categories of short run marginal costs are fuel costs, emission allowance costs, operating costs, and energy market opportunity costs.¹⁴³

Avoidable costs are annual costs that would be avoided if energy were not produced over an annual period. The PJM rules divide avoidable costs into those that are directly related to electric production and those not directly related to electric production. The distinction is ambiguous at best. PJM includes overhaul and maintenance costs, replacement of obsolete equipment, and overtime staffing costs in costs related to electric production. PJM includes taxes, preventative maintenance to auxiliary equipment, improvement of working equipment, maintenance expenses triggered by a time milestone (e.g. annual, weekly) and pipeline reservation charges in costs not related to electric production.

Fixed costs are costs associated with an investment in a facility including the return on and of capital.

The MMU recommends that PJM require that the level of costs includable in cost-based offers not exceed the unit's short run marginal cost.

Fuel Cost Policies

Fuel cost policies (FCP) document the process by which market sellers calculate the fuel cost component of their cost-based offers. Short run marginal fuel costs include commodity costs, transportation costs, fees, and taxes for the purchase of fuel.

Fuel Cost Policy Review

Table 3-104 shows the status of all fuel cost policies (FCP) as of March 31, 2021. As of March 31, 2021, 790 units (87 percent) had an FCP passed by the MMU, zero units had an FCP under MMU review (submitted) and 123 units

¹⁴³ See OA Schedule 2(a).

(13 percent) had an FCP failed by the MMU. The units with fuel cost policies failed by the MMU represented 22,864 MW. All units' FCPs were approved by PJM. The number of units with fuel cost policies passed by the MMU increased by 17 by March 31, 2021 compared to December 31, 2020.

Table 3-104 FCP Status for PJM generating units: March 31, 2021

PJM Status	MMU Status			Total
	Pass	Submitted	Fail	
Submitted	0	0	0	0
Under Review	8	0	0	8
Customer Input Required	0	0	0	0
Approved	782	0	123	905
Total	790	0	123	913

The MMU performed a detailed review of every FCP. PJM approved the FCPs that the MMU passed. PJM approved every FCP failed by the MMU.

The standards for the MMU's market power evaluation are that FCPs be algorithmic, verifiable and systematic, accurately reflecting the short run marginal cost of producing energy. In its filings with FERC, PJM agreed with the MMU that FCPs should be verifiable and systematic.¹⁴⁴ Verifiable means that the FCP requires a market seller to provide a fuel price that can be calculated by the MMU after the fact with the same data available to the market seller at the time the decision was made, and documentation for that data from a public or a private source. Systematic means that the FCP must document a clearly defined quantitative method or methods for calculating fuel costs, including objective triggers for each method.¹⁴⁵ PJM and FERC did not agree that fuel cost policies should be algorithmic, although PJM's effectively requires algorithmic fuel cost policies by describing the requirements.¹⁴⁶ Algorithmic means that the FCP must use a set of defined, logical steps, analogous to a recipe, to calculate the fuel costs. These steps may be as simple as a single number from a contract, a simple average of broker quotes, a simple average of bilateral offers, or the weighted average index price posted on the Intercontinental Exchange trading platform ('ICE').¹⁴⁷

¹⁴⁴ Answer of PJM Interconnection, L.L.C. to Protests and Comments, Docket No. ER16-372-002 (October 7, 2016) ("October 7th Filing") at P 11.

¹⁴⁵ Protest of the Independent Market Monitor for PJM, Docket No. ER16-372-002 (September 16, 2016) ("September 16th Filing") at P 8. ¹⁴⁶ October 7th Filing at P12; 158 FERC ¶ 61,133 at P 57 (2017).

¹⁴⁷ September 16th Filing at P 8.

FCPs are not verifiable and systematic if they are not algorithmic. The natural gas FCPs failed by the MMU and approved by PJM are not verifiable and systematic.

Not all FCPs approved by PJM met the standard of the PJM tariff. The tariff standards that some fuel cost policies did not meet are:¹⁴⁸ accuracy (reflect applicable costs accurately); procurement practices (provide information sufficient for the verification of the market seller's fuel procurement practices where relevant); fuel contracts (reflect the market seller's applicable commodity and/or transportation contracts where it holds such contracts).

The MMU failed FCPs not related to natural gas submitted by some market sellers because they do not accurately describe the short run marginal cost of fuel. Some policies include contractual terms (in dollars per MWh or in dollars per MMBtu) that do not reflect the actual cost of fuel. The MMU determined that the terms used in these policies do not reflect the cost of fuel based on the information provided by the market sellers and information gathered by the MMU for similar units.

The MMU failed the remaining FCPs because they do not accurately reflect the cost of natural gas. The main issues identified by the MMU in the natural gas policies were the use of unverifiable fuel costs and the use of available market information that results in inaccurate expected costs.

Some of the failed fuel cost policies include unverifiable cost estimates. Some policies include options under which the estimate of the natural gas commodity cost can be calculated by the market seller without specifying a verifiable, systematic method. For example, some FCPs specify that the source of the natural gas cost would be communications with traders within the market seller's organization. A fuel cost from discretionary and undocumented decision making within the market seller's organization is not verifiable. The point of FCPs is to eliminate such practices as the basis for fuel costs, as most companies have done. Verifiability requires that fuel cost estimates be transparently derived from market information and that PJM or the MMU could reproduce the same fuel cost estimates after the fact by

¹⁴⁸ See PJM Operating Agreement, Schedule 2 § 2.3 (a).

applying the methods documented in the FCP to the same inputs. Verifiable is a key requirement of an FCP. If it is not verifiable, an FCP is meaningless and has no value. Unverifiable fuel costs permit the exercise of market power.

Some of the failed fuel cost policies include the use of available market information that results in inaccurate expected costs because the information does not represent a cleared market price. Some market sellers include the use of offers to sell natural gas on ICE as the sole basis for the cost of natural gas. An offer to sell is generally not a market clearing price and is not an accurate indication of the expected fuel cost. The price of uncleared offers on the exchange generally exceeds the price of cleared transactions, often by a wide margin. Use of sell offers alone is equivalent to using the supply curve alone to determine the market price of a good without considering the demand curve. It is clearly incorrect.

The FCPs that failed the MMU's evaluation also fail to meet the standards defined in the PJM tariff. PJM should not have approved noncompliant fuel cost policies. The MMU recommends that PJM require that all fuel cost policies be algorithmic, verifiable, and systematic.

Cost-Based Offer Penalties

Market Sellers are assessed penalties when they submit cost-based offers that do not comply with Schedule 2 of the PJM Operating Agreement and PJM Manual 15.¹⁴⁹ Penalties are assessed when both PJM and the MMU are in agreement.

In the first three months of 2021, 69 penalty cases were identified, seven resulted in assessed cost-based offer penalties, five resulted in disagreement between the MMU and PJM, and 57 remain pending PJM's determination. The five disagreements in 2021 between the MMU and PJM are related to calculation of fuel costs during pipeline constrained situations. These cases were for 69 units owned by nine different companies. Table 3-106 shows the penalties by the year in which participants were notified.

¹⁴⁹ See PJM Operating Agreement, Schedule 2 § 6.

Table 3-105 Cost-based offer penalty cases by year notified: May 2017 through March 2021

Year notified	Cases	Assessed penalties	MMU and PJM		Number of units impacted	Number of companies impacted
			Disagreement	Pending cases		
2017	57	56	1	0	55	16
2018	187	161	26	0	138	35
2019	57	57	0	0	57	19
2020	142	136	5	1	124	25
2021	69	7	5	57	69	9
Total	512	417	37	58	366	55

Since 2017, 512 penalty cases have been identified, 417 resulted in assessed cost-based offer penalties, 37 resulted in disagreement between the MMU and PJM, and 58 remain pending PJM's determination. The 417 cases were from 366 units owned by 55 different companies. The total penalties were \$2.8 million, charged to units that totaled 87,505 available MW. The average penalty was \$1.46 per available MW. This means that a 100 MW unit would have paid a penalty of \$3,500.¹⁵⁰ Table 3-106 shows the total cost-based offer penalties since 2017 by year.

Table 3-106 Cost-based offer penalties by year: May 2017 through March 2021

Year	Number of units	Number of companies	Penalties	Average Available Capacity Charged (MW)	Average Penalty (\$/MW)
2017	92	20	\$556,826	16,930	\$1.56
2018	127	34	\$1,265,698	26,343	\$2.27
2019	79	20	\$490,926	19,798	\$1.10
2020	130	26	\$367,709	20,096	\$0.83
2021	13	4	\$72,208	4,339	\$0.84
Total	441	58	\$2,753,367	87,505	\$1.46

The incorrect cost-based offers resulted from incorrect application of Fuel Cost Policies, lack of approved fuel cost policies, fuel cost policy violations, miscalculation of no load costs, inclusion of prohibited maintenance costs,

¹⁵⁰ Cost-based offer penalties are assessed by hour. Therefore, a \$1 per available MW penalty results in a total of \$24 for a 1 MW unit if the violation is for the entire day.

use of incorrect incremental heat rates, use of incorrect start cost, and use of incorrect emission costs.

2020 Fuel Cost Policy Changes

On July 28, 2020, the Commission approved tariff revisions that modified the fuel cost policy process and the cost-based offer penalties.¹⁵¹

The tariff revisions replaced the annual review process with a periodic review set by PJM. The revisions reinstated the periodic review process employed by the MMU prior to PJM's involvement in the review and approval of fuel cost policies. Monitoring participant behavior through the use of fuel cost policies is an ongoing process that necessitates frequent updates. Market sellers must revise their fuel cost policies whenever circumstances change that impact fuel pricing (e.g. different pricing points, dual fuel addition capability).

The tariff revisions removed the requirement for units with zero marginal cost to have an approved fuel cost policy but also included a zero offer cap for cost-based offers for units that do not have an approved fuel cost policy.

The tariff revisions allow a temporary cost offer method for units that do not have an approved fuel cost policy. The revisions allow units to submit nonzero cost-based offers without an approved fuel cost policy if they follow the temporary cost offer method. The use of the method results in cost-based offers that do not follow the fuel cost policy rules. The approach significantly weakens market power mitigation by allowing market sellers to make offers without an approved fuel cost policy. The proposed approach allows the use of an inaccurate and unsupported fuel cost calculation in place of an accurate fuel cost policy.

The MMU recommends that the temporary cost method be removed and that all units that submit nonzero cost-based offers be required to have an approved fuel cost policy.

The tariff revisions replace the fuel cost policy revocation provision with the ability for PJM to terminate fuel cost policies.

¹⁵¹ 172 FERC ¶ 61,094.

The tariff revisions reduce the penalties for noncompliant cost-based offers in two situations. When market sellers report their noncompliant cost-based offers, the penalty is reduced by 75 percent. When market sellers do not meet conditions defined to measure a potential market impact the penalty is reduced by 90 percent. The conditions include if the market seller failed the TPS test, if the unit was committed on its cost-based offer, if the unit was marginal or if the unit was paid uplift.

The tariff revisions eliminate penalties entirely when units submit noncompliant cost-based offers if PJM determines that an unforeseen event hindered the market seller's ability to submit a compliant cost-based offer. This new provision allows market sellers to not follow their fuel cost policy, submit cost-based offers that are not verifiable or systematic and not face any penalties for doing so.

The MMU recommends that the penalty exemption provision be removed and that all units that submit nonzero cost-based offers be required to follow their approved fuel cost policy.

Cost Development Guidelines

The Cost Development Guidelines contained in PJM Manual 15 do not clearly or accurately describe the short run marginal cost of generation. The MMU recommends that PJM Manual 15 be replaced with a straightforward description of the components of cost-based offers based on short run marginal costs and the correct calculation of cost-based offers.

Variable Operating and Maintenance Costs

PJM Manual 15 and the PJM Operating Agreement Schedule 2 include rules related to VOM costs. On October 29, 2018, PJM filed tariff revisions changing the rules related to VOM costs.¹⁵² The changes proposed by PJM attempted but failed to clarify the rules. The proposed rules defined all costs directly related to electricity production as includable in cost-based offers. This also included the long term maintenance costs of combined cycles and combustion turbines, which had been explicitly excluded in PJM Manual 15.

¹⁵² See PJM Interconnection Maintenance Adder Revisions to the Amended and Restated Operating Agreement, L.L.C., Docket No. EL19-8-000.

On April 15, 2019, FERC accepted PJM's filing order, subject to revisions requested by FERC.¹⁵³ On October 28, 2019, FERC issued a final order accepting PJM's compliance filing.¹⁵⁴ Regardless of the changes, the rules remain unclear and are now inconsistent with economic theory and effective market power mitigation and competitive market results.

Maintenance costs are not short run marginal costs. Generators perform maintenance during outages. Generators do not perform maintenance in the short run, while operating the generating unit. Generators do not perform maintenance in real time to increase the output of a unit. Some maintenance costs are correlated with the historic operation of a generator. Correlation between operating hours or starts and maintenance expenditures over a long run, multiyear time frame does not indicate the necessity of any specific maintenance expenditure to produce power in the short run.

A generating unit does not consume a defined amount of maintenance parts and labor in order to start. A generating unit does not consume a defined amount of maintenance parts and labor in order to produce an additional MWh. Maintenance events do not occur in the short run. The company cannot optimize its maintenance costs in the short run.

PJM allows for the calculation of VOM costs in dollars per MWh, dollars per MMBtu, dollars per run hour, dollars per equivalent operating hour (EOH) and dollars per start. The MMU converted all VOM costs into dollars per MWh using the units' heat rates, the average economic maximum and average minimum run time of the units in 2020.

The average variable operating and maintenance cost approved by PJM for combustion turbines and diesels for 2020 was 16 percent lower than the approved variable operating and maintenance cost approved by PJM in 2019.¹⁵⁵

¹⁵³ 167 FERC ¶ 61,030.

¹⁵⁴ 168 FERC ¶ 61,134.

¹⁵⁵ PJM reviews VOM once per year. The results reflect PJM's most recent review.

The average variable operating and maintenance cost approved by PJM for combined cycles for 2020 was seven percent higher than the approved variable operating and maintenance cost approved by PJM in 2019.

The average variable operating and maintenance cost approved by PJM for coal units for 2020 was 8 percent lower than the approved variable operating and maintenance cost approved by PJM in 2019.

Table 3-107 shows the amount of capacity offered within several ranges of VOM costs. Table 3-107 shows that 1,000 MW have an approved effective VOM above \$100 per MWh and 3,146 MW have an approved effective VOM between \$50 and \$100 per MWh.

Table 3-107 2019/2020 Approved Effective VOM Costs

Approved VOM Range (\$/MWh)	Offered MW	
	2019/2020	2020/2021
\$0 to \$5 per MWh	69,025	71,898
\$5 to \$10 per MWh	37,325	30,325
\$10 to \$20 per MWh	14,276	15,931
\$20 to \$50 per MWh	5,402	4,938
\$50 to \$100 per MWh	2,302	3,146
Above \$100 per MWh	1,159	1,044

High VOM levels allow generators to economically withhold energy and to exercise market power even when offers are capped at the cost-based offer to mitigate market power. The MMU recommendation to limit cost-based offers to short run marginal costs would prevent such withholding. When units are not committed due to high VOM costs and instead a unit with higher short run marginal costs is committed, the market outcome is inefficient. When units that fail the TPS test are committed on their price-based offer when their short run marginal cost is lower, the market outcome is inefficient.

MMU analysis shows that as CTs, CCs and coal units run for more hours, the VOM cost approved by PJM decreases. This is an indication that fixed costs are included in VOM costs. Fuel costs per MWh remain constant or increase as run hours and the heat rate increase. Fixed costs should not be includable in cost-based energy offers.

The level of costs accepted by PJM for inclusion in VOM depends on PJM's interpretation of the maintenance activities or expenses directly related to electricity production and the level of detailed support provided by market sellers to PJM.

PJM's VOM review is not adequate to determine whether all costs included in VOM are compliant. PJM's VOM review focuses only on the expenses submitted for the last year of up to 20 years of data and PJM's review is dependent on the level of detail provided by the market seller. Recent changes in PJM's review process, triggered by MMU questions, required more details from market sellers and have led to the appropriate exclusion of expenses that were previously included.¹⁵⁶

The flaws in PJM's review process for VOM are compounded by the ambiguity in the criteria used to determine if costs are includable. PJM's definition of allowable costs for cost-based offers, "costs resulting from electric production," is so broad as to be meaningless. Most costs incurred at a generating station result from electric production in one way or another. The generator itself would not exist but for the need for electric production. PJM's broad definition cannot identify which costs associated with electric production are includable in cost-based offers. The definition is not verifiable or systematic and permits wide discretion by PJM and generators.

The MMU recommends that market participants be required to document the amount and cost of consumables used when operating in order to verify that the total operating cost is consistent with the total quantity used and the unit characteristics.

The MMU recommends, given that maintenance costs are currently allowed in cost-based offers, that market participants be permitted to include only variable maintenance costs, linked to verifiable operational events and that can be supported by clear and unambiguous documentation of operational data (e.g. run hours, MWh, MMBtu) that support the maintenance cycle of the equipment being serviced/replaced.

¹⁵⁶ See "Maintenance Adder & Operating Cost Submission Process," 55-57 PJM presentation to the Tech Change Forum. (April 21, 2020) <<https://pjm.com/-/media/committees-groups/forums/tech-change/2020/20200421-special/20200421-item-01-maintenance-adder-and-operating-cost-submission-process.ashx>>.

The MMU understands that companies have different document retention policies but in order to be allowed to include maintenance costs, such costs must be verified, and they cannot be verified without documentation. Supporting documentation includes internal financial records, maintenance project documents, invoices, and contracts. Market participants should be required to provide the operational data (e.g. run hours, MWh, MMBtu) that supports the maintenance cycle of the equipment being serviced/replaced. For example, if equipment is serviced every 5,000 run hours, the market participant must include at least 5,000 run hours of historical operation in its maintenance cost history.

FERC System of Accounts

PJM Manual 15 relies on the FERC System of Accounts, which predates markets and does not define costs consistent with market economics. Market sellers should not rely solely on the FERC System of Accounts for the calculation of their variable operating and maintenance costs. The FERC System of Accounts does not differentiate between short run marginal costs and avoidable costs. The FERC System of Accounts does not differentiate between costs directly related to energy production and costs not directly related to energy production. Reliance on the FERC System of Accounts for the calculation of variable operating and maintenance costs is likely to lead to incorrect, overstated costs.

The MMU recommends removal of all references to and reliance on the FERC System of Accounts in PJM Manual 15.

Cyclic Starting and Peaking Factors

The use of cyclic starting and peaking factors for calculating VOM costs for combined cycles and combustion turbines is designed to allocate a greater proportion of long term maintenance costs to starts and the tail block of the incremental offer curve. The use of such factors is not appropriate given that long term maintenance costs are not short run marginal costs and should not be included in cost offers. PJM Manual 15 allows for a peaking cyclic factor of three, which means that a unit with a \$300 per hour (EOH) VOM cost can add \$180 per MWh to a 5 MW peak segment.¹⁵⁷

¹⁵⁷ The peak adder is equal to \$300 times three divided by 5 MW.

The MMU recommends the removal of all cyclic starting and peaking factors from PJM Manual 15.

Labor Costs

PJM Manual 15 allows for the inclusion of plant staffing costs in energy market cost offers. This is inappropriate given that labor costs are not short run marginal costs.

The MMU recommends the removal of all labor costs from the PJM Manual 15.

Combined Cycle Start Heat Input Definition

PJM Manual 15 defines the start heat input of combined cycles as the amount of fuel used from the firing of the first combustion turbine to the close of the steam turbine breaker plus any fuel used by other combustion turbines in the combined cycle from firing to the point at which the HRSG steam pressure matches the steam turbine steam pressure. This definition is inappropriate given that after each combustion turbine is synchronized, some of the fuel is used to produce energy for which the unit is compensated in the energy market. To account for this, PJM Manual 15 requires reducing the station service MWh used during the start sequence by the output in MWh produced by each combustion turbine after synchronization and before the HRSG steam pressure matches the steam turbine steam pressure. The formula and the language in this definition are not appropriate and are unclear.

The MMU recommends changing the definition of the start heat input for combined cycles to include only the amount of fuel used from firing each combustion turbine in the combined cycle to the breaker close of each combustion turbine. This change will make the treatment of combined cycles consistent with steam turbines. Exceptions to this definition should be granted when the amount of fuel used from synchronization to steam turbine breaker close is greater than the no load heat plus the output during this period times the incremental heat rate.

Nuclear Costs

The fuel costs for nuclear plants are fixed in the short run and amortized over the period between refueling outages. The short run marginal cost of fuel for nuclear plants is zero. Operations and maintenance costs for nuclear power plants consist primarily of labor and maintenance costs incurred during outages, which are also fixed in the short run.

The MMU recommends the removal of nuclear fuel and nonfuel operations and maintenance costs that are not short run marginal costs from the PJM Manual 15.

Pumped Hydro Costs

The calculation of pumped hydro costs for energy storage in Section 7.3 of PJM Manual 15 is inaccurate. The mathematical formulation does not take into account the purchase of power for pumping in the day-ahead market.

The MMU recommends revising the pumped hydro fuel cost calculation to include day-ahead and real-time power purchases.

Frequently Mitigated Units (FMU) and Associated Units (AU)

The rules for determining the qualification of a unit as an FMU or AU became effective November 1, 2014. The number of units that were eligible for an FMU or AU adder declined from an average of 70 units during the first 11 months of 2014, to zero units eligible for an FMU or AU adder for the period between December 2014 and August 2019.¹⁵⁸ One unit qualified for an FMU adder for the months of September and October, 2019. In 2020, five units qualified for an FMU adder in at least one month. In the first three months of 2021, one unit qualified for an FMU adder in January.

Table 3-108 shows, by month, the number of FMUs and AUs from January 2020 through March 2021. For example, in September 2020, there was one FMU and AU in Tier 1, zero FMUs and AUs in Tier 2, and two FMUs and AUs in Tier 3.

¹⁵⁸ For a definition of FMUs and AUs, and for historical FMU/AU results, see the 2018 State of the Market Report for PJM, Volume 2, Section 3, Energy Market, at Frequently Mitigated Units (FMU) and Associated Units (AU).

Table 3-108 Number of frequently mitigated units and associated units (By month): January 2020 through March 2021

	2020				2021			
	Tier 1	Tier 2	Tier 3	Total Eligible for Any Adder	Tier 1	Tier 2	Tier 3	Total Eligible for Any Adder
January	0	0	0	0	0	1	0	1
February	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0
April	0	0	0	0				
May	0	0	0	0				
June	2	0	0	2				
July	2	0	0	2				
August	1	0	0	1				
September	1	0	2	3				
October	2	0	2	4				
November	2	1	2	5				
December	2	1	2	5				

Effective in the 2020/2021 planning year, default Avoidable Cost Rates will no longer be defined in the tariff. If a generating unit's Projected PJM Market Revenues plus the unit's PJM capacity market revenues on a rolling 12-month basis (in \$/MW-year) are greater than zero, and if the generating unit does not have an approved unit specific Avoidable Cost Rate, the generating unit will not qualify as an FMU as the Avoidable Cost Rate will be assumed to be zero for FMU qualification purposes.

The MMU recommends the elimination of FMU and AU adders. FMU and AU adders no longer serve the purpose for which they were created and interfere with the efficient operation of PJM markets.

Market Performance

Ownership of Marginal Resources

Table 3-109 shows the contribution to real-time, load-weighted LMP by individual marginal resource owners.¹⁵⁹ The contribution of each marginal resource to price at each load bus is calculated for each five-minute interval of the first three months of 2021, and summed by the parent company that offers the marginal resource into the real-time energy market. In the first three

¹⁵⁹ See the MMU Technical Reference for PJM Markets, at "Calculation and Use of Generator Sensitivity/Unit Participation Factors."

months of 2021, the offers of one company resulted in 13.5 percent of the real-time, load-weighted PJM system LMP and the offers of the top four companies resulted in 46.4 percent of the real-time, load-weighted, average PJM system LMP. In the first three months of 2021, the offers of one company resulted in 12.8 percent of the peak hour real-time, load-weighted PJM system LMP.

Table 3-109 Marginal unit contribution to real-time, load-weighted LMP (By parent company): January through March, 2020 and 2021

Company	2020 (Jan - Mar)					2021 (Jan - Mar)					
	All Hours		Peak Hours			All Hours		Peak Hours			
	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent
1	17.2%	17.2%	1	18.4%	18.4%	1	13.5%	13.5%	1	12.8%	12.8%
2	12.6%	29.8%	2	15.6%	34.0%	2	12.9%	26.4%	2	12.8%	25.6%
3	11.0%	40.9%	3	11.3%	45.3%	3	12.1%	38.5%	3	12.5%	38.1%
4	9.1%	50.0%	4	8.6%	53.9%	4	7.9%	46.4%	4	7.1%	45.2%
5	5.6%	55.5%	5	5.1%	59.1%	5	6.3%	52.7%	5	6.8%	52.0%
6	4.5%	60.0%	6	5.0%	64.0%	6	6.0%	58.7%	6	6.8%	58.7%
7	4.4%	64.4%	7	3.8%	67.9%	7	4.7%	63.4%	7	4.7%	63.4%
8	4.3%	68.7%	8	3.6%	71.4%	8	4.1%	67.6%	8	3.4%	66.9%
9	4.2%	72.9%	9	2.3%	73.7%	9	3.1%	70.6%	9	3.3%	70.2%
Other (54 companies)	27.1%	100.0%	Other (47 companies)	26.3%	100.0%	Other (60 companies)	29.4%	100.0%	Other (60 companies)	29.8%	100.0%

Figure 3-61 shows the marginal unit contribution to the real-time, load-weighted PJM system LMP summed by parent companies since 2012.

Figure 3-61 Marginal unit contribution to real-time, load-weighted LMP (By parent company): January through March, 2012 through 2021

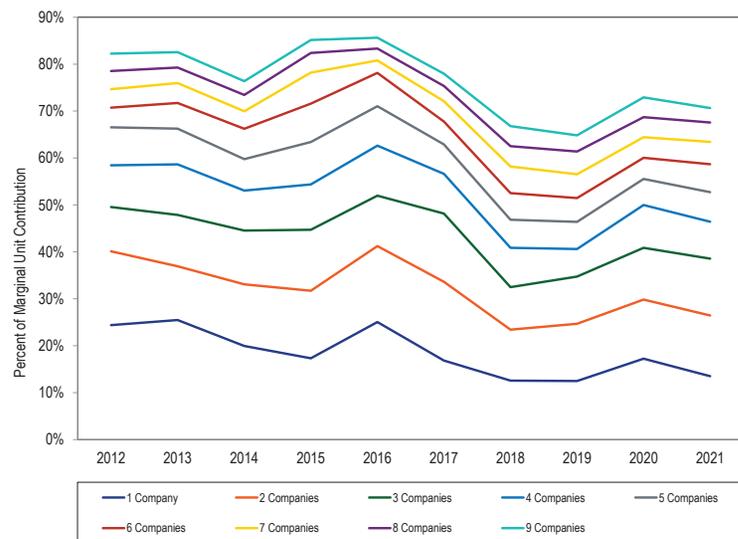


Table 3-110 shows the contribution to day-ahead, load-weighted LMP by individual marginal resource owners.¹⁶⁰ The contribution of each marginal resource to price at each load bus is calculated hourly, and summed by the parent company that offers the marginal resource into the day-ahead energy market. The results show that in the first three months of 2021, the offers of one company contributed 9.5 percent of the day-ahead, load-weighted, PJM system LMP and that the offers of the top four companies contributed 28.5 percent of the day-ahead, load-weighted, average, PJM system LMP.

Table 3-110 Marginal resource contribution to day-ahead, load-weighted LMP (By parent company): January through March, 2020 and 2021

2020 (Jan - Mar)						2021 (Jan - Mar)					
All Hours			Peak Hours			All Hours			Peak Hours		
Company	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent	Company	Percent of Price	Cumulative Percent
1	15.0%	15.0%	1	15.7%	15.7%	1	9.5%	9.5%	1	8.6%	8.6%
2	12.7%	27.8%	2	15.3%	15.3%	2	6.9%	16.5%	2	6.2%	14.7%
3	6.6%	34.4%	3	5.4%	5.4%	3	6.1%	22.6%	3	5.4%	20.1%
4	4.7%	39.1%	4	4.1%	4.1%	4	5.9%	28.5%	4	5.3%	25.5%
5	4.3%	43.4%	5	3.8%	3.8%	5	5.3%	33.7%	5	5.1%	30.6%
6	3.3%	46.7%	6	3.6%	3.6%	6	4.3%	38.0%	6	4.5%	35.1%
7	3.2%	49.9%	7	3.5%	3.5%	7	3.2%	41.3%	7	3.3%	38.4%
8	3.1%	53.0%	8	3.5%	3.5%	8	3.0%	44.3%	8	2.7%	41.1%
9	3.0%	56.0%	9	3.2%	3.2%	9	2.6%	47.0%	9	2.7%	43.8%
Other (117 companies)	44.0%	100.0%	Other (108 companies)	41.9%	41.9%	Other (121 companies)	53.0%	100.0%	Other (108 companies)	56.2%	100.0%

Markup

The markup index is a measure of the competitiveness of participant behavior for individual units. The markup in dollars is a measure of the impact of participant behavior on the generator bus market price when a unit is marginal. As an example, if unit A has a \$90 cost and a \$100 price, while unit B has a \$9 cost and a \$10 price, both would show a markup index of 10 percent, but the price impact of unit A's markup at the generator bus would be \$10 while the price impact of unit B's markup at the generator bus would be \$1. Depending on each unit's location on the transmission system, those bus level impacts could also have different impacts on total system price. Markup

¹⁶⁰ *Id.*

can also affect prices when units with markups are not marginal by altering the economic dispatch order of supply.

The MMU calculates an explicit measure of the impact of marginal unit incremental energy offer markups on LMP using the mathematical relationships among LMPs in the market solution.¹⁶¹ The markup impact calculation sums, over all marginal units, the product of the dollar markup of the unit and the marginal impact of the unit's offer on the system load-weighted LMP. The markup impact includes the impact of the identified markup behavior of all marginal units. Positive and negative markup impacts may offset one another.

The markup analysis is a direct measure of market performance. It does not take into account whether or not marginal units have either locational or aggregate structural market power.

The markup calculation is not based on a counterfactual redispatch of the system to determine the marginal units and their marginal costs that would have occurred if all units

had made all offers at short run marginal cost. A full redispatch analysis is practically impossible and a limited redispatch analysis would not be dispositive. Nonetheless, such a hypothetical counterfactual analysis would reveal the extent to which the actual system dispatch is less than competitive if it showed a difference between dispatch based on short run marginal cost and actual dispatch. It is possible that the unit-specific markup, based on a redispatch analysis, would be lower than the markup component of price if the reference point were an inframarginal unit with a lower price and a higher cost than the actual marginal unit. If the actual marginal unit has

¹⁶¹ The MMU calculates the impact on system prices of marginal unit price-cost markup, based on analysis using sensitivity factors. The calculation shows the markup component of LMP based on a comparison between the price-based incremental energy offer and the cost-based incremental energy offer of each actual marginal unit on the system. This is the same method used to calculate the fuel cost adjusted LMP and the components of LMP. The markup analysis does not include markup in start up or no load offers. See Calculation and Use of Generator Sensitivity/Unit Participation Factors, 2010 State of the Market Report for PJM: Technical Reference for PJM Markets.

short run marginal costs that would cause it to be inframarginal, a new unit would be marginal. If the offer of that new unit were greater than the cost of the original marginal unit, the markup impact would be lower than the MMU measure. If the newly marginal unit is on a price-based schedule, the analysis would have to capture the markup impact of that unit as well.

Real-Time Markup

Markup Component of Real-Time Price by Fuel, Unit Type

The markup component of price is the difference between the system price, when the system price is determined by the active offers of the marginal units, whether price or cost-based, and the system price, based on the cost-based offers of those marginal units.

Table 3-111 shows the impact (markup component of LMP) of the marginal unit markup behavior by fuel type and unit type on the real-time, load-weighted, average system LMP, using unadjusted and adjusted offers. The adjusted markup component of LMP increased from \$1.76 per MWh in the first three months of 2020 to \$1.83 per MWh in the first three months of 2021. The adjusted markup contribution of coal units in the first three months of 2021 was \$0.24 per MWh. The adjusted markup component of gas fired units in the first three months of 2021 was \$1.54 per MWh, a decrease of \$0.07 per MWh from the first three months of 2020. The markup component of wind units was less than \$0.0 per MWh. If a price-based offer is negative, but less negative than a cost-based offer, the markup is positive. In the first three months of 2021, among the wind units that were marginal, 87.1 percent had negative offer prices.

Table 3-111 Markup component of real-time, load-weighted, average LMP by primary fuel type and unit type: January through March, 2020 and 2021¹⁶²

Fuel	Technology	2020 (Jan - Mar)		2021 (Jan - Mar)	
		Markup Component of LMP (Unadjusted)	Markup Component of LMP (Adjusted)	Markup Component of LMP (Unadjusted)	Markup Component of LMP (Adjusted)
Coal	Steam	(\$0.57)	\$0.15	(\$0.26)	\$0.24
Gas	CC	\$0.71	\$1.59	(\$0.12)	\$1.36
Gas	CT	\$0.00	\$0.03	\$0.04	\$0.15
Gas	RICE	\$0.07	\$0.07	\$0.00	\$0.01
Gas	Steam	(\$0.11)	(\$0.08)	(\$0.00)	\$0.02
Landfill Gas	CT	\$0.00	\$0.00	(\$0.00)	(\$0.00)
Municipal Waste	RICE	\$0.00	\$0.00	\$0.00	\$0.00
Oil	CC	\$0.00	\$0.00	\$0.00	\$0.01
Oil	CT	\$0.00	\$0.00	(\$0.00)	\$0.03
Oil	RICE	\$0.00	\$0.00	\$0.00	\$0.00
Oil	Steam	\$0.00	\$0.00	\$0.00	\$0.00
Other	Steam	(\$0.00)	(\$0.00)	\$0.00	\$0.00
Wind	Wind	(\$0.00)	(\$0.00)	\$0.01	\$0.01
Total		\$0.10	\$1.76	(\$0.33)	\$1.83

Markup Component of Real-Time Price

Table 3-112 shows the markup component, calculated using unadjusted offers, of average prices and of average monthly on peak and off peak prices. Table 3-113 shows the markup component, calculated using adjusted offers, of average prices and of average monthly on peak and off peak prices. In the first three months of 2021, when using unadjusted cost-based offers, -\$0.33 per MWh of the PJM real-time, load-weighted, average LMP was attributable to markup. Using adjusted cost-based offers, \$1.83 per MWh of the PJM real-time, load-weighted, average LMP was attributable to markup. In the first three months of 2021, the peak markup component was highest in March, \$0.16 per MWh using unadjusted cost-based offers and peak markup component was highest in March, \$1.85 per MWh using adjusted cost-based offers. This corresponds to 0.58 percent and 6.9 percent of the real-time, peak, load-weighted, average LMP in March.

¹⁶² The unit type RICE refers to Reciprocating Internal Combustion Engines.

Table 3-112 Monthly markup components of real-time, load-weighted, LMP (Unadjusted): January 2020 through March, 2021

	2020			2021		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
Jan	\$0.49	\$0.94	\$0.03	(\$0.46)	(\$0.30)	(\$0.60)
Feb	(\$0.15)	(\$0.00)	(\$0.28)	(\$0.53)	\$0.06	(\$1.12)
Mar	(\$0.09)	\$0.46	(\$0.66)	\$0.02	\$0.16	(\$0.13)
Apr	(\$0.07)	\$0.17	(\$0.33)			
May	\$0.54	\$1.03	\$0.10			
Jun	\$1.24	\$2.02	\$0.30			
Jul	\$0.83	\$1.75	(\$0.30)			
Aug	\$1.80	\$2.88	\$0.70			
Sep	\$0.47	\$0.97	(\$0.08)			
Oct	\$0.09	\$0.71	(\$0.57)			
Nov	(\$0.01)	\$0.72	(\$0.68)			
Dec	\$0.37	\$0.37	\$0.37			
Total	\$0.50	\$1.08	(\$0.10)	(\$0.33)	(\$0.02)	(\$0.63)

Table 3-113 Monthly markup components of real-time, load-weighted, LMP (Adjusted): January 2020 through March, 2021

	2020			2021		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
Jan	\$2.21	\$2.80	\$1.60	\$1.47	\$1.73	\$1.24
Feb	\$1.57	\$1.85	\$1.30	\$2.41	\$3.21	\$1.60
Mar	\$1.44	\$2.07	\$0.81	\$1.63	\$1.85	\$1.39
Apr	\$1.43	\$1.73	\$1.11			
May	\$1.98	\$2.65	\$1.39			
Jun	\$2.77	\$3.75	\$1.58			
Jul	\$2.70	\$3.81	\$1.33			
Aug	\$3.61	\$4.83	\$2.35			
Sep	\$1.89	\$2.50	\$1.22			
Oct	\$1.76	\$2.51	\$0.95			
Nov	\$1.68	\$2.53	\$0.88			
Dec	\$2.46	\$2.56	\$2.37			
Total	\$2.19	\$2.90	\$1.44	\$1.83	\$2.27	\$1.40

Hourly Markup Component of Real-Time Prices

Figure 3-62 shows the markup contribution to the hourly load-weighted, LMP using unadjusted cost offers in 2020 and the first three months of 2021. Figure 3-63 shows the markup contribution to the hourly load-weighted, LMP using adjusted cost-based offers in 2020 and the first three months of 2021.

Figure 3-62 Markup contribution to real-time, hourly, load-weighted LMP (Unadjusted): 2020 through March 2021

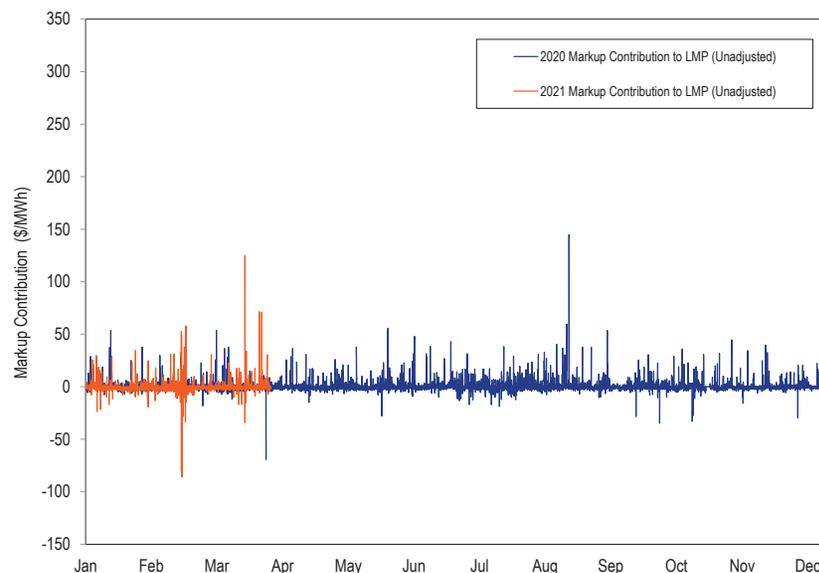
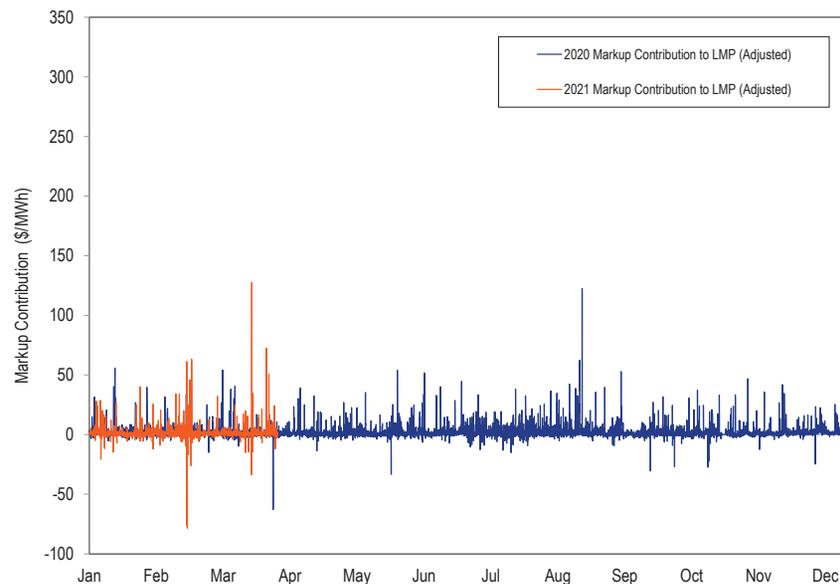


Figure 3-63 Markup contribution to real-time, hourly, load-weighted, LMP (Adjusted): 2020 through March 2021



Markup Component of Real-Time Zonal Prices

The unit markup component of average real-time price using unadjusted offers is shown for each zone in the first three months of 2020 and the first three months of 2021 in Table 3-114 and for adjusted offers in Table 3-115.¹⁶³ The smallest zonal all hours average markup component using unadjusted offers in the first three months of 2021, was in the DUQ Control Zone, -\$0.52 per MWh, while the highest was in the DPL Control Zone, \$0.05 per MWh. The smallest zonal on peak average markup component using unadjusted offers in the first three months of 2021, was in the OVEC Control Zone, \$-0.76 per MWh, while the highest was in the DPL Control Zone, \$0.49 per MWh.

Table 3-114 Average, real-time, zonal markup component (Unadjusted): January through March, 2020 and 2021

	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
ACEC	\$0.01	\$0.08	(\$0.07)	(\$0.14)	\$0.24	(\$0.51)
AEP	\$0.02	\$0.13	(\$0.09)	(\$0.39)	(\$0.13)	(\$0.65)
APS	\$0.02	\$0.13	(\$0.09)	(\$0.38)	(\$0.03)	(\$0.71)
ATSI	\$0.02	\$0.12	(\$0.08)	(\$0.41)	(\$0.05)	(\$0.76)
BGE	\$0.04	\$0.16	(\$0.08)	(\$0.33)	\$0.05	(\$0.69)
COMED	\$0.04	\$0.12	(\$0.04)	(\$0.42)	(\$0.03)	(\$0.81)
DAY	\$0.02	\$0.13	(\$0.09)	(\$0.27)	(\$0.01)	(\$0.53)
DOM	\$0.02	\$0.13	(\$0.09)	(\$0.35)	(\$0.10)	(\$0.59)
DPL	\$0.01	\$0.08	(\$0.07)	\$0.05	\$0.49	(\$0.36)
DUKE	\$0.02	\$0.13	(\$0.10)	(\$0.41)	(\$0.30)	(\$0.52)
DUQ	\$0.03	\$0.13	(\$0.07)	(\$0.52)	(\$0.22)	(\$0.82)
EKPC	\$0.02	\$0.15	(\$0.12)	(\$0.47)	(\$0.40)	(\$0.54)
JCPLC	\$0.00	\$0.07	(\$0.06)	(\$0.17)	\$0.11	(\$0.46)
MEC	\$0.02	\$0.09	(\$0.06)	(\$0.20)	\$0.22	(\$0.62)
OVEC	\$0.00	\$0.14	(\$0.11)	(\$0.39)	(\$0.76)	(\$0.07)
PE	\$0.03	\$0.13	(\$0.08)	(\$0.33)	\$0.20	(\$0.87)
PECO	\$0.01	\$0.08	(\$0.07)	(\$0.18)	\$0.15	(\$0.50)
PEPCO	\$0.04	\$0.15	(\$0.08)	(\$0.35)	(\$0.20)	(\$0.51)
PPL	\$0.05	\$0.10	\$0.00	(\$0.15)	\$0.11	(\$0.41)
PSEG	\$0.00	\$0.07	(\$0.07)	(\$0.21)	\$0.12	(\$0.54)
REC	(\$0.01)	\$0.06	(\$0.08)	(\$0.18)	\$0.04	(\$0.42)

¹⁶³ A marginal unit's offer price affects LMPs in the entire PJM market. The markup component of average zonal real-time price is based on offers of units located within the zone and units located outside the transmission zone.

Table 3-115 Average, real-time, zonal markup component (Adjusted): January through March, 2020 and 2021

	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
ACEC	\$0.37	\$0.45	\$0.29	\$1.79	\$2.24	\$1.37
AEP	\$0.46	\$0.59	\$0.33	\$1.76	\$2.19	\$1.33
APS	\$0.46	\$0.59	\$0.33	\$1.78	\$2.27	\$1.30
ATSI	\$0.46	\$0.58	\$0.33	\$1.70	\$2.19	\$1.21
BGE	\$0.48	\$0.61	\$0.34	\$2.23	\$2.84	\$1.65
COMED	\$0.44	\$0.55	\$0.32	\$1.67	\$2.21	\$1.12
DAY	\$0.47	\$0.60	\$0.33	\$1.98	\$2.43	\$1.53
DOM	\$0.43	\$0.55	\$0.31	\$1.96	\$2.41	\$1.54
DPL	\$0.42	\$0.50	\$0.33	\$2.10	\$2.58	\$1.65
DUKE	\$0.44	\$0.57	\$0.30	\$1.80	\$2.13	\$1.48
DUQ	\$0.45	\$0.57	\$0.32	\$1.55	\$1.99	\$1.12
EKPC	\$0.48	\$0.62	\$0.33	\$1.79	\$2.11	\$1.50
JCPLC	\$0.39	\$0.46	\$0.31	\$1.76	\$2.07	\$1.44
MEC	\$0.44	\$0.52	\$0.35	\$1.80	\$2.29	\$1.30
OVEC	\$0.50	\$0.68	\$0.35	\$1.74	\$1.58	\$1.87
PE	\$0.45	\$0.57	\$0.32	\$1.70	\$2.34	\$1.06
PECO	\$0.40	\$0.49	\$0.31	\$1.71	\$2.09	\$1.34
PEPCO	\$0.47	\$0.60	\$0.33	\$2.01	\$2.40	\$1.64
PPL	\$0.46	\$0.52	\$0.40	\$1.76	\$2.10	\$1.43
PSEG	\$0.39	\$0.48	\$0.30	\$1.88	\$2.36	\$1.39
REC	\$0.35	\$0.44	\$0.26	\$2.08	\$2.68	\$1.44

Markup by Real-Time Price Levels

Table 3-116 shows the markup contribution to the LMP, based on the unadjusted cost-based offers and adjusted cost-based offers of the marginal units, when the PJM system wide, load-weighted, average, LMP was in the identified price range.

Table 3-116 Real-time markup contribution (By load-weighted, LMP category, unadjusted): January through March, 2020 and 2021

LMP Category	2020 (Jan - Mar)		2021 (Jan - Mar)	
	Markup Component	Frequency	Markup Component	Frequency
< \$10	(\$0.90)	1.1%	\$0.00	0.0%
\$10 to \$15	(\$0.14)	16.8%	(\$1.73)	0.7%
\$15 to \$20	(\$1.17)	48.6%	(\$0.96)	22.8%
\$20 to \$25	\$0.11	25.2%	(\$1.11)	34.8%
\$25 to \$50	\$5.09	7.3%	(\$0.13)	33.5%
\$50 to \$75	\$19.82	0.8%	\$2.98	4.2%
\$75 to \$100	\$19.38	0.2%	(\$0.78)	1.8%
\$100 to \$125	\$0.00	0.0%	\$0.51	1.2%
\$125 to \$150	\$0.00	0.0%	\$5.31	0.5%
>= \$150	\$0.00	0.0%	\$24.40	0.5%

Table 3-117 Real-time markup contribution (By load-weighted, LMP category, adjusted): January through March, 2020 and 2021

LMP Category	2020 (Jan - Mar)		2021 (Jan - Mar)	
	Markup Component	Frequency	Markup Component	Frequency
< \$10	\$0.01	1.1%	\$0.00	0.0%
\$10 to \$15	\$1.10	16.8%	(\$0.44)	0.7%
\$15 to \$20	\$0.51	48.4%	\$0.53	22.8%
\$20 to \$25	\$2.02	25.4%	\$0.78	34.8%
\$25 to \$50	\$7.08	7.3%	\$2.19	33.5%
\$50 to \$75	\$21.99	0.8%	\$5.91	4.2%
\$75 to \$100	\$21.43	0.2%	\$4.57	1.8%
\$100 to \$125	\$0.00	0.0%	\$7.30	1.2%
\$125 to \$150	\$0.00	0.0%	\$12.47	0.5%
>= \$150	\$0.00	0.0%	\$29.69	0.5%

Markup by Company

Table 3-118 shows the markup contribution based on the unadjusted cost-based offers and adjusted cost-based offers to real-time, load-weighted, average LMP by individual marginal resource owners. The markup contribution of each marginal resource to price at each load bus is calculated for each five-minute interval, and summed by the parent company that offers the marginal resource into the real-time energy market. In the first three months of 2021, when using unadjusted cost-based offers, the markup of one company accounted for 0.8 percent of the load-weighted, average LMP, the markup of the top five companies accounted for 2.3 percent of the load-weighted, average LMP and the markup of all companies accounted for -1.1 percent of the load-weighted, average LMP. The top five companies' markup contribution to the load-weighted, average LMP and the dollar values of their markup decreased in the first three months of 2021. The markup contribution to the load-weighted, average LMP and share of the markup contribution to the load-weighted, average LMP also decreased in the first three months of 2021. The markup contribution of a unit to the real-time, load-weighted, average LMP can be positive or negative.

Table 3-118 Markup component of real-time, load-weighted, average LMP by Company: January through March, 2020 and 2021

	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Markup Component of LMP (Unadjusted)		Markup Component of LMP (Adjusted)		Markup Component of LMP (Unadjusted)		Markup Component of LMP (Adjusted)	
	\$/MWh	Percent of Load Weighted LMP	\$/MWh	Percent of Load Weighted LMP	\$/MWh	Percent of Load Weighted LMP	\$/MWh	Percent of Load Weighted LMP
Top 1 Company	\$0.44	2.2%	\$0.70	3.5%	\$0.26	0.8%	\$0.36	1.2%
Top 2 Companies	\$0.63	3.2%	\$0.93	4.7%	\$0.48	1.5%	\$0.70	2.3%
Top 3 Companies	\$0.78	3.9%	\$1.14	5.7%	\$0.57	1.9%	\$0.99	3.2%
Top 4 Companies	\$0.86	4.3%	\$1.32	6.7%	\$0.65	2.1%	\$1.26	4.1%
Top 5 Companies	\$0.93	4.7%	\$1.43	7.2%	\$0.71	2.3%	\$1.52	4.9%
All Companies	\$0.10	0.5%	\$1.76	8.9%	(\$0.33)	-1.1%	\$1.83	5.9%

Day-Ahead Markup

Markup Component of Day-Ahead Price by Fuel, Unit Type

The markup component of the PJM day-ahead, load-weighted average LMP by primary fuel and unit type is shown in Table 3-119. INC, DEC and up to congestion transactions (UTC) have zero markups. UTCs were 37.7 percent of marginal resources, INCs were 16.7 percent of marginal resources and DEC were 24.8 percent of marginal resources in the first three months of 2021.

The adjusted markup of coal, gas and oil units is calculated as the difference between the price-based offer, and the cost-based offer excluding the 10 percent adder. Table 3-119 shows the markup component of LMP for marginal generating resources. Generating resources were only 20.5 percent of marginal resources in the first three months of 2021. Using adjusted cost-based offers, the markup component of LMP for marginal generating resources increased for coal fired steam units from \$0.07 to \$0.27 per MWh and decreased for gas fired CC units from \$1.06 to \$1.04 per MWh.

Table 3-119 Markup component of day-ahead, load-weighted, average LMP by primary fuel type and technology type: January through March, 2020 and 2021

Fuel	Technology	2020 (Jan - Mar)			2021 (Jan - Mar)		
		Markup Component of LMP (Unadjusted)	Markup Component of LMP (Adjusted)	Frequency	Markup Component of LMP (Unadjusted)	Markup Component of LMP (Adjusted)	Frequency
Coal	Steam	(\$0.72)	\$0.07	34.8%	(\$0.30)	\$0.27	36.0%
Gas	CC	\$0.61	\$1.06	59.1%	(\$0.04)	\$1.04	56.6%
Gas	CT	(\$0.00)	\$0.00	0.6%	(\$0.01)	(\$0.00)	0.5%
Gas	RICE	(\$0.00)	(\$0.00)	0.1%	(\$0.00)	\$0.00	0.6%
Gas	Steam	(\$0.05)	(\$0.03)	1.1%	\$0.03	\$0.09	1.1%
Municipal Waste	RICE	\$0.00	\$0.00	0.0%	\$0.00	\$0.00	0.3%
Oil	CC	\$0.00	\$0.00	0.0%	\$0.00	\$0.00	0.1%
Oil	CT	\$0.00	\$0.00	0.2%	(\$0.00)	\$0.00	0.2%
Oil	RICE	\$0.00	\$0.00	0.0%	\$0.00	\$0.00	0.1%
Oil	Steam	\$0.00	\$0.00	0.0%	\$0.00	\$0.00	0.0%
Other	Solar	\$0.00	\$0.00	0.0%	\$0.00	\$0.00	0.2%
Other	Steam	(\$0.00)	(\$0.00)	0.1%	(\$0.00)	(\$0.00)	0.2%
Uranium	Steam	\$0.00	\$0.00	1.6%	\$0.00	\$0.00	0.5%
Wind	Wind	\$0.01	\$0.01	2.3%	\$0.24	\$0.24	3.7%
Total		(\$0.15)	\$1.11	100.0%	(\$0.07)	\$1.64	100.0%

Markup Component of Day-Ahead Price

The markup component of price is the difference between the system price, when the system price is determined by the active offers of the marginal units, whether price or cost-based, and the system price, based on the cost-based offers of those marginal units. Only hours when generating units were marginal on either priced-based offers or on cost-based offers were included in the markup calculation.

Table 3-120 shows the markup component of average prices and of average monthly on peak and off peak prices using unadjusted cost-based offers. In the first three months of 2021, when using unadjusted cost-based offers, -\$0.07 per MWh of the PJM day-ahead load-weighted, average LMP was attributable to markup. In the first three months of 2021, the peak markup component was highest in February, \$2.13 per MWh using unadjusted cost-based offers.

Table 3-120 Monthly markup components of day-ahead (Unadjusted), load-weighted LMP: January 2020 through March 2021

	2020			2021		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
Jan	(\$0.03)	\$0.29	(\$0.35)	(\$0.42)	(\$0.25)	(\$0.56)
Feb	(\$0.23)	(\$0.08)	(\$0.39)	(\$0.35)	\$2.13	(\$2.90)
Mar	(\$0.21)	(\$0.19)	(\$0.23)	\$0.62	\$0.55	\$0.70
Apr	(\$0.27)	(\$0.19)	(\$0.36)			
May	(\$0.19)	\$0.17	(\$0.52)			
Jun	\$0.07	\$0.39	(\$0.33)			
Jul	(\$0.54)	(\$0.41)	(\$0.72)			
Aug	\$0.07	\$0.70	(\$0.59)			
Sep	(\$0.01)	\$0.55	(\$0.63)			
Oct	\$0.15	\$0.48	(\$0.21)			
Nov	(\$0.22)	\$0.28	(\$0.70)			
Dec	\$0.13	\$0.37	(\$0.12)			
Annual	(\$0.11)	\$0.19	(\$0.43)	(\$0.07)	\$0.83	(\$0.95)

Table 3-121 shows the markup component of average prices and of average monthly on peak and off peak prices using adjusted cost-based offers. In the first three months of 2021, when using adjusted cost-based offers, \$1.64 per MWh of the PJM day-ahead, load-weighted, average LMP was attributable to markup. In the first three months of 2021, the peak markup component was highest in February, \$4.51 per MWh using adjusted cost-based offers.

Table 3-121 Monthly markup components of day-ahead (Adjusted), load-weighted, LMP: January 2020 through March 2021

	2020			2021		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
Jan	\$1.35	\$1.65	\$1.03	\$1.11	\$1.22	\$1.02
Feb	\$0.99	\$1.17	\$0.83	\$2.07	\$4.51	(\$0.42)
Mar	\$0.96	\$1.02	\$0.90	\$1.77	\$1.72	\$1.82
Apr	\$0.70	\$0.91	\$0.47			
May	\$0.72	\$1.00	\$0.47			
Jun	\$1.04	\$1.35	\$0.67			
Jul	\$0.65	\$0.75	\$0.51			
Aug	\$1.14	\$1.77	\$0.48			
Sep	\$0.95	\$1.50	\$0.34			
Oct	\$1.12	\$1.37	\$0.84			
Nov	\$0.89	\$1.29	\$0.52			
Dec	\$1.49	\$1.68	\$1.29			
Annual	\$1.01	\$1.29	\$0.70	\$1.64	\$2.51	\$0.78

Markup Component of Day-Ahead Zonal Prices

The markup component of annual average day-ahead price using unadjusted cost-based offers is shown for each zone in Table 3-122. The markup component of annual average day-ahead price using adjusted cost-based offers is shown for each zone in Table 3-123. The smallest zonal all hours average markup component using adjusted cost-based offers for the first three months of 2021 was in the ATSI Zone, \$0.34 per MWh, while the highest was in the BGE Control Zone, \$2.81 per MWh. The smallest zonal on peak average markup using adjusted cost-based offers was in the ATSI Control Zone, \$0.48 per MWh, while the highest was in the BGE Control Zone, \$5.20 per MWh.

Table 3-122 Day-ahead, average, zonal markup component (Unadjusted): January through March, 2020 and 2021

	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
ACEC	\$0.15	\$0.30	(\$0.01)	(\$0.14)	\$0.04	(\$0.31)
AEP	(\$0.36)	(\$0.22)	(\$0.49)	(\$0.17)	\$0.66	(\$0.97)
APS	(\$0.32)	(\$0.14)	(\$0.51)	\$0.08	\$1.15	(\$0.96)
ATSI	(\$0.35)	(\$0.21)	(\$0.49)	(\$1.50)	(\$1.37)	(\$1.63)
BGE	(\$0.59)	(\$0.42)	(\$0.76)	\$1.17	\$3.79	(\$1.31)
COMED	(\$0.32)	(\$0.17)	(\$0.47)	(\$0.03)	\$1.01	(\$1.10)
DAY	(\$0.36)	(\$0.21)	(\$0.51)	(\$0.07)	\$0.75	(\$0.91)
DOM	(\$0.44)	(\$0.32)	(\$0.56)	\$0.31	\$1.83	(\$1.09)
DPL	\$0.21	\$0.38	\$0.04	(\$0.14)	(\$0.20)	(\$0.09)
DUKE	(\$0.36)	(\$0.23)	(\$0.50)	(\$0.20)	\$0.76	(\$1.15)
DUQ	(\$0.51)	(\$0.47)	(\$0.56)	(\$0.99)	(\$0.74)	(\$1.24)
EKPC	(\$0.37)	(\$0.23)	(\$0.50)	\$0.07	\$1.68	(\$1.39)
JCPLC	\$0.15	\$0.29	(\$0.01)	(\$0.10)	\$0.15	(\$0.35)
MEC	\$0.26	\$0.39	\$0.12	\$0.31	\$0.90	(\$0.29)
OVEC	\$0.01	(\$0.28)	\$0.22	\$0.12	\$0.59	(\$0.33)
PE	\$0.04	\$0.23	(\$0.19)	(\$0.29)	\$0.16	(\$0.77)
PECO	\$0.19	\$0.34	\$0.04	\$0.04	\$0.30	(\$0.22)
PEPCO	(\$0.36)	(\$0.16)	(\$0.56)	\$0.74	\$2.63	(\$1.15)
PPL	\$1.62	\$2.13	\$1.10	\$0.20	\$0.62	(\$0.21)
PSEG	\$0.15	\$0.31	(\$0.01)	(\$0.27)	(\$0.04)	(\$0.49)
REC	\$0.29	\$0.63	(\$0.08)	(\$0.40)	(\$0.10)	(\$0.72)

Table 3-123 Day-ahead, average, zonal markup component (Adjusted): January through March, 2020 and 2021

	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component	Markup Component (All Hours)	Peak Markup Component	Off Peak Markup Component
ACEC	\$1.38	\$1.57	\$1.19	\$1.65	\$1.91	\$1.40
AEP	\$0.93	\$1.08	\$0.78	\$1.53	\$2.31	\$0.77
APS	\$0.97	\$1.17	\$0.77	\$1.81	\$2.83	\$0.82
ATSI	\$0.95	\$1.09	\$0.79	\$0.34	\$0.48	\$0.20
BGE	\$0.73	\$0.93	\$0.54	\$2.81	\$5.20	\$0.53
COMED	\$0.92	\$1.08	\$0.74	\$1.61	\$2.64	\$0.57
DAY	\$0.96	\$1.11	\$0.81	\$1.71	\$2.50	\$0.90
DOM	\$0.86	\$1.00	\$0.72	\$2.02	\$3.45	\$0.71
DPL	\$1.44	\$1.63	\$1.25	\$1.46	\$1.36	\$1.55
DUKE	\$0.93	\$1.08	\$0.79	\$1.50	\$2.43	\$0.58
DUQ	\$0.75	\$0.79	\$0.71	\$0.76	\$1.00	\$0.52
EKPC	\$0.91	\$1.05	\$0.78	\$1.79	\$3.30	\$0.41
JCPLC	\$1.41	\$1.58	\$1.22	\$1.69	\$1.99	\$1.38
MEC	\$1.47	\$1.63	\$1.31	\$1.93	\$2.54	\$1.32
OVEC	\$1.22	\$0.96	\$1.40	\$1.93	\$2.36	\$1.53
PE	\$1.23	\$1.41	\$1.04	\$1.39	\$1.89	\$0.86
PECO	\$1.42	\$1.60	\$1.23	\$1.77	\$2.09	\$1.45
PEPCO	\$0.95	\$1.17	\$0.73	\$2.45	\$4.23	\$0.68
PPL	\$2.71	\$3.21	\$2.20	\$1.84	\$2.28	\$1.41
PSEG	\$1.38	\$1.57	\$1.19	\$1.47	\$1.79	\$1.15
REC	\$1.52	\$1.87	\$1.13	\$1.24	\$1.56	\$0.91

Markup by Day-Ahead Price Levels

Table 3-124 and Table 3-125 show the average markup component of LMP, based on the unadjusted cost-based offers and adjusted cost-based offers of the marginal units, when the PJM system LMP was in the identified price range.

Table 3-124 Average, day-ahead markup component (By LMP category, unadjusted): January through March, 2020 and 2021

LMP Category	2020 (Jan - Mar)		2021 (Jan - Mar)	
	Average Markup Component	Frequency	Average Markup Component	Frequency
< \$10	\$0.00	0.7%	\$0.00	0.0%
\$10 to \$15	\$0.01	9.6%	(\$0.00)	0.1%
\$15 to \$20	(\$0.25)	49.8%	\$0.06	14.2%
\$20 to \$25	\$0.04	30.3%	(\$0.10)	35.4%
\$25 to \$50	\$0.05	9.5%	\$0.07	44.0%
\$50 to \$75	\$0.00	0.1%	(\$0.34)	3.0%
\$75 to \$100	\$0.00	0.0%	\$0.11	1.2%
\$100 to \$125	\$0.00	0.0%	\$0.02	0.8%
\$125 to \$150	\$0.00	0.0%	(\$0.05)	0.7%
>= \$150	\$0.00	0.0%	\$0.16	0.4%

Table 3-125 Average, day-ahead markup component (By LMP category, adjusted): January through March, 2020 and 2021

LMP Category	2020 (Jan - Mar)		2021 (Jan - Mar)	
	Average Markup Component	Frequency	Average Markup Component	Frequency
< \$10	\$0.00	0.7%	\$0.00	0.0%
\$10 to \$15	\$0.08	9.6%	(\$0.00)	0.1%
\$15 to \$20	\$0.40	49.8%	\$0.20	14.2%
\$20 to \$25	\$0.47	30.3%	\$0.38	35.4%
\$25 to \$50	\$0.15	9.5%	\$0.86	44.0%
\$50 to \$75	\$0.00	0.1%	(\$0.21)	3.0%
\$75 to \$100	\$0.00	0.0%	\$0.15	1.2%
\$100 to \$125	\$0.00	0.0%	\$0.08	0.8%
\$125 to \$150	\$0.00	0.0%	(\$0.01)	0.7%
>= \$150	\$0.00	0.0%	\$0.19	0.4%

Market Structure, Participant Behavior, and Market Performance

The goal of regulation through competition is to achieve competitive market outcomes even in the presence of market power. Market structure in the PJM energy market is not competitive in local markets created by transmission constraints. At times, market structure is not competitive in the aggregate energy market. Market sellers pursuing their financial interests may choose behavior that benefits from structural market power in the absence of an effective market power mitigation program. The overall competitive assessment evaluates the extent to which that participant behavior results in competitive or above competitive pricing. The competitive assessment brings together the structural measures of market power, HHI and pivotal suppliers, with participant behavior, specifically markup, and pricing outcomes.

HHI and Markup

In theory, the HHI provides insight into the relationship between market structure, behavior, and performance. In the case where participants compete by producing output at constant, but potentially different, marginal costs, the HHI is directly proportional to the expected average price cost markup in the market:¹⁶⁴

$$\frac{HHI}{\varepsilon} = \frac{P - MC}{P}$$

where ε is the absolute value of the price elasticity of demand, P is the market price, and MC is the average marginal cost of production. This is called the Lerner Index. The left side of the equation quantifies market structure, and the right side of the equation measures market performance. The assumed participant behavior is profit maximization. As HHI decreases, implying a more competitive market, prices converge to marginal cost, the competitive market outcome. But even a low HHI may result in substantial markup with a low price elasticity of demand. If HHI is very high, meaning competition is lacking, prices can reach the monopoly level. Price elasticity of demand (ε) determines the degree to which suppliers with market power can impose higher prices on customers. The Lerner Index is a measure of market power that

¹⁶⁴ See Tirole, Jean. *The Theory of Industrial Organization*, MIT (1988), Chapter 5: Short-Run Price Competition.

connects market structure (HHI and demand elasticity) to market performance (markup).

The PJM energy market HHIs and application of the FERC concentration categories may understate the degree of market power because, in the absence of aggregate market power mitigation, even the unconcentrated HHI level would imply substantial markups due to the low short run price elasticity of demand. For example, research estimates find short run electricity demand elasticity ranging from -0.2 to -0.4.¹⁶⁵ Using the Lerner Index, the elasticities imply, for example, an average markup ranging from 25 to 50 percent at the unconcentrated to moderately concentrated threshold HHI of 1000:¹⁶⁶

$$\frac{HHI}{\varepsilon} = \frac{0.1}{0.2} = \frac{P - MC}{P} = 50\%$$

With knowledge of HHI, elasticity, and marginal cost, one can solve for the price level theoretically indicated by the Lerner Index, based on profit maximizing behavior including the exercise of market power. With marginal costs of \$31.17 per MWh and an average HHI of 738 in the first three months of 2021, average PJM prices would theoretically range from \$38 to \$49 per MWh using the elasticity range of -0.2 to -0.4.¹⁶⁷ The theoretical prices exceed marginal costs because the exercise of market power is profit maximizing in the absence of market power mitigation. Actual prices, averaging \$30.84 per MWh, and markups, at -1.1 percent, are lower than the theoretical range, supporting the MMU's competitive assessment of the market. However, markup is not zero. In some market intervals, markup and prices reach levels that reflect the exercise of market power.

Market Power Mitigation and Markup

Fully effective market power mitigation would not allow a seller that fails the structural market power test (the TPS test) to set prices with a positive markup.

¹⁶⁵ See Patrick, Robert H. and Frank A. Wolak (1997), "Estimating the Customer-Level Demand for Electricity Under Real-Time Market Prices," <https://web.stanford.edu/group/fwolak/cgi-bin/sites/default/files/files/Estimating%20the%20Customer-Level%20Demand%20for%20Electricity%20Under%20Real-Time%20Market%20Prices_Aug%201997_Patrick,%20Wolak.pdf>, last accessed August 3, 2018 and Fan, Shu and Rob Hyndman (2010), "The price elasticity of electricity demand in South Australia," <<https://robhyndman.com/papers/Elasticity2010.pdf>>.

¹⁶⁶ The HHI used in the equation is based on market shares. For the FERC HHI thresholds and standard HHI reporting, market shares are multiplied by 100 prior to squaring the market shares.

¹⁶⁷ The average HHI is found in Table 3-1. Marginal costs are the sum of all components of LMP except markup, as shown in Table 3-51.

With the flaws in PJM's implementation of the TPS test, resources can and do set prices with a positive markup while failing the TPS test.

Table 3-126 categorizes day-ahead and real-time marginal unit intervals by markup level and TPS test status. In the first three months of 2021, 4.0 percent of real-time marginal unit intervals and 4.2 percent of day-ahead marginal unit hours included a positive markup even though the resource failed the TPS test for local market power. Unmitigated local market power affects PJM market prices. Zero markup with a TPS test failure indicates the mitigation of a marginal unit.

Table 3-126 Percent of real-time marginal unit intervals with markup and local market power: 2019 and 2020

Markup Category	Day-ahead Market			Real-time Market		
	Not Failing TPS Test	Failing TPS Test	Percent in Category	Not Failing TPS Test	Failing TPS Test	Percent in Category
Negative Markup	38.0%	8.1%	46.1%	38.2%	9.0%	47.2%
Zero Markup	16.8%	5.8%	22.6%	16.3%	8.7%	25.1%
\$0 to \$5	21.9%	3.3%	25.2%	19.7%	3.2%	22.9%
\$5 to \$10	1.9%	0.4%	2.3%	2.3%	0.3%	2.6%
\$10 to \$15	0.8%	0.2%	1.0%	0.6%	0.2%	0.7%
\$15 to \$20	1.4%	0.1%	1.5%	0.2%	0.1%	0.3%
\$20 to \$25	0.3%	0.1%	0.4%	0.3%	0.0%	0.3%
\$25 to \$50	0.4%	0.1%	0.5%	0.4%	0.2%	0.6%
\$50 to \$75	0.3%	0.1%	0.4%	0.1%	0.0%	0.1%
\$75 to \$100	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
Above \$100	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
Total Positive Markup	27.1%	4.2%	31.3%	23.7%	4.0%	27.7%
Total	82.0%	18.0%	100.0%	78.2%	21.8%	100.0%

The markup of marginal units was zero or negative in only 72.3 percent of real-time marginal unit intervals and 68.7 percent of day-ahead marginal unit intervals in the first three months of 2021. Pivotal suppliers in the aggregate market also set prices with high markups in the first three months of 2021. Allowing positive markups to affect prices in the presence of market power permits the exercise of market power and has a negative impact on the competitiveness of the PJM energy market. This problem can and should be addressed.

Energy Uplift (Operating Reserves)

Energy uplift is paid to market participants under specified conditions in order to ensure that competitive energy and ancillary service market outcomes do not require efficient resources to operate for the PJM system at a loss.¹ Referred to in PJM as operating reserve credits, lost opportunity cost credits, reactive services credits, synchronous condensing credits or black start services credits, these uplift payments are intended to be one of the incentives to generation owners to offer their energy to the PJM energy market for dispatch based on short run marginal costs and to operate their units as directed by PJM operators. These credits are paid by PJM market participants as operating reserve charges, reactive services charges, synchronous condensing charges or black start services charges. Effective November 1, 2020, UTC transactions are allocated day-ahead and real-time uplift charges, and are treated for uplift purposes as being equivalent to a decrement bid (DEC) at the sink point of the UTC.²

Uplift is an inherent part of the PJM market design. Part of that uplift is the result of the nonconvexity of power production costs. Uplift payments cannot be eliminated, but uplift payments should be limited to the efficient level. In wholesale power market design, a choice must be made between efficient prices and prices that fully compensate costs. Economists recognize that no single price achieves both goals in markets with nonconvex production costs, like the costs of producing electric power.³ ⁴ In wholesale power markets like PJM, efficient prices equal the short run marginal cost of production by location. The dispatch of generators based on these efficient price signals minimizes the total market cost of production. For generators with nonconvex costs, marginal cost prices may not cover the total cost of starting the generator and running at the efficient output level. Uplift payments cover the difference. The PJM market design incorporates efficient prices with minimal uplift

¹ Loss exists when gross energy and ancillary services market revenues are less than short run marginal costs, including all elements of the energy offer, which are startup, no load and incremental offers.

² See 172 FERC ¶ 61,046 (2020).

³ See Stoft, *Power System Economics: Designing Markets for Electricity*, New York: Wiley (2002) at 272; Mas-Colell, Whinston, and Green, *Microeconomic Theory*, New York: Oxford University Press (1995) at 570; and Quinzii, *Increasing Returns and Efficiency*, New York: Oxford University Press (1992).

⁴ The production of output is convex if the production function has constant or decreasing returns to scale, which result in constant or rising average costs with increases in output. Production is nonconvex with increasing returns to scale, which is the case when generating units have start or no load costs that are large relative to marginal costs. See Mas-Colell, Whinston, and Green at 132.

payments. There are improvements to the market design and uplift rules that could further reduce uplift payments while maintaining efficient prices.

In PJM, all energy payments to demand response resources are uplift payments. The energy payments to these resources are not part of the supply and demand balance, they are not paid by LMP revenues and therefore the energy payments to demand response resources have to be paid as out of market uplift. The energy payments to economic DR are funded by real-time load and real-time exports. The energy payments to emergency DR are funded by participants with net energy purchases in the real-time energy market. The current payment structure for DR is an inefficient element of the PJM market design.⁵

Overview

Energy Uplift Credits

- **Types of credits.** In the first three months of 2021, energy uplift credits were \$34.4 million, including \$4.5 million in day-ahead generator credits, \$20.4 million in balancing generator credits, \$4.5 million in lost opportunity cost credits, and \$4.2 million in local constraint control credits.
- **Types of units.** In the first three months of 2021, coal units received 75.5 percent of day-ahead generator credits, and combustion turbines received 92.8 percent of balancing generator credits and 98.4 percent of lost opportunity cost credits.
- **Economic and Noneconomic Generation.** In the first three months of 2021, 88.7 percent of the day-ahead generation eligible for operating reserve credits was economic and 60.2 percent of the real-time generation eligible for operating reserve credits was economic.
- **Day-Ahead Unit Commitment for Reliability.** In the first three months of 2021, 0.2 percent of the total day-ahead generation MWh was scheduled as must run for reliability by PJM, of which 74.6 percent received energy uplift payments.

⁵ Demand response payments are addressed in Section 6: Demand Response.

- **Concentration of Energy Uplift Credits.** In the first three months of 2021, the top 10 units receiving energy uplift credits received 27.9 percent of all credits and the top 10 organizations received 79.5 percent of all credits. The HHI for day-ahead operating reserves was 7592, the HHI for balancing operating reserves was 3402 and the HHI for lost opportunity cost was 7044, all of which are classified as highly concentrated.
- **Lost Opportunity Cost Credits.** Lost opportunity cost credits increased by \$3.0 million or 191.0 percent, in the first three months of 2021 compared to the first three months of 2020, from \$1.5 million to \$4.5 million. Some combustion turbines and diesels are scheduled day-ahead but not requested in real time, and receive day-ahead lost opportunity cost credits as a result. This was the source of 99.5 percent of the \$4.5 million. The day-ahead generation paid LOC credits for this reason decreased by 130.5 GWh or 73.6 percent during 2021, compared to 2020, from 177.4 GWh to 46.9 GWh.
- **Following Dispatch.** Some units are incorrectly paid uplift despite not meeting uplift eligibility requirements, including not following dispatch, not having the correct commitment status, or not operating with proper offer parameters. Since 2018, the MMU has made cumulative resettlement requests for overpaid units that total \$12.1 million, of which PJM has resettled 11.4 percent.

Energy Uplift Charges

- **Energy Uplift Charges.** Total energy uplift charges increased by \$27.2 million, or 378.5 percent, in the first three months of 2021 compared to the first three months of 2020, from \$7.2 million to \$34.4 million.
- **Energy Uplift Charges Categories.** The increase of \$27.2 million in the first three months of 2021 was comprised of a \$4.2 million increase in day-ahead operating reserve charges, a \$22.3 million increase in balancing operating reserve charges, and a \$0.7 million increase in reactive services charges.
- **Average Effective Operating Reserve Rates in the Eastern Region.** Day-ahead load paid \$0.020 per MWh, real-time load paid \$0.067 per MWh, DECs and UTCs paid \$0.265 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.245 per MWh.
- **Average Effective Operating Reserve Rates in the Western Region.** Day-ahead load paid \$0.020 per MWh, real-time load paid \$0.053 per MWh, DECs and UTCs paid \$0.225 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.205 per MWh in the first three months of 2021.
- **Reactive Services Rates.** PPL was the only zone with local voltage support rates, excluding reactive capability payments. PPL had a rate of \$0.064 per MWh.

Geography of Charges and Credits

- In the first three months of 2021, 87.6 percent of all uplift charges allocated regionally (day-ahead operating reserves and balancing operating reserves) were paid by transactions at control zones, 3.2 percent by transactions at hubs and aggregates, and 9.2 percent by transactions at interchange interfaces.
- In the first three months of 2021, generators in the Eastern Region received 55.7 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In the first three months of 2021, generators in the Western Region received 41.9 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In the first three months of 2021, external generators received 2.4 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.

Recommendations

- The MMU recommends that uplift be paid only based on operating parameters that reflect the flexibility of the benchmark new entrant unit (CONE unit) in the PJM Capacity Market. (Priority: High. First reported 2018. Status: Not adopted.)

- The MMU recommends that PJM initiate an analysis of the reasons why a significant number of combustion turbines and diesels scheduled in the day-ahead energy market are not called in real time when they are economic. (Priority: Medium. First Reported 2012. Status: Partially adopted, 2019.)
- The MMU recommends that PJM develop and implement an accurate metric to define when a unit is following dispatch to determine eligibility to receive balancing operating reserve credits and for assessing generator deviations. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM designate units whose offers are flagged for fixed generation in Markets Gateway as not eligible for uplift. Units that are flagged for fixed generation are not dispatchable. Following dispatch is an eligibility requirement for uplift compensation. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends eliminating intraday segments from the calculation of uplift payments and returning to calculating the need for uplift based on the entire 24 hour operating day. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends the elimination of day-ahead uplift to ensure that units receive an energy uplift payment based on their real-time output and not their day-ahead scheduled output. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends enhancing the current energy uplift allocation rules to reflect the recommended elimination of day-ahead uplift, the timing of commitment decisions and the commitment reasons. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends reincorporating the use of net regulation revenues as an offset in the calculation of balancing operating reserve credits. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that self scheduled units not be paid energy uplift for their startup cost when the units are scheduled by PJM to start before the self scheduled hours. (Priority: Low. First reported 2013. Status: Not adopted. Stakeholder process.)
- The MMU recommends three modifications to the energy lost opportunity cost calculations:
 - The MMU recommends calculating LOC based on 24 hour daily periods for combustion turbines and diesels scheduled in the day-ahead energy market, but not committed in real time. (Priority: Medium. First reported 2014. Status: Not adopted.)
 - The MMU recommends that units scheduled in the day-ahead energy market and not committed in real time should be compensated for LOC based on their real-time desired and achievable output, not their scheduled day-ahead output. (Priority: Medium. First reported 2015. Status: Not adopted.)
 - The MMU recommends that only flexible fast start units (startup plus notification times of 10 minutes or less) and units with short minimum run times (one hour or less) be eligible by default for the LOC compensation to units scheduled in the day-ahead energy market and not committed in real time. Other units should be eligible for LOC compensation only if PJM explicitly cancels their day-ahead commitment. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that up to congestion transactions be required to pay energy uplift charges for both the injection and the withdrawal sides of the UTC. (Priority: High. First reported 2011. Status: Partially adopted.)
- The MMU recommends eliminating the use of internal bilateral transactions (IBTs) in the calculation of deviations used to allocate balancing operating reserve charges. (Priority: High. First reported 2013. Status: Adopted 2018.⁶)
- The MMU recommends allocating the energy uplift payments to units scheduled as must run in the day-ahead energy market for reasons other than voltage/reactive or black start services as a reliability charge to real-time load, real-time exports and real-time wheels. (Priority: Medium. First reported 2014. Status: Not adopted. Stakeholder process.)

⁶ As of November 1, 2018, internal bilateral transactions are no longer used for the calculation of deviations for purposes of allocating balancing operating reserve charges. See the *2018 State of the Market Report for PJM*, Volume II, Section 3: "Energy Market" at "Internal Bilateral Transactions" for an analysis of the impact of this change on virtual bidding activity.

- The MMU recommends that the total cost of providing reactive support be categorized and allocated as reactive services. Reactive services credits should be calculated consistent with the balancing operating reserve credit calculation. (Priority: Medium. First reported 2012. Status: Not adopted. Stakeholder process.)
- The MMU recommends including real-time exports and real-time wheels in the allocation of the cost of providing reactive support to the 500 kV system or above, in addition to real-time load. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends modifications to the calculation of lost opportunity costs credits paid to wind units. The lost opportunity costs credits paid to wind units should be based on the lesser of the desired output, the estimated output based on actual wind conditions and the capacity interconnection rights (CIRs). The MMU recommends that PJM allow wind units to request CIRs that reflect the maximum output wind units want to inject into the transmission system at any time. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM clearly identify and classify all reasons for incurring operating reserves in the day-ahead and the real-time energy markets and the associated operating reserve charges in order to make all market participants aware of the reasons for these costs and to help ensure a long term solution to the issue of how to allocate the costs of operating reserves. (Priority: Medium. First reported 2011. Status: Partially adopted.)
- The MMU recommends that PJM revise the current uplift (operating reserve) confidentiality rules in order to allow the disclosure of complete information about the level of uplift (operating reserve charges) by unit and the detailed reasons for the level of operating reserve credits by unit in the PJM region. (Priority: High. First reported 2013. Status: Partially adopted.⁷)
- The MMU recommends that PJM pay uplift based on the offer at the lower of the actual unit output or the dispatch signal MW. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM eliminate the exemption for fast start resources (CTs and diesels) from the requirement to follow dispatch. The performance of these resources should be evaluated in a manner consistent with all other resources (Priority: Medium. First reported 2018. Status: Not adopted.)

Conclusion

Competitive market outcomes result from energy offers equal to short run marginal costs that incorporate flexible operating parameters. When PJM permits a unit to include inflexible operating parameters in its offer and pays uplift based on those inflexible parameters, there is an incentive for the unit to remain inflexible. The rules regarding operating parameters should be implemented in a way that creates incentives for flexible operations rather than inflexible operations. The standard for paying uplift should be the maximum achievable flexibility, based on OEM standards for the benchmark new entrant unit (CONE unit) in the PJM Capacity Market. Applying a weaker standard effectively subsidizes inflexible units by paying them based on inflexible parameters that result from lack of investment and that could be made more flexible. The result both inflates uplift costs and suppresses energy prices.

It is not appropriate to accept that inflexible units should be paid or set price based on short run marginal costs plus start up and no load costs. The question of why units make inflexible offers should be addressed directly. Are units inflexible because they are old and inefficient, because owners have not invested in increased flexibility or because they serve as a mechanism for the exercise of market power? The question of why the inflexible unit was built, whether it was built under cost of service regulation and whether it is efficient to retain the unit should be answered directly. The question of how to provide market incentives for investment in flexible units and for investment in increased flexibility of existing units should be addressed directly. The

⁷ On September 7, 2018, PJM made a compliance filing for FERC Order No. 844 to publish unit specific uplift credits. The compliance filing was accepted by FERC on March 21, 2019. 166 FERC ¶ 61,210. PJM began posting unit specific uplift reports on May 1, 2019. 167 FERC ¶ 61,280 (2019).

question of whether inflexible units should be paid uplift at all should be addressed directly. Marginal cost pricing without paying uplift to inflexible units would create incentives for market participants to provide flexible solutions including replacing inefficient units with flexible, efficient units.

Implementing combined cycle modeling, to permit the energy market model optimization to take advantage of the versatility and flexibility of combined cycle technology in commitment and dispatch, would provide significant flexibility without requiring a distortion of the market rules.

The reduction of uplift payments should not be a goal to be achieved at the expense of the fundamental logic of the LMP system. For example, the use of closed loop interfaces to reduce uplift should be eliminated because it is not consistent with LMP fundamentals and constitutes a form of subjective price setting. The same is true of what PJM terms its CT price setting logic. The same is true of fast start pricing and of convex hull pricing. The same is true of PJM's proposal to modify the ORDC in order to increase energy prices and reduce uplift.

Accurate short run price signals, equal to the short run marginal cost of generating power, provide market incentives for cost minimizing production to all economically dispatched resources and provide market incentives to load based on the marginal cost of additional consumption. The objective of efficient short run price signals is to minimize system production costs, not to minimize uplift. Repricing the market to reflect commitment costs will create a tradeoff between minimizing production costs and reduction of uplift. The tradeoff will exist because when commitment costs are included in prices, the price signal no longer equals the short run marginal cost and therefore no longer provides the correct signal for efficient behavior for market participants making decisions on the margin, whether resources, load, interchange transactions, or virtual traders. This tradeoff will be created by PJM's fast start pricing proposal (limited convex hull pricing). Fast start pricing has been approved by FERC subject to a PJM compliance filing on the definition of fast start resources, and is expected to be implemented in 2021.⁸ Fast start pricing will affect uplift calculations.

⁸ See 173 FERC ¶ 61,244 (2020).

When units receive substantial revenues through energy uplift payments, these payments are not fully transparent to the market, in part because of the current confidentiality rules. As a result, other market participants, including generation and transmission developers, do not have the opportunity to compete to displace them. As a result, substantial energy uplift payments to a concentrated group of units and organizations have persisted. FERC Order No. 844 authorized the publication of unit specific uplift payments for credits incurred after July 1, 2019.⁹ However, Order No. 844 failed to require the publication of unit specific uplift credits for the largest units receiving significant uplift payments, inflexible steam units committed for reliability in the day-ahead market.

One part of addressing the level and allocation of uplift payments is to eliminate all day-ahead operating reserve credits. It is illogical and unnecessary to pay units day-ahead operating reserve credits because units do not incur any costs to run and any revenue shortfalls are addressed by balancing operating reserve credits.

On July 16, 2020, following its investigation of the issue, the Commission ordered PJM to revise its rules so that UTCs are required to pay uplift on the withdrawal side (DEC) only.¹⁰ The uplift payments for UTCs began on November 1, 2020.¹¹

PJM needs to pay substantially more attention to the details of uplift payments including accurately tracking whether units are following dispatch, identifying the actual need for units to be dispatched out of merit and determining whether local reserve zones or better definitions of constraints would be a more market based approach. PJM pays uplift to units even when they do not operate as requested by PJM, i.e. they do not follow dispatch. PJM uses dispatcher logs as a primary screen to determine if units are eligible for uplift regardless of how they actually operate or if they followed the PJM dispatch signal. The reliance

⁹ On March 21, 2019 FERC accepted PJM's Order No. 844 compliance filing. 166 FERC ¶ 61,210 The filing stated that PJM would begin posting unit specific uplift reports on May 1, 2019. On April 8, 2019, PJM filed for an extension on the implementation date of the zonal uplift reports and unit specific uplift reports to July 1, 2019. On June 28, 2019, FERC accepted PJM's request for extension of effective dates. 167 FERC ¶ 61,280.

¹⁰ See 172 FERC ¶ 61,046.

¹¹ On October 17, 2017, PJM filed a proposed tariff change at FERC to allocate uplift to UTC transactions in the same way uplift is allocated to other virtual transactions, as a separate injection and withdrawal deviation. FERC rejected the proposed tariff change. See 162 FERC ¶ 61,019 (2018).

on dispatcher logs for this purpose is impractical, inefficient, and incorrect. PJM needs to define and implement rules for determining when units are following dispatch as a primary screen for eligibility for uplift payments.

The MMU notifies PJM and generators of instances in which, based on the PJM dispatch signal and the real time output of the unit, it is clear that the unit did not operate as requested by PJM. The MMU sends requests for resettlements to PJM to make these units ineligible for uplift credits. Since 2018, the MMU has identified \$12.1 million of incorrect uplift credits.

While energy uplift charges are an appropriate part of the cost of energy, market efficiency would be improved by ensuring that the level and variability of these charges are as low as possible consistent with the reliable operation of the system and consistent with pricing at short run marginal cost. The goal should be to minimize the total incurred energy uplift charges and to increase the transactions over which those charges are spread in order to reduce the impact of energy uplift charges on markets. The result would be to reduce the level of per MWh charges, to reduce the uncertainty associated with uplift charges and to reduce the impact of energy uplift charges on decisions about how and when to participate in PJM markets. The result would also be to increase incentives for flexible operation and to decrease incentives for the continued operation of inflexible and uneconomic resources.

Energy Uplift Credits Results

The level of energy uplift credits paid to specific units depends on the level of the resource's energy offer, the LMP, the resource's operating parameters and the decisions of PJM operators. Energy uplift credits result in part from decisions by PJM operators, who follow reliability requirements and market rules, to start resources or to keep resources operating even when LMP is less than the offer price including incremental, no load and startup costs. Energy uplift payments also result from units' operational parameters that require PJM to schedule or commit resources when they are not economic. The resulting costs not covered by energy revenues are collected as energy uplift.

Table 4-1 shows the totals for each credit category for the first three months of 2020 and 2021.¹² In the first three months of 2021, energy uplift credits increased by \$27.2 million or 378.5 percent compared to the first three months of 2020.

Table 4-1 Energy uplift credits by category: January through March, 2020 and 2021¹³

Category	Type	(Jan - Mar) 2020 Credits (Millions)	(Jan - Mar) 2021 Credits (Millions)	Change	Percent Change	2020 Share	2021 Share
Day-Ahead	Generators	\$0.3	\$4.5	\$4.2	1,378.4%	4.3%	13.1%
	Imports	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Load Response	\$0.0	\$0.0	(\$0.0)	NA	0.0%	0.0%
Balancing	Canceled Resources	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Generators	\$3.2	\$20.4	\$17.2	545.1%	44.0%	59.2%
	Imports	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Load Response	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Local Constraints Control	\$2.1	\$4.2	\$2.1	102.0%	29.1%	12.3%
	Lost Opportunity Cost	\$1.6	\$4.5	\$3.0	191.0%	21.5%	13.1%
	Day-Ahead	\$0.0	\$0.3	\$0.3	7,776.2%	0.0%	0.8%
Reactive Services	Local Constraints Control	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Lost Opportunity Cost	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Reactive Services	\$0.0	\$0.4	\$0.4	948.4%	0.6%	1.3%
	Synchronous Condensing	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
Synchronous Condensing	Day-Ahead	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Black Start Services	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
Black Start Services	Balancing	\$0.0	\$0.0	\$0.0	NA	0.0%	0.0%
	Testing	\$0.0	\$0.1	\$0.0	NA	0.6%	0.2%
Total		\$7.2	\$34.4	\$27.2	378.5%	100.0%	100.0%

¹² Billing data can be modified by PJM Settlements at any time to reflect changes in the evaluation of energy uplift. The billing data reflected in this report were current on April 12, 2021.

¹³ Year to year change is rounded to one tenth of a million, and includes values less than \$0.05 million.

Characteristics of Credits

Types of Units

Table 4-2 shows the distribution of total energy uplift credits by unit type for 2020 and 2021. Uplift credits increased for most unit types, with the exception of wind units. A combination of factors led to increased uplift payments in the first three months of 2021, including higher natural gas prices, increased load due to winter weather in the first three months of 2021, and new operational behavior by CTs in the balancing market. Higher natural gas prices increased the costs of gas units and resulted in increased make whole payments to combustion turbines and increased coal generation. Coal units had the largest percent increase in uplift credits, with an increase of \$3.8 million or 1,309.0 percent in the first three months of 2021 compared with the same period in 2020. This increase can largely be attributed to a small number of coal units in the BGE, PEPCO, and DPL Zones. Combustion turbines had the largest change in uplift credits with an increase of \$22.3 million or 366.6 percent.

In the first three months of 2021, uplift credits to wind units were \$0.1 million, down by 17.4 percent compared to the first three months of 2020.

Table 4-2 Total energy uplift credits by unit type: January through March, 2020 and 2021^{14 15}

Unit Type	(Jan - Mar) 2020 Credits (Millions)	(Jan - Mar) 2021 Credits (Millions)	Change	Percent Change	(Jan - Mar) 2020 Share	(Jan - Mar) 2021 Share
Combined Cycle	\$0.7	\$1.4	\$0.7	114.1%	9.1%	4.1%
Combustion Turbine	\$6.1	\$28.3	\$22.3	366.6%	84.4%	82.3%
Diesel	\$0.1	\$0.4	\$0.3	264.2%	1.5%	1.1%
Hydro	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%
Nuclear	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%
Solar	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%
Steam - Coal	\$0.3	\$4.1	\$3.8	1,309.0%	4.0%	11.8%
Steam - Other	\$0.0	\$0.2	\$0.2	4,870.9%	0.0%	0.5%
Wind	\$0.064	\$0.052	(\$0.0)	(17.4%)	0.9%	0.2%
Total	\$7.2	\$34.4	\$27.2	378.6%	100.0%	100.0%

¹⁴ Table 4-2 does not include balancing imports credits and load response credits in the total amounts.

¹⁵ Solar units should be ineligible for all uplift payments because they do not follow PJM's dispatch instructions. The MMU notified PJM of the discrepancy.

Table 4-3 shows the distribution of energy uplift credits by category and by unit type in the first three months of 2021. The characteristics of the different unit types explain why uplift in specific categories is paid primarily to specific unit types. For example, the majority of day-ahead credits, 78.3 percent, went to steam units because steam units tend to be longer lead time units that are committed before the operating day. If a steam unit is needed for reliability and it is uneconomic it will be committed in the day-ahead energy market and receive day-ahead credits. Combustion turbines, which, unlike other unit types, can be committed and decommitted in the real-time market, received 92.8 percent of balancing credits and 94.9 percent of lost opportunity credits. Combustion turbines committed in the real-time market tend to require balancing credits due to inflexible operating parameters, volatile real-time LMPs, and intraday segment settlements. Combustion turbines with a day-ahead schedule and not committed in real time receive lost opportunity credits when they incur a loss as a result of not operating. A unit incurs a loss when the real-time LMPs are greater than the day-ahead LMPs at the unit's pricing node and the unit's balancing charges are greater than its day-ahead revenues.

Table 4-3 Energy uplift credits by unit type: January through March, 2021

Unit Type	Day-Ahead Generator	Balancing Generator	Canceled Resources	Local Constraints Control	Lost Opportunity Cost	Reactive Services	Synchronous Condensing	Black Start Services
Combined Cycle	18.2%	2.6%	0.0%	0.0%	0.8%	0.0%	0.0%	24.9%
Combustion Turbine	3.5%	92.8%	0.0%	100.0%	94.9%	100.0%	0.0%	75.1%
Diesel	0.0%	1.2%	0.0%	0.0%	3.5%	0.0%	0.0%	0.0%
Hydro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Solar	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Steam - Coal	75.5%	3.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Steam - Other	2.8%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wind	0.0%	0.1%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%
Total (Millions)	\$4.5	\$20.4	\$0.0	\$4.2	\$4.5	\$0.7	\$0.0	\$0.1

Day-Ahead Unit Commitment for Reliability

PJM may schedule units as must run in the day-ahead energy market that would otherwise not have been committed in the day-ahead market when needed in real time to address reliability issues. Such reliability issues include reactive transfer interface control needed to maintain system reliability in a zone or reactive service.¹⁶ Participants can submit units as self scheduled (must run), meaning that the unit must be committed, but a unit submitted as must run by a participant is not eligible for day-ahead operating reserve credits.¹⁷ Units committed for reliability by PJM are eligible for day-ahead operating reserve credits and may set LMP if raised above economic minimum and follow the dispatch signal.

Table 4-4 shows total day-ahead generation and the subset of that generation committed for reliability by PJM. There was a significant increase in the day-ahead generation committed for reliability by PJM, from 11 MW in the first three months of 2020 to 317 MW in the first three months of 2021. The increase in day-ahead generation committed for reliability by PJM was due to an increased need to commit uneconomic units in the BGE, PEPCO, and DPL Zones for reliability. Delayed transmission maintenance during the COVID 19 pandemic increased the transmission outages in the first three months of 2021, resulting in an increased need for reliability commitments.

Table 4-4 Day-ahead generation committed for reliability (GWh): January through March, 2020 and 2021

	2020			2021		
	Total Day-Ahead Generation (GWh)	Day-Ahead PJM Must Run Generation (GWh)	Share	Total Day-Ahead Generation (GWh)	Day-Ahead PJM Must Run Generation (GWh)	Share
Jan	71,116	0	0.0%	73,635	95	0.1%
Feb	65,827	5	0.0%	71,354	13	0.0%
Mar	63,058	6	0.0%	64,713	209	0.3%
Total (Jan - Mar)	200,001	11	0.0%	209,702	317	0.2%

¹⁶ See OA Schedule 1 § 3.2.3(b).

¹⁷ See PJM, "PJM Markets Gateway User Guide," Section Managing Unit Data (version July 16, 2018) at 33, <<http://www.pjm.com/-/media/ctools/markets-gateway/markets-gateway-user-guide.ashx?a=en>>.

Pool scheduled units and units committed for reliability are made whole in the day-ahead energy market if their total offer (including no load and startup costs) is greater than the revenues from the day-ahead energy market. Such units are paid day-ahead uplift (operating reserve credits). Total day-ahead operating reserve credits in the first three months of 2021 were \$4.5 million. The top 10 units received \$3.8 million or 83.3 percent of all day-ahead operating reserve credits. These units were large units with long commitment times and inflexible operating parameters.

It is illogical and unnecessary to pay units day-ahead operating reserves because units do not incur any costs to run in the day-ahead market and any revenue shortfalls are addressed by balancing operating reserve payments.

Table 4-5 shows the total day-ahead generation committed for reliability by PJM by category. In the first three months of 2021, 74.6 percent of the day-ahead generation committed for reliability by PJM received operating reserve credits, 72.0 percent paid as day-ahead operating reserve credits and 2.6 percent paid as reactive services credits. The remaining 25.4 percent was economic, meaning prices covered all resource operating costs and the unit did not receive operating reserve credits.

Table 4-5 Day-ahead generation committed for reliability by category (GWh): January through March, 2021

	Reactive Services (GWh)	Day-Ahead Operating Reserves (GWh)	Economic (GWh)	Total (GWh)
Jan	7.0	44.3	43.2	94.6
Feb	1.3	4.1	7.5	12.9
Mar	0.0	179.6	29.5	209.1
Total (Jan - Mar)	8.3	228.0	80.2	316.5
Share	2.6%	72.0%	25.4%	100.0%

Total day-ahead operating reserve credits in the first three months of 2021 were \$4.5 million, of which \$2.6 million or 56.8 percent was paid to units committed for reliability by PJM, and not scheduled to provide reactive services. An additional 5.8 percent, or \$0.3 million, was paid to units scheduled to provide reactive services.

Balancing Operating Reserve Credits

Balancing operating reserve (BOR) credits are paid to resources operating at PJM's request that do not recover their operating costs from market revenues. BOR credits are calculated as the difference between a resource's revenues (day-ahead market, balancing market, reserve markets, reactive service credits, and day-ahead operating reserve credits) and its real-time costs (startup, no load, and energy offer). Combustion turbines (CTs) received \$18.8 million or 92.8 percent of all balancing operating reserve (BOR) credits in 2020. The majority of these credits, 98.7 percent, are paid to CTs that are committed in real time either without or outside of a day-ahead schedule.¹⁸ Uplift is higher than necessary because settlement rules do not include all revenues and costs for the entire day.

Uplift is also higher than necessary because settlement rules do not disqualify units from receiving uplift when they do not follow PJM's dispatch instructions. Units are disqualified from receiving uplift when the PJM dispatcher is able to identify units that are not following the dispatch signals, and after agreement with the generator, the dispatch reason is changed to self scheduled. PJM dispatchers should not be forced to decide which units qualify for uplift.

¹⁸ Operating outside of a day-ahead schedule refers to units that operate for a period either before or after their day-ahead schedule, or are committed in the real-time market and do not have a day-ahead schedule for any part of the day.

The MMU recommends that PJM develop and implement an accurate metric to define when a unit is following dispatch, instead of relying on PJM dispatchers' manual determinations, to evaluate eligibility for receiving balancing operating reserve credits and for assessing generator deviations. As part of the metric, the MMU recommends that PJM designate units whose offers are flagged for fixed generation in Markets Gateway as not eligible for uplift. Units that are flagged for fixed generation are not dispatchable. Following dispatch is an eligibility requirement for uplift compensation.

Balancing operating reserve credits for generators increased by 545.1 percent in the first three months of 2021 compared to the first three months of 2020. Rising natural gas prices contributed to increased LMPs and higher balancing operating reserve credits during the first three months of 2021. The overall increase in credits in the DOM and AEP Zones accounted for 42.6 percent of the total annual change in balancing operating reserve credits.

The credits paid to combustion turbines committed in real time without a day-ahead commitment occurs despite the fact that the total combustion turbine MW committed in the day-ahead energy market are similar to the totals in the real-time energy market. Table 4-6 shows the monthly day-ahead and real-time generation by combustion turbines. In the first three months of 2021, generation by combustion turbines was 41.2 percent higher in the real-time energy market than in the day-ahead energy market, although this varied by month. Table 4-6 shows that only 4.7 percent of generation from combustion turbines in the day-ahead market was uneconomic, while 57.3 percent of generation from combustion turbines in the real-time market was uneconomic and required \$18.8 million in BOR credits. This increase in uneconomic real-time generation resulted in increased BOR credits during the first three months of 2021.

Table 4-6 Characteristics of day-ahead and real-time generation by combustion turbines: January through March, 2021

Month	Day-Ahead Generation (GWh)	Percent of Day-Ahead Generation that was Noneconomic	Day-Ahead Generator Credits (Millions)	Real-Time Generation (GWh)	Percent of Real-Time Generation that was Noneconomic	Balancing Generator Credits (Millions)	Generation Difference as a Percent of Real-Time Generation
Jan	240	6.5%	\$0.0	483	62.7%	\$4.4	50.3%
Feb	298	5.8%	\$0.1	485	57.4%	\$9.9	38.6%
Mar	309	2.1%	\$0.1	471	51.6%	\$4.5	34.5%
Total (Jan - Mar)	847	4.7%	\$0.2	1,440	57.3%	\$18.8	41.2%

An analysis of real-time generation by combustion turbines shows that BOR credits are incurred primarily by combustion turbines operating without or outside a day-ahead schedule.

Table 4-7 and Table 4-8 show real-time generation by combustion turbines by day-ahead commitment status during the first three months of 2021 and 2020. CTs that operated on a day-ahead schedule during the first three months of 2021 constituted 38.4 percent of real-time generation by CTs, of which 37.5 percent was uneconomic in the real-time market and received \$0.3 million in BOR credits. CTs that operated on a day-ahead schedule during the first three months of 2020 constituted 69.5 percent of real-time generation by CTs, of which 4.2 percent was uneconomic in the real-time market and received zero BOR credits.

In the first three months of 2021, 61.6 percent of real-time generation by CTs was from CTs that operated outside of a day-ahead schedule, of which 69.6 percent was uneconomic in the real-time market and received \$18.4 million in BOR credits. In the first three months of 2020, 30.5 percent of real-time generation by CTs was from CTs that operated outside of a day-ahead schedule, of which 33.0 percent was uneconomic in the real-time market and received \$2.8 million in BOR credits. During the first three months of 2021, real-time generation operating on a day-ahead schedule decreased significantly compared to the first three months of 2020, while real-time generation operating outside of a day-ahead schedule increased significantly. This shift of real-time generation operating on a day-ahead schedule to real-time generation operating outside of a day-ahead schedule is a significant source of the increase of BOR credits. Balancing operating reserves for real-time generation committed on a day-ahead schedule are calculated differently than for real-time generation committed outside of a day-ahead schedule, and this difference resulted in increased credits.

There are multiple reasons why the commitment of CTs is different in the day-ahead and real-time markets, including differences in the hourly pattern of load; differences in interchange transactions; and behavior by other generators. Modeling differences between the day-ahead and real-time markets also affect CT commitment, including: the modeling of different transmission constraints in the day-ahead and real-time market models; the exclusion of soak time for generators in the day-ahead market model; and the different time scales used in the day-ahead and real-time markets.

Table 4-7 Real-time generation by combustion turbines by day-ahead commitment: January through March, 2021

Month	Real-Time Generation Operating on a Day-Ahead Schedule				Real-Time Generation Operating Outside of a Day-Ahead Schedule			
	Generation (GWh)	Share of Real-Time Generation	Percent of Generation that was Noneconomic	Balancing Generator Credits (Millions)	Generation (GWh)	Share of Real-Time Generation	Percent of Generation that was Noneconomic	Balancing Generator Credits (Millions)
Jan	154	31.8%	44.2%	\$0.1	330	68.2%	71.3%	\$4.3
Feb	184	38.0%	32.3%	\$0.2	301	62.0%	72.8%	\$9.7
Mar	214	45.5%	37.1%	\$0.1	257	54.5%	63.7%	\$4.4
Total (Jan - Mar)	553	38.4%	37.5%	\$0.3	887	61.6%	69.6%	\$18.4

Table 4-8 Real-time generation by combustion turbines by day-ahead commitment: January through March, 2020

Month	Real-Time Generation Operating on a Day-Ahead Schedule				Real-Time Generation Operating Outside of a Day-Ahead Schedule			
	Generation (GWh)	Share of Real-Time Generation	Percent of Generation that was Noneconomic	Balancing Generator Credits (Millions)	Generation (GWh)	Share of Real-Time Generation	Percent of Generation that was Noneconomic	Balancing Generator Credits (Millions)
Jan	363	66.1%	3.8%	\$0.0	186	33.9%	37.1%	\$1.5
Feb	241	76.1%	4.3%	\$0.0	76	23.9%	32.3%	\$0.6
Mar	316	69.1%	4.8%	\$0.0	141	30.9%	27.9%	\$0.8
Total (Jan - Mar)	919	69.5%	4.2%	\$0.0	403	30.5%	33.0%	\$2.8

Lost Opportunity Cost Credits

Balancing operating reserve lost opportunity cost (LOC) credits are intended to provide an incentive for units to follow PJM's dispatch instructions when PJM's dispatch instructions deviate from a unit's desired or scheduled output. LOC credits are paid under two different scenarios. The first scenario occurs if a unit of any type generating in real time with an offer price lower than the real-time LMP at the unit's bus is manually reduced or suspended by PJM due to a transmission constraint or other reliability issue. In this scenario the unit will receive a credit for LOC based on its desired output. Such units are not actually forgoing an option to increase output because the reliability of the system and in some cases the generator depend on reducing output. This LOC is referred to as real-time LOC. The second scenario occurs if a combustion turbine or diesel engine is scheduled to operate in the day-ahead energy market, but it is not requested by PJM in real time. In this scenario the unit will receive a credit which covers any loss in the day-ahead financial position of the unit plus the balancing spot energy market position. This LOC will be referred to as day-ahead LOC.

Table 4-9 shows monthly day-ahead and real-time LOC credits in the first three months of 2020 and 2021. In the first three months of 2021, LOC credits increased by \$3.0 million or 191.0 percent compared to the first three months of 2020. The increase of \$3.0 million is comprised of a \$3.0 million increase in day-ahead LOC and a less than \$0.1 million decrease in real-time LOC. The increase in day-ahead LOC credits was the result of increased day-ahead generation by combustion turbines and diesels not requested by PJM in real-time.

In the first three months of 2021, wind units received less than \$0.1 million of real-time LOC, down by 82.1 percent from the first three months of 2020. In the first three months of 2021, real-time LOC credits to wind units accounted for 60.8 percent of the uplift payments to wind units. Wind units in the AEP and COMED Zones received 100 percent of real-time lost opportunity cost credits to wind units.

Table 4-10 shows day-ahead generation for combustion turbines and diesels, including scheduled day-ahead generation, scheduled day-ahead generation not requested in real time, and the subset of day-ahead generation receiving LOC credits. In the first three months of 2021, 12.5 percent of day-ahead generation by combustion turbines and diesels was not requested in real time, 4.7 percentage points lower than in the first three months of 2020. In the first three months of 2021 compared to the first three months of 2020, day-ahead generation by combustion turbines decreased 32.6 percent, day-ahead generation not requested in real time decreased by 50.9 percent, and day-ahead generation not requested in real time receiving lost opportunity costs decreased by 73.6 percent. Unlike steam units, combustion turbines that clear the day-ahead energy market have to be instructed by PJM to come online in real time.

Table 4-9 Monthly lost opportunity cost credits (Millions): January through March, 2020 and 2021

	2020			2021		
	Day-Ahead Lost Opportunity Cost	Real-Time Lost Opportunity Cost	Total	Day-Ahead Lost Opportunity Cost	Real-Time Lost Opportunity Cost	Total
Jan	\$0.5	\$0.0	\$0.5	\$0.4	\$0.0	\$0.4
Feb	\$0.4	\$0.0	\$0.4	\$0.6	\$0.0	\$0.6
Mar	\$0.6	\$0.1	\$0.6	\$3.5	\$0.0	\$3.6
Total (Jan - Mar)	\$1.5	\$0.07	\$1.5	\$4.5	\$0.05	\$4.5
Share (Jan - Mar)	95.4%	4.6%	100.0%	98.9%	1.1%	100.0%

Table 4-10 Day-ahead generation from combustion turbines and diesels (GWh): January through March, 2020 and 2021

	2020			2021		
	Day-Ahead Generation (GWh)	Day-Ahead Generation Not Requested in Real Time (GWh)	Day-Ahead Generation Not Requested in Real Time Receiving LOC Credits (GWh)	Day-Ahead Generation (GWh)	Day-Ahead Generation Not Requested in Real Time (GWh)	Day-Ahead Generation Not Requested in Real Time Receiving LOC Credits (GWh)
Jan	873	171	73	486	70	17
Feb	653	114	49	507	54	13
Mar	729	103	55	527	66	17
Total (Jan - Mar)	2,255	388	177	1,520	191	47
Share (Jan - Mar)	100.0%	17.2%	7.9%	100.0%	12.5%	3.1%

Uplift Eligibility

In PJM, units can have either a pool scheduled or self scheduled commitment status. Pool scheduled units are committed by PJM as a result of the day-ahead and real-time market clearing while self scheduled units are committed by generation owners. Table 4-11 provides a description of commitment and dispatch status, uplift eligibility and the ability to set price.¹⁹ In the day-ahead energy market only pool scheduled resources are eligible for day-ahead operating reserve credits. A unit may self schedule in day ahead to clear and then pool schedule in subsequent days to remain online, in which case they would be eligible for uplift for the subsequent days. In the real-time energy market only pool scheduled resources that follow PJM's dispatch are eligible for balancing operating reserve credits. Units are paid day-ahead operating reserve credits based on their scheduled operation for the entire day. Balancing operating reserve credits are paid on a segmented basis for each period defined by the greater of the day-ahead schedule and minimum run time. Resources receive day-ahead and balancing operating reserve credits only when they are eligible and unable to recover their operating cost for the day or segment.²⁰

¹⁹ PJM has modified the basic rules of eligibility to set price using its CT price setting logic.

²⁰ Resources do not recover their operating cost when market revenues for the day are less than the short run marginal cost defined by the startup, no load, and incremental offer curve.

Table 4-11 Dispatch status, commitment status and uplift eligibility²¹

Dispatch Status	Dispatch Description	Commitment Status		
		Eligible to Set LMP	Self Scheduled (units committed by the generation owner)	Pool Scheduled (units committed by PJM)
Block Loaded	MWh offered to PJM as a single MWh block which is not dispatchable	No	Not eligible to receive uplift	Eligible to receive uplift
Economic Minimum	MWh from the nondispatchable economic minimum component for units that offer a dispatchable range to PJM	No	Not eligible to receive uplift	Eligible to receive uplift
Dispatchable	MWh above the economic minimum level for units that offer a dispatchable range to PJM.	Yes	Only eligible to receive LOC credits if dispatched down by PJM	Eligible to receive uplift

Table 4-12 shows day-ahead and real-time generation by commitment and dispatch status.

Table 4-12 Day-ahead and real-time generation by offer status and eligibility to set LMP (GWh): January through March, 2021

	Self Scheduled			Pool Scheduled			Total GWh	Total Pool Scheduled	Total Self Scheduled	Total Generation Eligible to Set Price
	Dispatchable	Economic Minimum	Block Loaded	Dispatchable	Economic Minimum	Block Loaded				
Day-Ahead Generation	25,411	50,473	48,662	40,219	39,134	5,802	209,702	85,156	124,546	65,630
Share of Day-Ahead	12.1%	24.1%	23.2%	19.2%	18.7%	2.8%	100.0%	40.6%	59.4%	31.3%
Real-Time Generation	22,466	48,301	48,535	40,228	42,665	6,839	209,035	89,733	119,303	62,694
Share of Real-Time	10.7%	23.1%	23.2%	19.2%	20.4%	3.3%	100.0%	42.9%	57.1%	30.0%

Economic and Noneconomic Generation²²

Economic generation includes units scheduled day ahead by PJM or producing energy in real time at an incremental offer less than or equal to the LMP at the unit's bus. Noneconomic generation includes units that are scheduled to produce energy day ahead or produce energy in real time at an incremental offer higher than the LMP at the unit's bus. The MMU analyzed PJM's day-ahead and real-time generation eligible for operating reserve credits to determine the shares of economic and noneconomic generation. Each unit's hourly generation was determined to be economic or noneconomic based on the unit's hourly incremental offer, excluding the hourly no load and any applicable startup cost. A unit could be economic for every hour during a

²¹ PJM allows block loaded CTs to set LMP by relaxing the economic minimum by 10 to 20 percent using CT price setting logic.

²² The analysis of economic and noneconomic generation is based on units' incremental offers, the value used by PJM to calculate LMP. The analysis does not include no load or startup costs.

day or segment, but still receive operating reserve credits because the energy revenues did not cover the hourly no load and startup cost. A unit could be noneconomic for multiple hours and not receive operating reserve credits whenever the total revenues covered the total offer (including no load and startup cost) for the entire day or segment.

Table 4-13 shows the day-ahead and real-time economic and noneconomic generation from units eligible for operating reserve credits as defined by PJM. In the first three months of 2021, 88.7 percent of the day-ahead generation eligible for operating reserve credits was economic and 60.2 percent of the real-time generation eligible for operating reserve credits was economic. A unit's generation may be noneconomic for a portion of their daily generation and economic for the rest.

Table 4-13 Economic and noneconomic generation from units eligible for operating reserve credits (GWh): January through March, 2021

Energy Market	Economic Generation	Noneconomic Generation	Total Eligible Generation	Economic Generation Percent	Noneconomic Generation Percent
Day-Ahead	75,491	9,665	85,156	88.7%	11.3%
Real-Time	45,652	30,121	75,772	60.2%	39.8%

Noneconomic generation only leads to operating reserve credits when a unit is unable to recover its operating costs for the entire day or segment. Table 4-14 shows the generation receiving day-ahead and balancing operating reserve credits. In the first three months of 2021, 1.4 percent of the day-ahead generation eligible for operating reserve credits received credits and 1.1 percent of the real-time generation eligible for operating reserve credits received credits.

Table 4-14 Generation receiving operating reserve credits (GWh): January through March, 2021

Energy Market	Generation Eligible for Operating Reserve Credits	Generation Receiving Operating Reserve Credits	Generation Receiving Operating Reserve Credits	
			Percent	
Day-Ahead	85,156	1,190	1.4%	
Real-Time	75,772	814	1.1%	

Uplift Resettlement

Some units have been incorrectly paid uplift despite not meeting uplift eligibility requirements, such as not following dispatch, not having the correct commitment status, or not operating with proper offer parameters. The MMU has requested that PJM correctly resettle the uplift payments in these cases. Since 2018, the cumulative resettlement requests totaled \$12.1 million. Of that amount, PJM has agreed and resettled 11.4 percent of the requests, 85.3 percent remains pending. The remaining 3.3 percent occurred prior to March 2019 and would now require a directive from FERC for them to be resettled. The MMU continues to bring new cases to the attention of PJM.

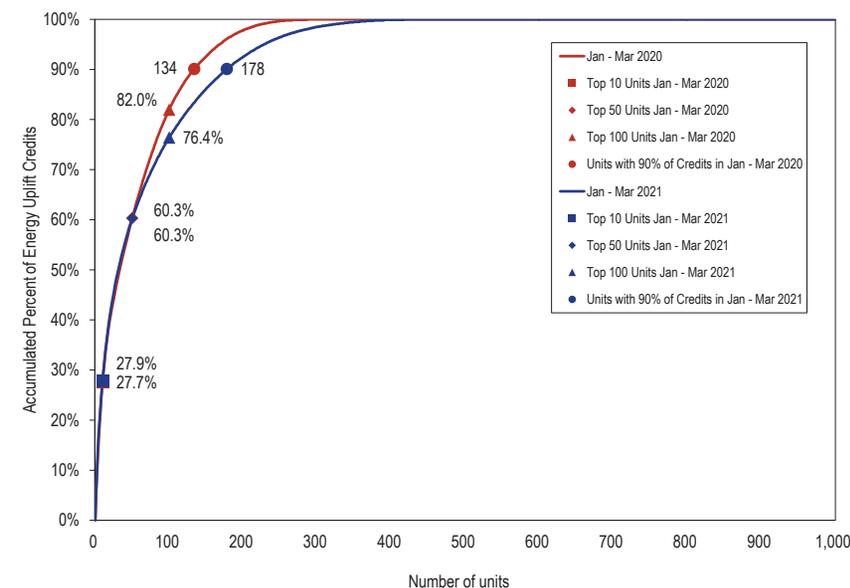
The MMU identifies units that are not following the dispatch signal, and that are therefore not eligible to receive uplift payments. These findings are communicated to PJM and/or Market Sellers. The units are identified by comparing their actual generation to the dispatch level that they should have achieved based on the real-time LMP, unit operating parameters (e.g. economic minimum, maximum and ramp rate) and energy offer.

Concentration of Energy Uplift Credits

The recipients of uplift payments are highly concentrated by unit and by company. This concentration results from a combination of unit operating parameters, PJM’s persistent need to commit specific units out of merit in particular locations and the fact that a lack of full transparency has made it more difficult for competition to affect these payments.²³

Figure 4-1 shows the concentration of energy uplift credits. The top 10 units received 27.9 percent of total energy uplift credits in the first three months of 2021, compared to 27.7 percent in the first three months of 2020. In the first three months of 2021, 177 units received 90 percent of all energy uplift credits, compared to 133 units in the first three months of 2020.

Figure 4-1 Cumulative share of energy uplift credits: January through March, 2020 and 2021 by unit



²³ As a result of FERC Order No. 844, PJM began publishing total uplift credits by unit by month for credits incurred on and after July 1, 2019 on September 10, 2019.

Table 4-15 shows the credits received by the top 10 units and top 10 organizations in each of the energy uplift categories paid to generators in 2020.

Table 4-15 Top 10 units and organizations energy uplift credits: January through March, 2021

Category	Type	Top 10 Units		Top 10 Organizations	
		Credits (Millions)	Credits Share	Credits (Millions)	Credits Share
Day-Ahead	Generators	\$3.8	83.3%	\$4.3	96.0%
	Canceled Resources	\$0.0	0.0%	\$0.0	0.0%
Balancing	Generators	\$4.1	19.9%	\$16.2	79.3%
	Local Constraints Control	\$4.2	100.0%	\$4.2	100.0%
	Lost Opportunity Cost	\$3.1	69.2%	\$4.2	93.6%
Reactive Services		\$0.7	100.0%	\$0.7	100.0%
Synchronous Condensing		\$0.0	0.0%	\$0.0	0.0%
Black Start Services		\$0.1	85.1%	\$0.1	100.0%
Total		\$9.6	27.9%	\$27.3	79.5%

Table 4-16 shows balancing operating reserve credits received by the top 10 units identified for reliability or for deviations in each region. In the first three months of 2021, 47.3 percent of all credits paid to these units were allocated to deviations while the remaining 52.7 percent were paid for reliability reasons.

Table 4-16 Balancing operating reserve credits to top 10 units by category and region: January through March, 2021

	Reliability			Deviations			Total
	RTO	East	West	RTO	East	West	
Credits (Millions)	\$1.7	\$0.4	\$0.0	\$1.3	\$0.6	\$0.0	\$4.1
Share	42.7%	9.8%	0.2%	33.2%	13.9%	0.1%	100.0%

In the first three months of 2021, concentration in all energy uplift credit categories was high.^{24 25} The HHI for energy uplift credits was calculated based on each organization's share of daily credits for each category.²⁶ Table 4-17 shows the average HHI for each category. HHI for day-ahead operating reserve credits to generators was 7592, for balancing operating reserve credits to generators was 3402, for lost opportunity cost credits was 7044 and for reactive services credits was 9777. All of these HHI values are characterized as highly concentrated.

Table 4-17 Daily energy uplift credits HHI: January through March, 2021

Category	Type	Average	Minimum	Maximum	Highest	Highest
					Market Share (One day)	Market Share (All days)
Day-Ahead	Generators	7592	2823	10000	100.0%	44.7%
	Imports	NA	NA	NA	NA	NA
	Load Response	NA	NA	NA	NA	NA
	Canceled Resources	NA	NA	NA	NA	NA
Balancing	Generators	3402	1089	10000	100.0%	20.7%
	Imports	NA	NA	NA	NA	NA
	Load Response	NA	NA	NA	NA	NA
	Lost Opportunity Cost	7044	1913	10000	100.0%	63.9%
Reactive Services		9777	5088	10000	100.0%	97.7%
Synchronous Condensing		NA	NA	NA	NA	NA
Black Start Services		9712	6475	10000	100.0%	24.8%
Total		2953	1052	9036	99.3%	15.3%

Unit Specific Uplift Payments

FERC Order No. 844 allows PJM and the MMU to publish unit specific uplift payments by category by month. Table 4-18 through Table 4-21 show the top 10 recipients of total uplift, day-ahead operating reserve credits and lost opportunity cost credits. The top 10 units receiving uplift credits received 27.9 percent of all credits, with the top recipient receiving 4.8 percent. The top 10 units receiving day-ahead operating reserves received 83.3 percent. The top 10 recipients of balancing operating reserves received 19.9 percent of balancing operating reserve credits. The top 10 recipients of lost opportunity cost credits received 69.2 percent of total lost opportunity cost credits.

²⁴ See the 2020 State of the Market Report for PJM Section 3: "Energy Market" at "Market Concentration" for a discussion of concentration ratios and the Herfindahl-Hirschman Index (HHI).

²⁵ Table 4-16 excludes local constraint control categories.

²⁶ Concentration is measured using the entity (or entities) to which the uplift credit is paid.

Table 4-18 Top 10 recipients of total uplift: January through March, 2021

Rank	Unit Name	Zone	Total Uplift Credit	Share of Total Uplift Credits
1	BC BRANDON SHORES 2 F	BGE	\$1,651,072	4.8%
2	DAY GREENVILLE 1 CT	DAY	\$1,439,330	4.2%
3	DAY GREENVILLE 4 CT	DAY	\$1,301,389	3.8%
4	DAY GREENVILLE 3 CT	DAY	\$1,173,233	3.4%
5	DPL COMM CHESAPEAKE - NEW CHURCH 3 CT	DPL	\$767,623	2.2%
6	PEP MORGANTOWN 1 F	PEPCO	\$706,653	2.1%
7	VP LOUISA 5 CT	DOM	\$683,982	2.0%
8	DPL INDIAN RIVER 4 F	DPL	\$649,819	1.9%
9	VP MARSHRUN 2 CT	DOM	\$627,762	1.8%
10	VP MARSHRUN 1 CT	DOM	\$600,875	1.7%
Total of Top 10			\$9,601,738	27.9%
Total Uplift Credits			\$34,400,961	100.0%

Table 4-19 Top 10 recipients of day-ahead generation credits: January through March, 2021

Rank	Unit Name	Zone	Day-Ahead Operating Reserve Credit	Share of Day-Ahead Operating Reserve Credits
1	BC BRANDON SHORES 2 F	BGE	\$1,542,458	34.1%
2	PEP MORGANTOWN 1 F	PEPCO	\$697,476	15.4%
3	DPL INDIAN RIVER 4 F	DPL	\$460,761	10.2%
4	VP BRUNSWICK 1CC	DOM	\$280,850	6.2%
5	BC BRANDON SHORES 1 F	BGE	\$254,942	5.6%
6	DPL WILDCAT POINT 1 CC	DPL	\$213,120	4.7%
7	PL BRUNNER ISLAND 1 F	PPL	\$161,282	3.6%
8	VP CLOVER 2 F	DOM	\$74,295	1.6%
9	DPL VIENNA 8 F	DPL	\$42,411	0.9%
10	PS BERGEN 2CC F	PSEG	\$39,250	0.9%
Total of Top 10			\$3,766,845	83.3%
Total day-ahead operating reserve credits			\$4,521,870	100.0%

Table 4-20 Top 10 recipients of balancing operating reserve credits: January through March, 2021

Rank	Unit Name	Zone	Balancing Operating Reserve Credit	Share of Balancing Operating Reserve Credits
1	VP LOUISA 5 CT	DOM	\$670,278	3.3%
2	VP MARSHRUN 2 CT	DOM	\$620,716	3.0%
3	VP MARSHRUN 1 CT	DOM	\$593,343	2.9%
4	VP MARSHRUN 3 CT	DOM	\$528,976	2.6%
5	VP FOUR RIVERS 1 CT	DOM	\$332,490	1.6%
6	BC PERRYMAN 6 CT	BGE	\$298,129	1.5%
7	FE LEMOYNE 1 CT	ATSI	\$280,694	1.4%
8	VP DOSWELL 3 CT	DOM	\$250,688	1.2%
9	EKPC JK SMITH 5 CT	EKPC	\$245,337	1.2%
10	EKPC JK SMITH 7 CT	EKPC	\$229,432	1.1%
Total of Top 10			\$4,050,085	19.9%
Total balancing operating reserve credits			\$20,381,544	100.0%

Table 4-21 Top 10 recipients of lost opportunity cost credits: January through March, 2021

Rank	Unit Name	Zone	Lost Opportunity Cost Credit	Share of Lost Opportunity Cost Credits
1	DPL COMM CHESAPEAKE - NEW CHURCH 3 CT	DPL	\$593,804	13.2%
2	DPL COMM CHESAPEAKE - NEW CHURCH 4 CT	DPL	\$545,976	12.1%
3	DPL COMM CHESAPEAKE - NEW CHURCH 5 CT	DPL	\$471,660	10.5%
4	DPL COMM CHESAPEAKE - NEW CHURCH 7 CT	DPL	\$406,181	9.0%
5	DPL COMM CHESAPEAKE - NEW CHURCH 2 CT	DPL	\$327,493	7.3%
6	DPL COMM CHESAPEAKE - NEW CHURCH 6 CT	DPL	\$275,766	6.1%
7	DPL COMM CHESAPEAKE - NEW CHURCH 1 CT	DPL	\$257,634	5.7%
8	VP LADYSMYTH 5 CT	DOM	\$95,886	2.1%
9	FE LEMOYNE 1 CT	ATSI	\$73,842	1.6%
10	AEP WOLF HILL 1 CT	AEP	\$68,688	1.5%
Total of Top 10			\$3,116,930	69.2%
Total lost opportunity cost credits			\$4,502,987	100.0%

Credits and Charges Categories

Energy uplift charges include day-ahead and balancing operating reserves, reactive services, synchronous condensing and black start services categories. Total energy uplift credits paid to PJM participants equal the total energy uplift charges paid by PJM participants. Table 4-22 and Table 4-23 show the categories of credits and charges and their relationship. These tables show how the charges are allocated.

Table 4-22 Day-ahead and balancing operating reserve credits and charges

Credits Received For:	Credits Category:		Charges Category:	Charges Paid By:
			Day-Ahead	
Day-Ahead Import Transactions and Generation Resources	Day-Ahead Operating Reserve Transaction	→	Day-Ahead Operating Reserve	Day-Ahead Load
	Day-Ahead Operating Reserve Generator			Day-Ahead Export Transactions in RTO Region
				Decrement Bids & UTCs
Economic Load Response Resources	Day-Ahead Operating Reserves for Load Response	→	Day-Ahead Operating Reserve for Load Response	Day-Ahead Load
				Day-Ahead Export Transactions in RTO Region
				Decrement Bids & UTCs
	Unallocated Negative Load Congestion Charges	→	Unallocated Congestion	Day-Ahead Load
	Unallocated Positive Generation Congestion Credits			Day-Ahead Export Transactions in RTO Region
				Decrement Bids & UTCs
			Balancing	
Generation Resources	Balancing Operating Reserve Generator	→	Balancing Operating Reserve for Reliability	Real-Time Load plus Real-Time Export Transactions in RTO, Eastern or Western Region
			Balancing Operating Reserve for Deviations	Deviations
			Balancing Local Constraint	Applicable Requesting Party
Canceled Resources	Balancing Operating Reserve Startup Cancellation	→	Balancing Operating Reserve for Deviations	Deviations in RTO Region
Lost Opportunity Cost (LOC)	Balancing Operating Reserve LOC			
Real-Time Import Transactions	Balancing Operating Reserve Transaction	→	Balancing Operating Reserve for Load Response	Deviations in RTO Region
Economic Load Response Resources	Balancing Operating Reserves for Load Response			

Table 4-23 Reactive services, synchronous condensing and black start services credits and charges

Credits Received For:	Credits Category:		Charges Category:	Charges Paid By:
		<u>Reactive</u>		
Resources Providing Reactive Service	Day-Ahead Operating Reserve	→	Reactive Services Charge	Zonal Real-Time Load
	Reactive Services Generator			
	Reactive Services LOC			
	Reactive Services Condensing			
	Reactive Services Synchronous Condensing LOC		Reactive Services Local Constraint	Applicable Requesting Party
		<u>Synchronous Condensing</u>		
Resources Providing Synchronous Condensing	Synchronous Condensing Synchronous Condensing LOC	→	Synchronous Condensing	Real-Time Load Real-Time Export Transactions
		<u>Black Start</u>		
Resources Providing Black Start Service	Day-Ahead Operating Reserve Balancing Operating Reserve Black Start Testing	→	Black Start Service Charge	Zone/Non-zone Peak Transmission Use and Point to Point Transmission Reservations

Energy Uplift Charges Results

Energy Uplift Charges

Total energy uplift charges increased by \$27.2 million or 378.5 percent in the first three months of 2021 compared to the first three months of 2020.

Table 4-24 shows total energy uplift charges by category in the first three months of 2020 and the first three months of 2021.²⁷ The increase of \$27.2 million is comprised of an increase of \$4.2 million in day-ahead operating reserve charges, an increase of \$22.3 million in balancing operating reserve charges and an increase of \$0.7 million in reactive service charges.

Table 4-24 Total energy uplift charges by category: January through March, 2020 and 2021

Category	(Jan – Mar) 2020 Charges (Millions)	(Jan – Mar) 2021 Charges (Millions)	Change (Millions)	Percent Change
Day-Ahead Operating Reserves	\$0.3	\$4.5	\$4.2	1,376.4%
Balancing Operating Reserves	\$6.8	\$29.1	\$22.3	328.2%
Reactive Services	\$0.0	\$0.7	\$0.7	1,442.5%
Synchronous Condensing	\$0.0	\$0.0	\$0.0	0.0%
Black Start Services	\$0.0	\$0.1	\$0.0	70.7%
Total	\$7.2	\$34.4	\$27.2	378.5%
Energy Uplift as a Percent of Total PJM Billing	0.1%	0.3%	0.2%	273.2%

²⁷ Table 4-24 includes all categories of charges as defined in Table 4-22 and Table 4-23 and includes all PJM Settlements billing adjustments. Billing data can be modified by PJM Settlements at any time to reflect changes in the evaluation of energy uplift. The billing data reflected in this report were current on April 12, 2021.

Table 4-25 compares monthly energy uplift charges by category for the first three months of 2020 and 2021.

Table 4-25 Monthly energy uplift charges: January through March, 2020 and 2021

	2020 Charges (Millions)						2021 Charges (Millions)					
	Day-Ahead	Balancing	Reactive Services	Synchronous Condensing	Black Start Services	Total	Day-Ahead	Balancing	Reactive Services	Synchronous Condensing	Black Start Services	Total
Jan	\$0.1	\$4.0	\$0.0	\$0.0	\$0.0	\$4.1	\$0.7	\$6.8	\$0.7	\$0.0	\$0.0	\$8.2
Feb	\$0.2	\$1.2	\$0.0	\$0.0	\$0.0	\$1.4	\$0.9	\$13.7	\$0.1	\$0.0	\$0.0	\$14.7
Mar	\$0.0	\$1.6	\$0.0	\$0.0	\$0.0	\$1.7	\$2.8	\$8.6	\$0.0	\$0.0	\$0.1	\$11.5
Total (Jan - Mar)	\$0.3	\$6.8	\$0.0	\$0.0	\$0.0	\$7.2	\$4.5	\$29.1	\$0.7	\$0.0	\$0.1	\$34.4
Share (Jan - Mar)	4.3%	94.5%	0.6%	0.0%	0.6%	100.0%	13.1%	84.6%	2.1%	0.0%	0.2%	100.0%

Table 4-26 shows the composition of day-ahead operating reserve charges. Day-ahead operating reserve charges consist of day-ahead operating reserve charges that pay for credits to generators and import transactions, day-ahead operating reserve charges for economic load response resources and day-ahead operating reserve charges from unallocated congestion charges.^{28 29} Day-ahead operating reserve charges increased by \$4.2 million, 1,376 percent in the first three months of 2021 compared to the first three months of 2020.

Table 4-26 Day-ahead operating reserve charges: January through March, 2020 and 2021

Type	(Jan - Mar) 2020 Charges (Millions)	(Jan - Mar) 2021 Charges (Millions)	Change (Millions)	(Jan - Mar) 2020 Share	(Jan - Mar) 2021 Share
Day-Ahead Operating Reserve Charges	\$0.3	\$4.5	\$4.2	99.9%	100.0%
Day-Ahead Operating Reserve Charges for Load Response	\$0.0	\$0.0	(\$0.0)	0.1%	0.0%
Unallocated Congestion Charges	\$0.0	\$0.0	\$0.0	0.0%	0.0%
Total	\$0.3	\$4.5	\$4.2	100.0%	100.0%

Table 4-27 shows the composition of the balancing operating reserve charges. Balancing operating reserve charges consist of balancing operating reserve reliability charges (credits to generators), balancing operating reserve deviation charges (credits to generators and import transactions), balancing operating reserve charges for economic load response and balancing local constraint charges. Balancing operating reserve charges increased by \$22.3 million or 328.2 percent in the first three months of 2021 compared to 2020.

Table 4-27 Balancing operating reserve charges: January through March, 2020 and 2021

Type	(Jan - Mar) 2020 Charges (Millions)	(Jan - Mar) 2021 Charges (Millions)	Change (Millions)	(Jan - Mar) 2020 Share	(Jan - Mar) 2021 Share
Balancing Operating Reserve Reliability Charges	\$1.2	\$12.1	\$10.9	17.8%	41.7%
Balancing Operating Reserve Deviation Charges	\$3.5	\$12.7	\$9.2	51.4%	43.8%
Balancing Operating Reserve Charges for Load Response	\$0.0	\$0.0	(\$0.0)	0.0%	0.0%
Balancing Local Constraint Charges	\$2.1	\$4.2	\$2.1	30.7%	14.5%
Total	\$6.8	\$29.1	\$22.3	100.0%	100.0%

²⁸ See PJM Operating Agreement Schedule 1 § 3.2.3(c). Unallocated congestion charges are added to the total costs of day-ahead operating reserves. Congestion charges have been allocated to day-ahead operating reserves only 10 times since 1999, totaling \$26.9 million.

²⁹ See the 2021 Quarterly State of the Market Report for PJM: January through March, Section 13, Financial Transmission Rights and Auction Revenue Rights.

Table 4-28 shows the composition of the balancing operating reserve deviation charges. Balancing operating reserve deviation charges are equal to the sum of the following three categories: make whole credits paid to generators and import transactions, energy lost opportunity costs paid to generators, and payments to resources scheduled by PJM but canceled by PJM before coming online. In the first three months of 2021, energy lost opportunity cost deviation charges increased by \$3.0 million or 191.0 percent, and make whole deviation charges increased by \$6.3 million or 322.5 percent compared to the first three months of 2020.

Table 4-28 Balancing operating reserve deviation charges: January through March, 2020 and 2021

Type	(Jan - Mar) 2020 Charges (Millions)	(Jan - Mar) 2021 Charges (Millions)	Change (Millions)	(Jan - Mar) 2020 Share	(Jan - Mar) 2021 Share
Balancing Operating Reserve Reliability Charges	\$1.2	\$12.1	\$10.9	17.8%	41.7%
Balancing Operating Reserve Deviation Charges	\$3.5	\$12.7	\$9.2	51.4%	43.8%
Balancing Operating Reserve Charges for Load Response	\$0.0	\$0.0	(\$0.0)	0.0%	0.0%
Balancing Local Constraint Charges	\$2.1	\$4.2	\$2.1	30.7%	14.5%
Total	\$6.8	\$29.1	\$22.3	100.0%	100.0%

Table 4-29 shows reactive services, synchronous condensing and black start services charges. Reactive services charges increased by \$0.7 million or 1,442.5 percent in the first three months of 2021, compared to the first three months of 2020.

Table 4-29 Additional energy uplift charges: January through March, 2020 and 2021

Type	(Jan - Mar) 2020 Charges (Millions)	(Jan - Mar) 2021 Charges (Millions)	Change (Millions)	(Jan - Mar) 2020 Share	(Jan - Mar) 2021 Share
Reactive Services Charges	\$0.0	\$0.7	\$0.7	53.0%	91.1%
Synchronous Condensing Charges	\$0.0	\$0.0	\$0.0	0.0%	0.0%
Black Start Services Charges	\$0.0	\$0.1	\$0.0	47.0%	8.9%
Total	\$0.1	\$0.8	\$0.7	100.0%	100.0%

Table 4-30 and Table 4-31 show the amount and shares of regional balancing charges in the first three months of 2020 and 2021. Regional balancing operating reserve charges consist of balancing operating reserve reliability and deviation charges. These charges are allocated regionally across PJM. In the first three months of 2021, the largest share of regional charges was paid by real-time load which paid 45.5 percent of all regional balancing charges. The regional balancing charges allocation table does not include charges attributed for resources controlling local constraints.

In the first three months of 2021, regional balancing operating reserve charges increased by \$20.2 million compared to the first three months of 2020. Balancing operating reserve reliability charges increased by \$10.9 million or 903.4 percent, and balancing operating reserve deviation charges increased by \$9.3 million, or 2 percent.

Table 4-30 Regional balancing charges allocation (Millions): January through March, 2020

Charge	Allocation	RTO		East		West		Total	
Reliability Charges	Real-Time Load	\$0.9	19.9%	\$0.2	5.0%	\$0.0	0.0%	\$1.2	24.8%
	Real-Time Exports	\$0.0	0.8%	\$0.0	0.1%	\$0.0	0.0%	\$0.0	0.9%
	Total	\$1.0	20.6%	\$0.2	5.1%	\$0.0	0.0%	\$1.2	25.7%
Deviation Charges	Demand	\$2.0	41.5%	\$0.2	3.4%	\$0.0	0.1%	\$2.1	45.0%
	Supply	\$0.6	11.9%	\$0.1	1.4%	\$0.0	0.0%	\$0.6	13.3%
	Generator	\$0.7	14.6%	\$0.1	1.3%	\$0.0	0.1%	\$0.8	16.0%
	Total	\$3.2	68.0%	\$0.3	6.1%	\$0.0	0.2%	\$3.5	74.3%
Total Regional Balancing Charges		\$4.2	88.6%	\$0.5	11.2%	\$0.0	0.2%	\$4.7	100%

Table 4-31 Regional balancing charges allocation (Millions): January through March, 2021

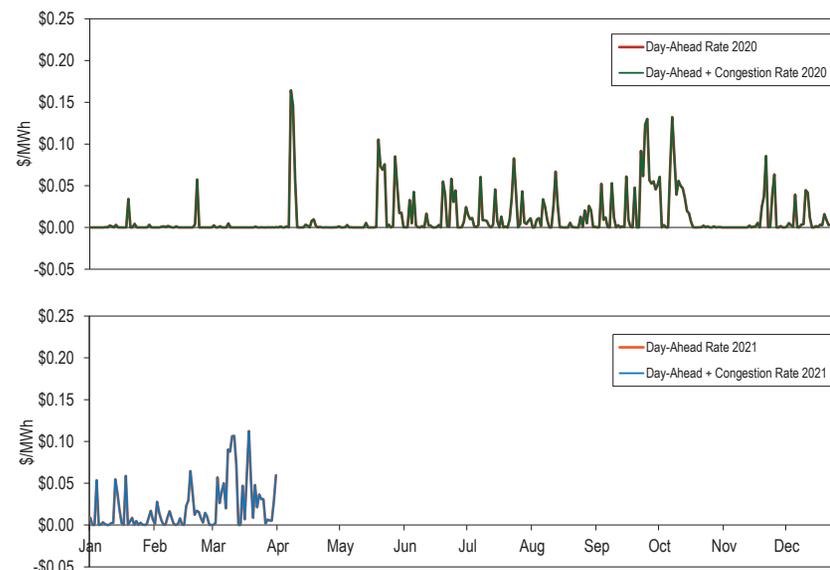
Charge	Allocation	RTO		East		West		Total	
Reliability Charges	Real-Time Load	\$9.4	37.7%	\$1.6	6.4%	\$0.3	1.4%	\$11.3	45.5%
	Real-Time Exports	\$0.7	2.8%	\$0.1	0.4%	\$0.0	0.1%	\$0.8	3.3%
	Total	\$10.1	40.5%	\$1.7	6.8%	\$0.4	1.5%	\$12.1	48.8%
Deviation Charges	Demand	\$8.4	33.8%	\$0.9	3.8%	\$0.2	1.0%	\$9.6	38.5%
	Supply	\$1.1	4.2%	\$0.1	0.5%	\$0.0	0.1%	\$1.2	4.8%
	Generator	\$1.7	6.8%	\$0.2	0.9%	\$0.0	0.2%	\$2.0	7.9%
	Total	\$11.2	44.8%	\$1.3	5.1%	\$0.3	1.2%	\$12.8	51.2%
Total Regional Balancing Charges		\$21.2	85.3%	\$3.0	11.9%	\$0.7	2.8%	\$24.9	100%

Operating Reserve Rates

Under the operating reserves cost allocation rules, PJM calculates nine separate rates, a day-ahead operating reserve rate, a reliability rate for each region, a deviation rate for each region, a lost opportunity cost rate and a canceled resources rate for the entire RTO region. Table 4-22 shows how these charges are allocated.³⁰

Figure 4-2 shows the daily day-ahead operating reserve rate for 2020 and 2021. The average rate during the first three months of 2021 was \$0.020 per MWh, \$0.018 per MWh higher than the average during the first three months of 2020. The highest rate during the first three months of 2021 occurred on March 18, when units were called on by reliability engineers due to transmission constraints, and the rate reached \$0.112 per MWh, \$0.055 per

MWh higher than the \$0.057 per MWh reached during the first three months of 2020, on February 21. Figure 4-2 also shows the daily day-ahead operating reserve rate including the congestion charges allocated to day-ahead operating reserves. There were no congestion charges allocated to day-ahead operating reserves in 2020 through the first three months of 2021.

Figure 4-2 Daily day-ahead operating reserve rate (\$/MWh): January 2020 through March 2021

³⁰ The lost opportunity cost and canceled resources rates are not posted separately by PJM. PJM adds the lost opportunity cost and the canceled resources rates to the deviation rate for the RTO Region since these three charges are allocated following the same rules.

Figure 4-3 shows the RTO and the regional reliability rates for 2020 and 2021. The average RTO reliability rate in the first three months of 2021 was \$0.050 per MWh. The highest RTO reliability rate in the first three months of 2021 occurred on February 15 when the rate reached \$0.433 per MWh, \$0.392 per MWh higher than the \$0.041 per MWh rate reached in 2020, on January 22.

Figure 4-3 Daily balancing operating reserve reliability rates (\$/MWh): January 2020 through March 2021

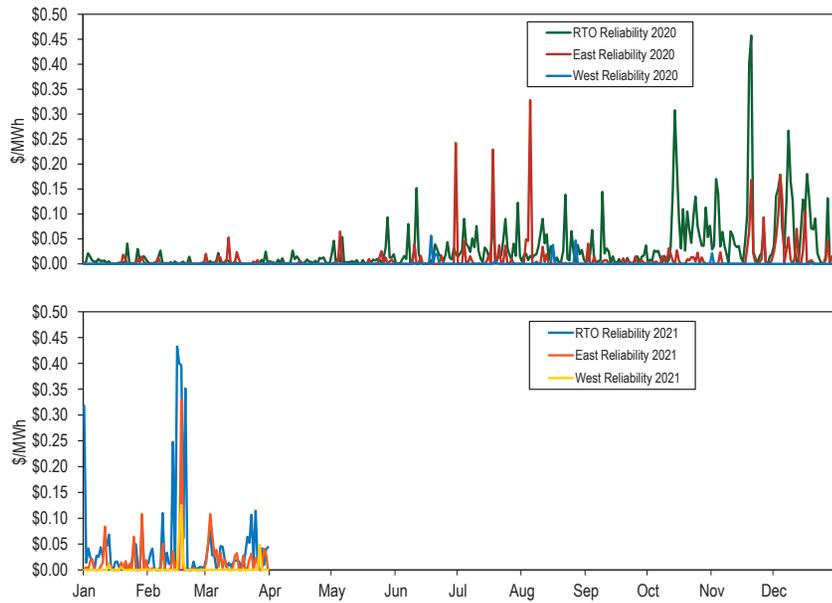


Figure 4-4 shows the RTO and regional deviation rates for 2020 and 2021. The average RTO deviation rate in the first three months of 2021 was \$0.116 per MWh. The highest daily rate in the first three months of 2021 occurred on February 15, when the RTO deviation rate reached \$1.214 per MWh, \$0.735 per MWh more than the \$0.479 per MWh rate reached in the first three months of 2020, on January 3.

Figure 4-4 Daily balancing operating reserve deviation rates (\$/MWh): January 2020 through March 2021

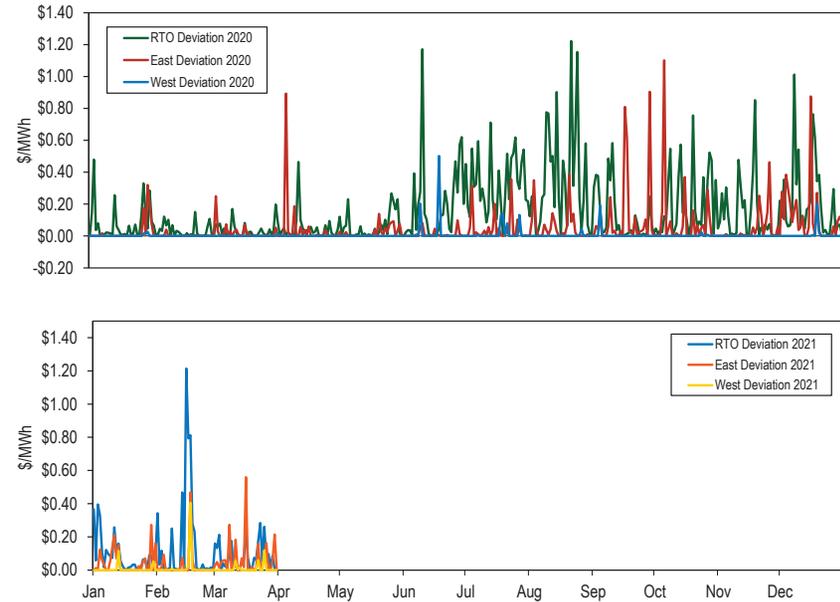


Figure 4-5 shows the daily lost opportunity cost rate and the daily canceled resources rate for 2020 and 2021. The average lost opportunity cost rate in 2020 was \$0.079 per MWh. The highest lost opportunity cost rate in the first three months of 2021 occurred on March 6, when it reached \$1.148 per MWh, \$0.846 per MWh higher than the \$0.302 per MWh rate reached in the first three months of 2020, on March 4.

Figure 4-5 Daily lost opportunity cost and canceled resources rates (\$/MWh): January 2020 through March 2021

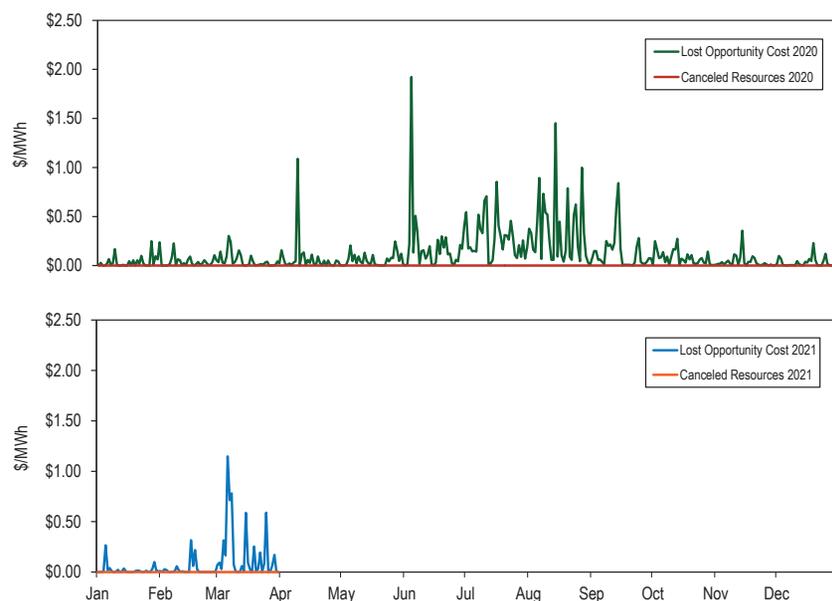


Table 4-32 shows the average rates for each region in each category for 2020 and 2021.

Table 4-32 Operating reserve rates (\$/MWh): January through March, 2020 and 2021

Rate	(Jan - Mar) 2020 (\$/MWh)	(Jan - Mar) 2021 (\$/MWh)	Difference (\$/MWh)	Percent Difference
Day-Ahead	0.002	0.020	0.018	1,200.1%
Day-Ahead with Unallocated Congestion	0.002	0.020	0.018	1,200.1%
RTO Reliability	0.005	0.050	0.045	895.1%
East Reliability	0.003	0.018	0.015	557.6%
West Reliability	0.000	0.004	0.004	N/A
RTO Deviation	0.047	0.116	0.069	147.3%
East Deviation	0.017	0.050	0.034	204.1%
West Deviation	0.001	0.010	0.009	1,519.3%
Lost Opportunity Cost	0.044	0.079	0.035	79.0%
Canceled Resources	0.000	0.000	NA	N/A

Table 4-33 shows the operating reserve cost of a one MW transaction in the first three months of 2021. For example, in the Eastern Region a day-ahead withdrawal, such as a decrement bid or UTC, (if not offset by other transactions) paid an average rate of \$0.265 per MWh with a maximum rate of \$1.371 per MWh, a minimum rate of less than \$0.001 per MWh and a standard deviation of \$0.317 per MWh. The rates in Table 4-33 include all operating reserve charges including RTO deviation charges. The rates also include charges for UTCs, which were implemented on November 1, 2020 and which are treated similarly to DECs. Table 4-33 illustrates both the average level of operating reserve charges by transaction types and the uncertainty reflected in the maximum, minimum and standard deviation levels. INCs, DECs, and UTCs have higher rates compared to real-time load because they always result in a deviation while day-ahead and real-time load do not always result in a deviation.

Table 4-33 Operating reserve rates statistics (\$/MWh): January through March, 2021

Region	Transaction	Rates Charged (\$/MWh)			Standard Deviation
		Maximum	Average	Minimum	
East	INC	1.342	0.245	0.000	0.310
	DEC/UTC	1.371	0.265	0.001	0.317
	DA Load	0.112	0.020	(0.000)	0.027
	RT Load	0.726	0.067	0.000	0.111
	Deviation	1.342	0.245	0.000	0.310
West	INC	1.280	0.205	0.000	0.289
	DEC/UTC	1.309	0.225	0.001	0.295
	DA Load	0.112	0.020	(0.000)	0.027
	RT Load	0.522	0.053	0.000	0.098
	Deviation	1.280	0.205	0.000	0.289

Reactive Services Rates

Reactive services charges associated with local voltage support are allocated to real-time load in the control zone or zones where the service is provided. These charges result from uplift payments to units committed by PJM to support reactive/voltage requirements that do not recover their energy offer through LMP payments. These charges are separate from the reactive service capability revenue requirement charges which are a fixed annual charge based on approved FERC filings.³¹ Reactive services charges associated with supporting reactive transfer interfaces above 345 kV are allocated daily to real-time load across the entire RTO based on the real-time load ratio share of each network customer.

While reactive services rates are not posted by PJM, a local voltage support rate for each control zone can be calculated and a reactive transfer interface support rate can be calculated for the entire RTO. Table 4-34 shows the reactive services rates associated with local voltage support in the first three months of 2020 and 2021. Table 4-34 shows that in 2020 only five zones incurred reactive charges, in addition to reactive capability charges. Real-time load in the PPL Zone, where reactive service charges were the highest, paid an average of \$0.064 per MWh for reactive services.

Table 4-34 Local voltage support rates: January through March, 2020 and 2021

Control Zone	(Jan - Mar) 2020 (\$/MWh)	(Jan - Mar) 2021 (\$/MWh)	Difference (\$/MWh)	Percent Difference
AECO	0.000	0.000	0.000	0.0%
AEP	0.000	0.000	0.000	0.0%
APS	0.000	0.000	0.000	0.0%
ATSI	0.000	0.000	0.000	0.0%
BGE	0.000	0.000	0.000	0.0%
ComEd	0.000	0.000	0.000	0.0%
DAY	0.000	0.000	0.000	0.0%
DEOK	0.000	0.000	0.000	0.0%
DLCO	0.000	0.000	0.000	0.0%
Dominion	0.000	0.000	0.000	0.0%
DPL	0.002	0.000	(0.002)	(100.0%)
EKPC	0.000	0.000	0.000	0.0%
JCPL	0.006	0.000	(0.006)	(100.0%)
Met-Ed	0.000	0.000	0.000	0.0%
OVEC	0.000	0.000	0.000	0.0%
PECO	0.000	0.000	0.000	0.0%
PENELEC	0.000	0.000	0.000	0.0%
Pepco	0.000	0.000	0.000	0.0%
PPL	0.000	0.064	0.064	NA
PSEG	0.000	0.000	0.000	0.0%
RECO	0.000	0.000	0.000	0.0%

³¹ See 2019 State of the Market Report for PJM, Volume 11, Section 10: Ancillary Service Markets.

Balancing Operating Reserve Determinants

Table 4-35 shows the determinants used to allocate the regional balancing operating reserve charges in the first three months of 2020 and 2021. Total real-time load and real-time exports were 203,017 GWh, 3.4 percent higher in the first three months of 2021 compared to the first three months 2020. Total deviations summed across the demand, supply, and generator categories were 57,156 GWh, 60.7 percent higher in the first three months of 2021 compared to the first three months of 2020.

Table 4-35 Balancing operating reserve determinants (GWh): January through March, 2020 and 2021

		Reliability Charge Determinants (GWh)			Deviation Charge Determinants (GWh)			
		Real-Time Load	Real-Time Exports	Reliability Total	Demand Deviations (MWh)	Supply Deviations (MWh)	Generator Deviations (MWh)	Deviations Total
(Jan - Mar) 2020	RTO	188,726	7,700	196,426	21,840	6,039	7,682	35,561
	East	88,375	2,712	91,088	10,303	3,607	3,556	17,466
	West	100,351	4,988	105,338	11,480	2,331	4,127	17,937
(Jan - Mar) 2021	RTO	194,067	8,950	203,017	42,508	5,737	8,911	57,156
	East	92,666	3,925	96,591	18,560	2,505	4,335	25,400
	West	101,400	5,025	106,426	23,530	3,127	4,577	31,234
Difference	RTO	5,341	1,250	6,591	20,667	(302)	1,229	21,595
	East	4,291	1,213	5,504	8,257	(1,102)	779	7,934
	West	1,050	37	1,087	12,050	796	450	13,296

Under PJM's operating reserve rules, balancing operating reserve charges are allocated regionally. PJM defined the Eastern and Western regions, in addition to the RTO region to allocate the cost of balancing operating reserves. These regions consist of three location types: zones, hubs/aggregates, and interfaces. The deviations, calculated between day-ahead and real-time generation, are aggregated regionally by location type, depending on where the charge occurs.

Credits paid to generators that are defined as operating for reliability purposes are charged to real-time load and exports. Credits paid to generators and credits paid to import transactions that are defined to be operating control deviations on the system, such as energy lost opportunity credits and cancellation credits, are charged to deviations.

Deviations fall into three categories: demand, supply and generator deviations. Table 4-36 shows the different categories by type of transactions that incurred deviations. In the first three months of 2021, 54.1 percent of all RTO deviations were incurred by virtual transactions, or by a transaction that combines virtuals with exports or load. During the first three months of 2021, the volume of UTC deviations represented 33.1 percent of total deviations.

Table 4-36 Deviations by transaction type: January through March, 2021

Deviation Category	Transaction	Deviation (GWh)			Share		
		RTO	East	West	RTO	East	West
Demand	DECs Only	6,699	3,685	2,923	11.7%	14.5%	9.4%
	UTCs Only	18,743	6,161	12,255	32.8%	24.3%	39.2%
	Load Only	14,599	7,800	6,799	25.5%	30.7%	21.8%
	Exports Only	1,716	651	1,066	3.0%	2.6%	3.4%
	Combination of Load/Exports with DECs/UTCs	748	261	487	1.3%	1.0%	1.6%
	Combination of Load/Exports without DECs/UTCs	2	2	0	0.0%	0.0%	0.0%
Supply	INCs Only	4,612	1,812	2,695	8.1%	7.1%	8.6%
	Combination of Imports Et INCs	109	84	26	0.2%	0.3%	0.1%
	Imports Only	1,015	610	406	1.8%	2.4%	1.3%
Generators		8,911	4,335	4,577	15.6%	17.1%	14.7%
Total		57,156	25,400	31,234	100.0%	100.0%	100.0%

Geography of Charges and Credits

Table 4-37 shows the geography of charges and credits in the first three months of 2021. Table 4-37 includes only day-ahead operating reserve charges and balancing operating reserve reliability and deviation charges since these categories are allocated regionally, while other charges, such as reactive services, synchronous condensing and black start services are allocated by control zone, and balancing local constraint charges are charged to the requesting party.

Charges are categorized by the location (control zone, hub, aggregate or interface) where they are allocated according to PJM's operating reserve rules. Credits are categorized by the location where the resources are located. The shares columns reflect the operating reserve credits and charges balance for each location. For example, transactions in the PPL Control Zone paid 5.2 percent of all operating reserve charges allocated regionally while resources in the PPL Control Zone were paid 2.2 percent of the corresponding credits. The PPL Control Zone received less operating reserve credits than operating reserve charges paid and had 8.1 percent of the deficit. The deficit is the net of the credits and charges paid at a location. Transactions in the BGE Control Zone paid 4.4 percent of all operating reserve charges allocated regionally, and resources in the BGE Control Zone were paid 9.4 percent of the corresponding credits. The BGE Control Zone received more operating reserve credits than operating reserve charges paid and had 13.4 percent of the surplus. The surplus is the net of the credits and charges paid at a location. Table 4-37 also shows that 87.6 percent of all charges were allocated in control zones, 3.2 percent in hubs and aggregates and 9.2 percent in interfaces.

Table 4-37 Geography of regional charges and credits: January through March, 2021

Location	Charges (Millions)	Credits (Millions)	Balance	Shares			
				Total Charges	Total Credits	Deficit	Surplus
Zones							
ACEC	\$0.4	\$0.2	(\$0.1)	1.2%	0.8%	1.2%	0.0%
AEP	\$4.4	\$3.0	(\$1.3)	14.9%	10.3%	12.3%	0.0%
APS	\$1.3	\$0.7	(\$0.6)	4.4%	2.4%	5.3%	0.0%
ATSI	\$1.6	\$1.1	(\$0.5)	5.5%	3.8%	4.6%	0.0%
BGE	\$1.3	\$2.8	\$1.5	4.4%	9.4%	0.0%	13.4%
COMED	\$2.8	\$2.7	(\$0.2)	9.6%	9.0%	1.6%	0.0%
DAY	\$0.5	\$0.8	\$0.3	1.7%	2.9%	0.0%	3.1%
DUKE	\$0.9	\$0.5	(\$0.4)	2.9%	1.7%	3.3%	0.0%
DUQ	\$0.4	\$0.0	(\$0.3)	1.2%	0.1%	3.0%	0.0%
DOM	\$3.3	\$6.6	\$3.2	11.3%	22.4%	0.0%	29.7%
DPL	\$0.7	\$4.9	\$4.2	2.4%	16.6%	0.0%	38.2%
EKPC	\$0.7	\$1.8	\$1.0	2.5%	6.0%	0.0%	9.5%
External	\$0.0	\$0.6	\$0.6	0.0%	2.0%	0.0%	5.4%
JCPLC	\$0.6	\$0.3	(\$0.4)	2.1%	0.9%	3.4%	0.0%
MEC	\$0.6	\$0.2	(\$0.3)	1.9%	0.8%	3.0%	0.0%
OVEC	\$0.1	\$0.0	(\$0.1)	0.3%	0.0%	0.7%	0.0%
PECO	\$1.2	\$0.2	(\$0.9)	4.0%	0.8%	8.7%	0.0%
PE	\$0.7	\$0.5	(\$0.3)	2.4%	1.5%	2.4%	0.0%
PEPCO	\$0.9	\$1.0	\$0.1	3.2%	3.4%	0.0%	0.7%
PPL	\$1.5	\$0.6	(\$0.9)	5.2%	2.2%	8.1%	0.0%
PSEG	\$1.7	\$0.9	(\$0.8)	5.7%	3.1%	7.0%	0.0%
REC	\$2.2	\$0.0	(\$0.2)	0.8%	0.0%	2.1%	0.0%
All Zones	\$25.8	\$29.4	\$3.6	87.6%	100.0%	66.6%	100.0%
Hubs and Aggregates							
AEP - Dayton	\$0.3	\$0.0	(\$0.3)	0.9%	0.0%	2.5%	0.0%
Dominion	\$0.1	\$0.0	(\$0.1)	0.4%	0.0%	1.0%	0.0%
Eastern	\$0.1	\$0.0	(\$0.1)	0.3%	0.0%	0.8%	0.0%
New Jersey	\$0.1	\$0.0	(\$0.1)	0.2%	0.0%	0.6%	0.0%
Ohio	\$0.1	\$0.0	(\$0.1)	0.4%	0.0%	1.2%	0.0%
Western Interface	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Western	\$0.3	\$0.0	(\$0.3)	0.9%	0.0%	2.4%	0.0%
RTEP B0328 Source	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
All Hubs and Aggregates	\$0.9	\$0.0	(\$0.9)	3.2%	0.0%	8.5%	0.0%
Interfaces							
CPLC Exp	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
CPLC Imp	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Duke Exp	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Duke Imp	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Hudson	\$0.2	\$0.0	(\$0.2)	0.6%	0.0%	1.7%	0.0%
IMO	\$0.1	\$0.0	(\$0.1)	0.3%	0.0%	0.8%	0.0%
Linden	\$0.1	\$0.0	(\$0.1)	0.3%	0.0%	0.8%	0.0%
MISO	\$1.3	\$0.0	(\$1.3)	4.5%	0.0%	12.1%	0.0%
NCMPA Imp	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Neptune	\$0.1	\$0.0	(\$0.1)	0.2%	0.0%	0.7%	0.0%
NIPSCO	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
Northwest	\$0.0	\$0.0	\$0.0	0.0%	0.0%	0.0%	0.0%
NYIS	\$0.3	\$0.0	(\$0.3)	1.1%	0.0%	2.9%	0.0%
South Exp	\$0.5	\$0.0	(\$0.5)	1.6%	0.0%	4.2%	0.0%
South Imp	\$0.2	\$0.0	(\$0.2)	0.6%	0.0%	1.6%	0.0%
All Interfaces	\$2.7	\$0.0	(\$2.7)	9.2%	0.0%	24.9%	0.0%
Total	\$29.4	\$29.4	\$0.0	100.0%	100.0%	100.0%	100.0%

Energy Uplift Issues

Intraday Segments Uplift Settlement

PJM pays uplift separately for multiple segmented blocks of time during the operating day (intraday).³² The use of intraday segments to calculate the need for uplift payments results in higher uplift payments than necessary to make units whole, including uplift payments to units that are profitable on a daily basis. The MMU recommends eliminating intraday segments from the calculation of uplift payments and returning to calculating the need for uplift based on the entire 24 hour operating day.

Table 4-38 shows balancing operating reserve credits calculated using intraday segments and balancing operating reserve payments calculated on a daily basis. In the first three months of 2020, balancing operating reserve credits would have been \$0.7 million or 22.3 percent lower if they were calculated on a daily basis. In the first three months of 2021, balancing operating reserve credits would have been \$2.8 million or 13.5 percent lower if they were calculated on a daily basis.

Table 4-38 Intraday segments and daily balancing operating reserve credits: January through March, 2020 and 2021

	2020 BOR Credits (Millions)			2021 BOR Credits (Millions)		
	Intraday Segments Calculation	Daily Calculation	Difference	Intraday Segments Calculation	Daily Calculation	Difference
Jan	\$1.6	\$1.3	(\$0.3)	\$4.8	\$4.2	(\$0.5)
Feb	\$0.7	\$0.5	(\$0.2)	\$10.6	\$9.4	(\$1.2)
Mar	\$0.9	\$0.7	(\$0.2)	\$5.0	\$4.0	(\$1.0)
Apr	\$1.1	\$0.9	(\$0.2)			
May	\$1.9	\$1.6	(\$0.3)			
Jun	\$5.1	\$4.1	(\$1.0)			
Jul	\$8.8	\$5.7	(\$3.0)			
Aug	\$8.1	\$6.0	(\$2.1)			
Sep	\$3.7	\$2.8	(\$0.9)			
Oct	\$6.8	\$5.9	(\$0.9)			
Nov	\$7.8	\$7.0	(\$0.8)			
Dec	\$11.8	\$11.0	(\$0.9)			
Total (Jan - Mar)	\$3.2	\$2.5	(\$0.7)	\$20.4	\$17.6	(\$2.8)

³² See PJM "Manual 28: Operating Reserve Accounting," Rev. 83 (Dec. 3, 2019).

Prior to April 1, 2018, for purposes of calculating LOC credits, each hour was defined as a unique segment. Following the implementation of five minute settlements on April 1, 2018, LOC credits are calculated with each five minute interval defined as a unique segment. Thus a profit in one five minute segment, resulting from the real-time LMP being lower than the day-ahead LMP, is not used to offset a loss in any other five minute segment. This change in settlements causes an increase in LOC credits compared to hourly settlement as generators are made whole for any losses incurred in a five minute interval while previously gains and losses were netted within the hour. Table 4-39 compares the impact on day-ahead LOC credits of adopting five minute settlements over hourly settlements in April 2018 and the impact of having adopted the recommended daily settlements over five minute settlements. For the first three months of 2021, LOC credits would have been 12.1 percent lower if they had been settled on an hourly basis rather than on a five minute basis. For the first three months of 2021, LOC credits would have been \$1.6 million or 34.8 percent lower if they had been settled on the recommended daily basis rather than being settled on a five minute settlement.

Table 4-39 Comparison of five minute, hourly, and daily settlement of day-ahead lost opportunity cost credits: January through March, 2021

	2021 Day-Ahead LOC Credits (Millions)				
	Five Minute Settlement (Status Quo)	Hourly Settlement (Pre-April 2018)	Difference	Daily Settlement (Recommendation)	Difference
Jan	\$0.4	\$0.3	(\$0.1)	\$0.2	(\$0.1)
Feb	\$0.6	\$0.5	(\$0.1)	\$0.4	(\$0.2)
Mar	\$3.5	\$3.1	(\$0.4)	\$2.3	(\$1.2)
Total (Jan - Mar)	\$4.5	\$3.9	(\$0.5)	\$2.9	(\$1.6)

Uplift Credits and Offer Capping

Absent market power mitigation, unit owners that submit noncompetitive offers or offers with inflexible operating parameters, can exercise market power, resulting in noncompetitive and excessive uplift payments.

The three pivotal supplier (TPS) test is the test for local market power in the energy market.³³ If the TPS test is failed, market power mitigation is applied by offer capping the resources of the owners identified as having local market power. Offer capping is designed to set offers at competitive levels.

Table 4-40 shows the uplift credits paid to units that were committed and dispatched on cost offers during the first three months of 2021.

Table 4-40 Operating Reserve Credits by Offer Type: January through March, 2021

Offer Type	Day Ahead Operating Reserve Credits (Millions)	Balancing Operating Reserve Credits (Millions)	Day Ahead Reactive Credits (Millions)	Real Time Reactive Credits (Millions)
Cost	\$0.5	\$4.1	0.3	\$0.4
Price	\$4.0	\$14.1	0.0	\$0.0
Price PLS	\$0.0	\$1.3	0.0	\$0.0
Cost & Price	\$0.0	\$0.9	0.0	\$0.0
Cost & PLS	\$0.0	\$0.0	0.0	\$0.0
Price & PLS	\$0.0	\$0.0	0.0	\$0.0
Total	\$4.5	\$20.3	0.3	\$0.4

Table 4-41 shows day-ahead operating reserve credits paid to units called on days with hot and cold weather alerts, classified by commitment schedule type. Of all the day-ahead credits received during days with weather alerts, 90.8 percent went to units that were committed on price schedules less flexible than PLS.

Table 4-41 Day-ahead operating reserve credits during weather alerts by commitment schedule: January through March, 2021

Commitment Type During Hot and Cold Weather Alerts	Day Ahead Operating Reserve Credits	Share of DAOR during Hot and Cold Weather Alerts
Committed on cost (cost capped)	\$0	0.0%
Committed on price schedule as flexible as PLS	\$0	0.0%
Committed on price schedule less flexible than PLS	\$26,908	90.8%
Committed on price PLS	\$2,737	9.2%
Total	\$29,645	100.0%

³³ See the MMU Technical Reference for PJM Markets, at "Three Pivotal Supplier Test" for a more detailed explanation of the three pivotal supplier test. <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

Capacity Market

Each organization serving PJM load must meet its capacity obligations through the PJM Capacity Market, where load serving entities (LSEs) must pay the locational capacity price for their zone. LSEs can also construct generation and offer it into the capacity market, enter into bilateral contracts, develop demand resources and energy efficiency (EE) resources and offer them into the capacity market, or construct transmission upgrades and offer them into the capacity market.

The Market Monitoring Unit (MMU) analyzed market structure, participant conduct and market performance in the PJM Capacity Market, including supply, demand, concentration ratios, pivotal suppliers, volumes, prices, outage rates and reliability.¹ The conclusions are a result of the MMU's evaluation of the last Base Residual Auction, for the 2021/2022 Delivery Year.

Table 5-1 The capacity market results were not competitive

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Not Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Not Competitive	
Market Performance	Not Competitive	Mixed

- The aggregate market structure was evaluated as not competitive. For almost all auctions held from 2007 to the present, the PJM region failed the three pivotal supplier test (TPS), which is conducted at the time of the auction.² Structural market power is endemic to the capacity market.
- The local market structure was evaluated as not competitive. For almost every auction held, all LDAs have failed the TPS test, which is conducted at the time of the auction.³

¹ The values stated in this report for the RTO and LDAs refer to the aggregate level including all nested LDAs unless otherwise specified. For example, RTO values include the entire PJM market and all LDAs. Rest of RTO values are RTO values net of nested LDA values.

² In the 2008/2009 RPM Third Incremental Auction, 18 participants in the RTO market passed the TPS test. In the 2018/2019 RPM Second Incremental Auction, 35 participants in the RTO market passed the test.

³ In the 2012/2013 RPM Base Residual Auction, six participants included in the incremental supply of EMAAC passed the TPS test. In the 2014/2015 RPM Base Residual Auction, seven participants in the incremental supply in MAAC passed the TPS test. In the 2021/2022 RPM First Incremental Auction, two participants in the incremental supply in EMAAC passed the TPS test. In the 2021/2022 RPM Second Incremental Auction, two participants in the incremental supply in EMAAC passed the TPS test.

- Participant behavior was evaluated as not competitive in the 2021/2022 RPM Base Residual Auction. Market power mitigation measures were applied when the capacity market seller failed the market power test for the auction, the submitted sell offer exceeded the defined offer cap, and the submitted sell offer, absent mitigation, would increase the market clearing price. But the net CONE times B offer cap under the capacity performance design, in the absence of 30 performance assessment hours, exceeds the competitive level and should be reevaluated for each BRA. In the 2021/2022 RPM Base Residual Auction, some participants' offers were above the competitive level. The MMU recognizes that these market participants followed the capacity market rules by offering at less than the stated offer cap of Net CONE times B. But Net CONE times B is not a competitive offer when the expected number of performance assessment intervals is zero or a very small number and the nonperformance charge rate is defined as Net CONE/30. Under these circumstances, a competitive offer, under the logic defined in PJM's capacity performance filing, is net ACR. That is the way in which most market participants offered in this and prior capacity performance auctions.
- Market performance was evaluated as not competitive based on the 2021/2022 RPM Base Residual Auction. Although structural market power exists in the Capacity Market, a competitive outcome can result from the application of market power mitigation rules. The outcome of the 2021/2022 RPM Base Residual Auction was not competitive as a result of participant behavior which was not competitive, specifically offers which exceeded the competitive level.
- Market design was evaluated as mixed because while there are many positive features of the Reliability Pricing Model (RPM) design and the capacity performance modifications to RPM, there are several features of the RPM design which still threaten competitive outcomes. These include the definition of DR which permits inferior products to substitute for capacity, the replacement capacity issue, the definition of unit offer parameters, the inclusion of imports which are not substitutes for internal capacity resources, and the definition of the default offer cap.

- PJM did not run the 2022/2023 Base Residual Auction in May 2019, the 2023/2024 Base Residual Auction in May 2020, or the 2022/2023 First Incremental Auction in September 2020 because the capacity market design was found to be not just and reasonable by FERC and a final market design had not been approved.

Overview

RPM Capacity Market

Market Design

The Reliability Pricing Model (RPM) Capacity Market is a forward-looking, annual, locational market, with a must offer requirement for Existing Generation Capacity Resources and mandatory participation by load, with performance incentives, that includes clear market power mitigation rules and that permits the direct participation of demand-side resources.⁴

Under RPM, capacity obligations are annual.⁵ Base Residual Auctions (BRA) are held for delivery years that are three years in the future. First, Second and Third Incremental Auctions (IA) are held for each delivery year.⁶ First, Second, and Third Incremental Auctions are conducted 20, 10, and three months prior to the delivery year.⁷ A Conditional Incremental Auction may be held if there is a need to procure additional capacity resulting from a delay in a planned large transmission upgrade that was modeled in the BRA for the relevant delivery year.⁸

The 2021/2022 RPM Third Incremental Auction was conducted in the first three months of 2021.

RPM prices are locational and may vary depending on transmission constraints and local supply and demand conditions.⁹ Existing generation capable of

⁴ The terms *PJM Region*, *RTO Region* and *RTO* are synonymous in this report and include all capacity within the PJM footprint.

⁵ Effective for the 2020/2021 and subsequent delivery years, the RPM market design incorporated seasonal capacity resources. Summer period and winter period capacity must be matched either with commercial aggregation or through the optimization in equal MW amounts in the LDA or the lowest common parent LDA.

⁶ See 126 FERC ¶ 61,275 at P 86 (2009).

⁷ See Letter Order, FERC Docket No. ER10-366-000 (January 22, 2010).

⁸ See 126 FERC ¶ 61,275 at P 88 (2009). There have been no Conditional Incremental Auctions.

⁹ Transmission constraints are local capacity import capability limitations (low capacity emergency transfer limit (CETL) margin over capacity emergency transfer objective (CETO)) caused by transmission facility limitations, voltage limitations or stability limitations.

qualifying as a capacity resource must be offered into RPM auctions, except for resources owned by entities that elect the fixed resource requirement (FRR) option. Participation by LSEs is mandatory, except for those entities that elect the FRR option. There is an administratively determined demand curve that defines scarcity pricing levels and that, with the supply curve derived from capacity offers, determines market prices in each BRA. RPM rules provide performance incentives for generation, including the requirement to submit generator outage data and the linking of capacity payments to the level of unforced capacity, and the performance incentives have been strengthened significantly under the Capacity Performance modifications to RPM. Under RPM there are explicit market power mitigation rules that define the must offer requirement, that define structural market power based on the marginal cost of capacity, that define offer caps, that define the minimum offer price, and that have flexible criteria for competitive offers by new entrants. Market power mitigation is effective only when these definitions are up to date and accurate. Demand resources and energy efficiency resources may be offered directly into RPM auctions and receive the clearing price without mitigation.

Market Structure

- **RPM Installed Capacity.** In the first three months of 2021, RPM installed capacity decreased 491.4 MW or 0.3 percent, from 184,270.0 MW on January 1 to 183,778.6 MW on March 31. Installed capacity includes net capacity imports and exports and can vary on a daily basis.
- **RPM Installed Capacity by Fuel Type.** Of the total installed capacity on March 31, 2021, 45.7 percent was gas; 26.8 percent was coal; 17.6 percent was nuclear; 4.8 percent was hydroelectric; 3.0 percent was oil; 1.2 percent was wind; 0.4 percent was solid waste; and 0.6 percent was solar.
- **Market Concentration.** In the 2021/2022 RPM Third Incremental Auction all participants in the total PJM market as well as the LDA RPM markets failed the three pivotal supplier (TPS) test.¹⁰ Offer caps were applied to all sell offers for resources which were subject to mitigation when the capacity market seller did not pass the test, the submitted sell offer

¹⁰ There are 27 Locational Deliverability Areas (LDAs) identified to recognize locational constraints as defined in "Reliability Assurance Agreement Among Load Serving Entities in the PJM Region," Schedule 10.1. PJM determines, in advance of each BRA, whether the defined LDAs will be modeled in the given delivery year using the rules defined in OATT Attachment DD § 5.10(a)(ii).

exceeded the defined offer cap, and the submitted sell offer, absent mitigation, increased the market clearing price.^{11 12 13}

- **Imports and Exports.** Of the 4,470.4 MW of imports in the 2021/2022 RPM Base Residual Auction, 4,051.8 MW cleared. Of the cleared imports, 1,909.9 MW (47.1 percent) were from MISO.
- **Demand-Side and Energy Efficiency Resources.** Capacity in the RPM load management programs was 10,586.0 MW for June 1, 2020, as a result of cleared capacity for demand resources and energy efficiency resources in RPM auctions for the 2020/2021 Delivery Year (13,015.2 MW) less purchases of replacement capacity (2,429.2 MW).

Market Conduct

- **2021/2022 RPM Third Incremental Auction.** Of the 481 generation resources that submitted Capacity Performance offers, the MMU calculated unit specific offer caps for zero generation resources (0.0 percent).

Market Performance

- The 2021/2022 RPM Third Incremental Auction was conducted in the first three months of 2021.¹⁴ The weighted average capacity price for the 2019/2020 Delivery Year is \$109.82 per MW-day, including all RPM auctions for the 2019/2020 Delivery Year. The weighted average capacity price for the 2020/2021 Delivery Year is \$111.05 per MW-day, including all RPM auctions for the 2020/2021 Delivery Year.
- For the 2020/2021 Delivery Year, RPM annual charges to load are \$7.0 billion.

- In the 2021/2022 RPM Base Residual Auction, the market performance was determined to be not competitive as a result of noncompetitive offers that affected market results.

Reliability Must Run Service

- Of the seven companies (23 units) that have provided RMR service, two companies (seven units) filed to be paid for RMR service under the deactivation avoidable cost rate (DACR), the formula rate. The other five companies (16 units) filed to be paid for RMR service under the cost of service recovery rate.

Generator Performance

- **Forced Outage Rates.** The average PJM EFORD in the first three months of 2021 was 8.1 percent, an increase from 4.5 percent in the first three months of 2020.¹⁵
- **Generator Performance Factors.** The PJM aggregate equivalent availability factor in the first three months of 2021 was 85.8 percent, a decrease from 87.6 percent in the first three months of 2020.

Recommendations¹⁶

Definition of Capacity

- The MMU recommends the enforcement of a consistent definition of capacity resource. The MMU recommends that the requirement to be a physical resource be enforced and enhanced. The requirement to be a physical resource should apply at the time of auctions and should also constitute a commitment to be physical in the relevant delivery year. The requirement to be a physical resource should be applied to all resource

¹¹ See OATT Attachment DD § 6.5.

¹² Prior to November 1, 2009, existing DR and EE resources were subject to market power mitigation in RPM Auctions. See 129 FERC ¶ 61,081 at P 30 (2009).

¹³ Effective January 31, 2011, the RPM rules related to market power mitigation were changed, including revising the definition for Planned Generation Capacity Resource and creating a new definition for Existing Generation Capacity Resource for purposes of the must offer requirement and market power mitigation, and treating a proposed increase in the capability of a generation capacity resource the same in terms of mitigation as a Planned Generation Capacity Resource. See 134 FERC ¶ 61,065 (2011).

¹⁴ FERC granted PJM's request for waiver of its Open Access Transmission Tariff to delay the 2022/2023 RPM Base Residual Auction from May 2019 to August 2019. See 164 FERC ¶ 61,153 (2018). FERC subsequently denied PJM's motion seeking clarification of the June 29, 2018, Order (163 FERC ¶ 61,236) and directed PJM not to run the 2022/2023 BRA in August 2019. See 168 FERC ¶ 61,051 (2019).

¹⁵ The generator performance analysis includes all PJM capacity resources for which there are data in the PJM generator availability data systems (GADS) database. Data was downloaded from the PJM GADS database on April 22, 2021. EFORD data presented in state of the market reports may be revised based on data submitted after the publication of the reports as generation owners may submit corrections at any time with permission from PJM GADS administrators.

¹⁶ The MMU has identified serious market design issues with RPM and the MMU has made specific recommendations to address those issues. These recommendations have been made in public reports. See Table 5-2.

types, including planned generation, demand resources and imports.^{17 18} (Priority: High. First reported 2013. Status: Not adopted.)

- The MMU recommends that DR providers be required to have a signed contract with specific customers for specific facilities for specific levels of DR at least six months prior to any capacity auction in which the DR is offered. (Priority: High. First reported 2016. Status: Not adopted.)

Market Design and Parameters

- The MMU recommends that the test for determining modeled Locational Deliverability Areas (LDAs) in RPM be redefined. A detailed reliability analysis of all at risk units should be included in the redefined model. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) VRR parameter reflect the actual flexibility of units in responding to price signals rather than using assumed fixed operating blocks that are not a result of actual unit limitations.^{19 20} The result of reflecting the actual flexibility is higher net revenues, which affect the parameters of the RPM demand curve and market outcomes. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that energy efficiency resources (EE) not be included on the supply side of the capacity market, because PJM's load forecasts now account for future EE, unlike the situation when EE was first added to the capacity market. However, the MMU recommends that the PJM load forecast method should be modified so that EE impacts immediately affect the forecast without the long lag times incorporated in the current forecast method. If EE is not included on the supply side, there is no reason to have an add back mechanism. If EE remains on the supply side, the implementation of the EE add back mechanism should be

modified to ensure that market clearing prices are not affected. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends that PJM reduce the number of incremental auctions to a single incremental auction held three months prior to the start of the delivery year and reevaluate the triggers for holding conditional incremental auctions. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM offer to sell back capacity in incremental auctions only at the BRA clearing price for the relevant delivery year. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends changing the RPM solution method to explicitly incorporate the cost of make whole payments in the objective function. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM clear the capacity market based on nodal capacity resource locations and the characteristics of the transmission system consistent with the actual electrical facts of the grid. The current nested LDA structure used in the capacity market does not adequately represent all the capacity transfers that are feasible among LDAs. Absent a fully nodal capacity market clearing process, the MMU recommends that PJM use a nonnested model for all LDAs and specify a VRR curve for each LDA separately. Each LDA requirement should be met with the capacity resources located within the LDA and exchanges from neighboring LDAs up to the transmission limit. LDAs should price separate if that is the result of the LDA supply curves and the transmission constraints. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that the maximum price on the VRR curve be defined as net CONE. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the Fixed Resource Requirement (FRR) rules, including obligations and performance requirements, be revised and updated to ensure that the rules reflect current market realities and that FRR entities do not unfairly take advantage of those customers paying

¹⁷ See also Comments of the Independent Market Monitor for PJM, Docket No. ER14-503-000 (December 20, 2013).

¹⁸ See "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

¹⁹ See PJM Interconnection, L.L.C., Docket No. ER12-513-000 (December 1, 2011) ("Triennial Review").

²⁰ See the 2019 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue.

for capacity in the PJM capacity market. (Priority: Medium. First reported 2019. Status: Not adopted.)

Offer Caps, Offer Floors, and Must Offer

- The MMU recommends use of the Sustainable Market Rule (SMR) in order to protect competition in the capacity market from nonmarket revenues.²¹ (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that, as part of the MOPR unit specific standard of review, all projects be required to use the same basic modeling assumptions. That is the only way to ensure that projects compete on the basis of actual costs rather than on the basis of modeling assumptions.²² (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that modifications to existing resources not be treated as new resources for purposes of market power related offer caps or MOPR offer floors. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the RPM market power mitigation rule be modified to apply offer caps in all cases when the three pivotal supplier test is failed and the sell offer is greater than the offer cap. This will ensure that market power does not result in an increase in make whole payments. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that the offer cap for capacity resources be defined as the net avoidable cost rate (ACR) of each unit so that the clearing prices are a result of such net ACR offers, consistent with the fundamental economic logic for a competitive offer of a CP resource. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM develop a process for calculating a forward looking estimate for the expected number of Performance Assessment Intervals (H) to use in calculating the Market Seller Offer Cap (MSOC). The MMU recommends that the Nonperformance Charge Rate be left at its current level. The MMU recommends that PJM develop a forward looking estimate for the Balancing Ratio (B) during Performance Assessment Intervals (PAIs) to use in calculating the MSOC. Both H and B parameters should be included in the annual review of planning parameters for the Base Residual Auction, and should incorporate the actual observed reserve margins, and other assumptions consistent with the annual IRM study. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that capacity market sellers be required to request the use of minimum MW quantities greater than 0 MW (inflexible sell offer segments) and that the requests should only be permitted for defined physical reasons. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM update the values in the CRF table in the tariff when the components change. (Priority: High. First reported 2020. Status: Not adopted.)

Performance Incentive Requirements of RPM

- The MMU recommends that any unit which is not capable of supplying energy consistent with its day-ahead offer which should equal its ICAP, reflect an appropriate outage. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that retroactive replacement transactions associated with a failure to perform during a PAI not be allowed and that, more generally, retroactive replacement capacity transactions not be permitted. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that there be an explicit requirement that capacity resource offers in the day-ahead energy market be competitive, where

²¹ Brief of the Independent Market Monitor for PJM, Docket No. EL16-49, ER18-1314-000,-001; EL18-178 (October 2, 2018).

²² See 143 FERC ¶ 61,090 (2013) ("We encourage PJM and its stakeholders to consider, for example, whether the unit-specific review process would be more effective if PJM requires the use of common modeling assumptions for establishing unit-specific offer floors while, at the same time, allowing sellers to provide support for objective, individual cost advantages. Moreover, we encourage PJM and its stakeholders to consider these modifications to the unit-specific review process together with possible enhancements to the calculation of Net CONE."); see also, Comments of the Independent Market Monitor for PJM, Docket No. ER13-535-001 (March 25, 2013); Complaint of the Independent Market Monitor for PJM v. Unnamed Participant, Docket No. EL12-63-000 (May 1, 2012); Motion for Clarification of the Independent Market Monitor for PJM, Docket No. ER11-2875-000, et al. (February 17, 2012); Protest of the Independent Market Monitor for PJM, Docket No. ER11-2875-002 (June 2, 2011); Comments of the Independent Market Monitor for PJM, Docket Nos. EL11-20 and ER11-2875 (March 4, 2011).

competitive is defined to be the short run marginal cost of the units. (Priority: Low. First reported 2013. Status: Not adopted.)

- The MMU recommends that Capacity Performance resources be required to perform without excuses. Resources that do not perform should not be paid regardless of the reason for nonperformance. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the market data posting rules be modified to allow the disclosure of expected performance, actual performance, shortfall and bonus MW during a PAI by area without the requirement that more than three market participants' data be aggregated for posting. (Priority: Low. First reported 2019. Status: Not adopted.)

Capacity Imports and Exports

- The MMU recommends that all capacity imports be required to be deliverable to PJM load prior to the relevant delivery year to ensure that they are full substitutes for internal, physical capacity resources. Pseudo ties alone are not adequate to ensure deliverability. (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends that all costs incurred as a result of a pseudo tied unit be borne by the unit itself and included as appropriate in unit offers in the capacity market. (Priority: High. First reported 2016. Status: Not adopted.)
- The MMU recommends clear, explicit and detailed rules that define the conditions under which PJM will and will not recall energy from PJM capacity resources and prohibit new energy exports from PJM capacity resources. The MMU recommends that those rules define the conditions under which PJM will purchase emergency energy while at the same time not recalling energy exports from PJM capacity resources. PJM has modified these rules, but the rules need additional clarification and operational details. (Priority: Low. First reported 2010. Status: Partially adopted.)

Deactivations/Retirements

- The MMU recommends that the notification requirement for deactivations be extended from 90 days prior to the date of deactivation to 12 months prior to the date of deactivation and that PJM and the MMU be provided 60 days rather than 30 days to complete their reliability and market power analyses. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that RMR units recover all and only the incremental costs, including incremental investment costs, required by the RMR service that the unit owner would not have incurred if the unit owner had deactivated its unit as it proposed. Customers should bear no responsibility for paying previously incurred costs, including a return on or of prior investments. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends elimination of the cost of service recovery rate in OATT Section 119, and that RMR service should be provided under the deactivation avoidable cost rate in Part V. The MMU also recommends specific improvements to the DACR provisions. (Priority: Medium. First reported 2017. Status: Not adopted.)

Conclusion

The analysis of PJM Capacity Markets begins with market structure, which provides the framework for the actual behavior or conduct of market participants. The analysis examines participant behavior within that market structure. In a competitive market structure, market participants are constrained to behave competitively. The analysis examines market performance, measured by price and the relationship between price and marginal cost, that results from the interaction of market structure and participant behavior. Market power is and will remain endemic to the structure of the PJM Capacity Market. Nonetheless a competitive outcome can be assured by appropriate market power mitigation rules.

The MMU concludes that the 2021/2022 RPM Base Residual Auction results were not competitive as a result of offers above the competitive level by some market participants. The MMU recognizes that these market participants

followed the capacity market rules by offering at less than the stated offer cap of net CONE times B. But net CONE times B is not a competitive offer when the expected number of performance assessment intervals is zero or a very small number and the nonperformance charge rate is defined as net CONE/30. Under these circumstances, a competitive offer, under the logic defined in PJM's capacity performance filing, is net ACR. That is the way in which most market participants offered in this and prior capacity performance auctions.

The FERC approved PJM tariff defines the offer cap as net CONE times B, rather than including the full logic supporting the definition of the offer cap under the capacity performance paradigm. If the tariff had defined the offer cap consistent with PJM's filing in the capacity performance matter, the offer cap would have been net ACR rather than net CONE times B.

The MMU filed a complaint with the Commission asserting that the market seller offer cap is overstated.²³ The result of an overstated market seller offer cap is to permit the exercise of market power, as occurred in the 2021/2022 BRA. On March 18, 2021, the Commission issued an order determining that the current default market seller offer cap "is incorrectly calibrated such that it may unjustly and unreasonably prevent the appropriate review of offers, thereby allowing potential exercises of market power."²⁴ The Commission asked the parties to file briefs to address "whether an alternative method for market power mitigation in the PJM capacity market would better address the concern that the current methodology precludes the Market Monitor from reviewing offers that raise market power concerns and mitigating offers where appropriate." The outcome of the complaint could have a significant and standalone impact on clearing prices in the 2022/2023 BRA.

The MMU is required to identify market issues and to report them to the Commission and to market participants. The Commission decides on any action related to the MMU's findings.

²³ In 2019, the MMU filed a complaint seeking an order directing PJM to update the assumptions regarding the expected number of performance assessment intervals (PAI) in calculating the default capacity market seller offer cap (MSOC). Complaint of the Independent Market Monitor for PJM, Docket No. EL19-47-000 (February 21, 2019).

²⁴ 174 FERC ¶ 61,212.

The MMU found serious market structure issues, measured by the three pivotal supplier test results in the PJM Capacity Market in the last BRA and in subsequent incremental auctions. Explicit market power mitigation rules in the RPM construct only partially offset the underlying market structure issues in the PJM Capacity Market under RPM. In the 2021/2022 RPM Base Residual Auction, the default offer cap of net CONE times B exceeded the competitive offer for a number of resources. Some seasonal resources were paid additional make whole based on a failure of the market power rules to apply offer capping.

The MMU has identified serious market design issues with RPM and the MMU has made specific recommendations to address those issues.^{25 26 27 28 29 30} In 2020 and the first three months of 2021, the MMU prepared a number of RPM related reports and testimony, shown in Table 5-2.

The capacity performance modifications to the RPM construct significantly improved the capacity market and addressed a number of issues that had been identified by the MMU. But significant issues remain in the PJM capacity market design.

The PJM markets have worked to provide incentives to entry and to retain capacity. PJM had excess reserves of 11,911.9 ICAP MW on June 1, 2020, and will have excess reserves of 14,228.2 ICAP MW on June 1, 2021, based on current positions.³¹ A majority of capacity investments in PJM were financed by market sources.³² Of the 41,979.4 MW of additional capacity that cleared in

²⁵ See "Analysis of the 2018/2019 RPM Base Residual Auction Revised," <http://www.monitoringanalytics.com/reports/Reports/2016/IMM_Analysis_of_the_20182019_RPM_Base_Residual_Auction_20160706.pdf> (July 6, 2016).

²⁶ See "Analysis of the 2019/2020 RPM Base Residual Auction Revised," <http://www.monitoringanalytics.com/reports/Reports/2016/IMM_Analysis_of_the_20192020_RPM_BRA_20160831-Revised.pdf> (August 31, 2016).

²⁷ See "Analysis of the 2020/2021 RPM Base Residual Auction," <http://www.monitoringanalytics.com/reports/Reports/2017/IMM_Analysis_of_the_20202021_RPM_BRA_20171117.pdf> (November 11, 2017).

²⁸ See "Analysis of the 2021/2022 RPM Base Residual Auction - Revised," <http://www.monitoringanalytics.com/reports/Reports/2018/IMM_Analysis_of_the_20212022_RPM_BRA_Revised_20180824.pdf> (August 24, 2018).

²⁹ See "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2017," <http://www.monitoringanalytics.com/reports/Reports/2017/IMM_Report_on_Capacity_Replacement_Activity_4_20171214.pdf> (December 14, 2017).

³⁰ See "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

³¹ The calculated reserve margin for June 1, 2021, does not account for cleared buy bids that have not been used in replacement capacity transactions.

³² "2020 PJM Generation Capacity and Funding Sources 2007/2008 through 2021/2022 Delivery Years," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf> (September 15, 2020).

RPM auctions for the 2007/2008 through 2019/2020 Delivery Years, 32,348.9 MW (77.1 percent) were based on market funding. Of the 3,032.2 MW of additional capacity that cleared in RPM auctions for the 2020/2021 through 2021/2022 Delivery Years, 2,742.8 MW (90.5 percent) were based on market funding. Those investments were made based on the assumption that markets would be allowed to work and that inefficient units would exit.

The issue of external subsidies, particularly for economic nuclear power plants, continued to evolve. The subsidies are not part of the PJM market design but nonetheless threaten the foundations of the PJM Capacity Market as well as the competitiveness of PJM markets overall. These subsidy programs originate from the fact that competitive markets result in the exit of uneconomic and uncompetitive generating units. Regardless of the specific rationales offered by unit owners, the proposed solution for all such generating units has been to provide out of market subsidies in order to retain such units. The proposed solution in all cases ignores the opportunity cost of subsidizing uneconomic units, which is the displacement of new resources and technologies that would otherwise be economic. Some subsidies were requested by the owners of economic resources. Some subsidies were requested by the owners of specific uneconomic generating units in order to improve the profitability of those specific units. These subsidies were not requested to accomplish broader social goals. Broader social goals can all be met with market-based mechanisms available to all market participants on a competitive basis and without discrimination.

Subsidies are contagious. Competition in the markets could be replaced and is now being replaced by competition to receive subsidies. Competition to receive subsidies is now a reality and is accelerating in PJM.

It is essential that any approach to the PJM markets incorporate a consistent view of how the preferred market design is expected to provide competitive results in a sustainable market design over the long run. A sustainable market design means a market design that results in appropriate incentives to competitive market participants to retire units and to invest in new units

over time such that reliability is ensured as a result of the functioning of the market.

A sustainable competitive wholesale power market must recognize three salient structural elements: state nonmarket revenues for renewable energy; a significant level of generation resources subject to cost of service regulation; and the structure and performance of the existing market based generation fleet.

Table 5-2 RPM related MMU reports: 2020 through March 2021

Date	Name
January 16, 2020	Net Revenues for PJM RPM Base Residual Auctions in 2020 http://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_Net_Revenues_20232024_RPM_BRA_20200116.pdf
January 17, 2020	IMM Request for Clarification re MOPR Order Docket Nos. EL16-49 and EL18-178 http://www.monitoringanalytics.com/filings/2020/IMM_Request_for_Clarification_Docket_Nos_EL16-49_EL18-178_20200117.pdf
January 21, 2020	CONE and ACR Values - Preliminary http://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MIC_Special_Special_Session_CONE_and_ACR_Values_20200128.pdf
February 5, 2020	IMM Answer to Requests for Rehearing's Docket No. EL14-69 and EL18-178 http://www.monitoringanalytics.com/filings/2020/IMM_Answer_To_RFRS_Docket_Nos_EL14-69_EL18-178_20200205.pdf
February 17, 2020	IMM MOPR Gross CONE Template http://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MOPR_Gross_CONE_Template_20200217.xlsx
February 18, 2020	IMM Second Request for Clarification re MOPR Docket No. EL18-178, EL16-49 http://www.monitoringanalytics.com/filings/2020/IMM_Second_Request_for_Clarification_Docket_No_EL18-178_%20EL16-49_20200218.pdf
February 18, 2020	Unit Specific Nuclear ACR Information http://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MIC_MOPR_Unit_Specific_Nuclear_ACR_Information_20200219.pdf
February 21, 2020	Generation Capacity Resources in PJM Region Subject to RPM Must Offer Obligation for 2020/2021, 2021/2022 and 2022/2023 Delivery Years http://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_RPM_Must_Offer_Obligations_20200221.pdf
February 28, 2020	Monitoring Analytics ACR Template http://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MIC_Special_Session_ACR_Template_20200228.pdf
March 20, 2020	Potential Impacts of the MOPR Order http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_MOPR_Order_20200320.pdf
April 16, 2020	Potential Impacts of the Creation of Maryland FRRs http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_Maryland_FRRs_20200416.pdf
May 6, 2020	Potential Compliance with P386 of FERC Order on Rehearing http://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MIC_Special_Session_Potential_Compliance_with_P386_of_FERC_Order_on_Rehearing_20200506.pdf
May 13, 2020	Potential Impacts of the Creation of New Jersey FRRs http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_New_Jersey_FRRs_20200513.pdf
May 15, 2020	IMM Request for Clarification re MOPR Ex Investigation Docket Nos. EL18-178-002 and EL16-49-002 http://www.monitoringanalytics.com/filings/2020/IMM_Request_for_Clarification_Docket_No_EL18-178-002_EL16-49-002_20200515.pdf
May 15, 2020	IMM Comments re MOPR-Ex Docket Nos. ER18-1314-00, EL16-49-000, EL18-178-000 http://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_ER18-1314-003_EL16-49_EL18-178_20200515.pdf
May 20, 2020	IMM Comments re NJBPU Investigation of Resource Adequacy Alternatives Docket No. E020030203 http://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_E020030203_20200520.pdf
June 22, 2020	IMM Comments re MOPR-Ex Compliance Filing Docket Nos. ER18-1314, EL16-49 and ERL8-178 http://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_ER18-1314_EL16-49_ER18-178_20200622.pdf
June 24, 2020	IMM Reply Comments re NJ BPU Resource Adequacy Alternatives Docket No. E020030203 http://www.monitoringanalytics.com/filings/2020/IMM_Reply_Comments_Docket_No_E020030203_20200624.pdf
June 30, 2020	Generation Capacity Resources in PJM Region Subject to RPM Must Offer Obligation for 2021/2022 and 2022/2023 Delivery Years http://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_RPM_Must_Offer_Obligations_20200630.pdf
July 15, 2020	IMM Answer to PSEG and Exelon Reply re New Jersey FRR Docket No. E020030203 http://www.monitoringanalytics.com/filings/2020/IMM_Answer_to_Exelon_PSEG_Docket_No_E020030203_20200715.pdf
July 17, 2020	Potential Impacts of the Creation of Ohio FRRs http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of%20Ohio_FRRs_20200717.pdf
July 20, 2020	IMM Comments re NJ BPU Nuclear Power Plant ZECs Docket No. E018080899 http://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_E018080899_20200720.pdf
July 23, 2020	IMM Answer re MOPR Ex Docket No. EL16-49, ER18-1314 and EL18-178 http://www.monitoringanalytics.com/filings/2020/IMM_Answer_Docket_No_EL16-49_ER18-1314_EL18-178_20200724.pdf
July 27, 2020	IMM Comments re ORDC Compliance Filing Docket No. EL19-58-002 and ER19-1486 http://www.monitoringanalytics.com/filings/2020/IMM_Comments_EL19-58-002_ER19-1486-20200727.pdf
September 15, 2020	2020 PJM Generation Capacity and Funding Sources: 2007/2008 through 2021/2022 http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf
September 19, 2020	ELCC-IMM Comments https://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MRC_ELCC_IMM_Comments_20200919.pdf
September 30, 2020	Generation Capacity Resources in PJM Region Subject to RPM Must Offer Obligation for 2021/2022 and 2022/2023 Delivery Years https://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_RPM_Must_Offer_Obligations_20200930.pdf
October 19, 2020	Issues with HVDC as Capacity https://www.monitoringanalytics.com/reports/Presentations/2020/IMM_HVDCSTF_Issues_with_HVDC_as_Capacity_20201019.pdf
October 19, 2020	IMM Answer re EAS Docket No. EL19-58-003 https://www.monitoringanalytics.com/filings/2020/IMM_Answer_Docket_No_EL19-58-003_20201019.pdf
November 5, 2020	PAI Settlement Issues https://www.monitoringanalytics.com/reports/Presentations/2020/IMM_MIC_PAI_Settlement_Issues_20201102.pdf
November 20, 2020	IMM Comments re ELCC Docket No. ER21-278 https://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_ER21-278_20201120.pdf
December 4, 2020	CRF Issues in the Capacity Market https://www.monitoringanalytics.com/reports/Market_Messages/IMM_CRF_Issues_in_the_Capacity_Market_20201204.pdf
December 14, 2020	IMM Answer and Motion for Consolidation re ELCC Docket No. ER21-278 https://www.monitoringanalytics.com/filings/2020/IMM_Answer_Docket_No_ER21-278_20201214.pdf
December 17, 2020	IMM Comments re PAI Docket No. ER15-623, et al https://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_ER15-623_et_al_20201217.pdf
December 18, 2020	IMM Answer re PJM ELCC Proposal Docket No. ER21-278 https://www.monitoringanalytics.com/filings/2020/IMM_Answer_Docket_No_ER21-278_20201218.pdf
December 29, 2020	Generation Capacity Resources in PJM Region Subject to RPM Must Offer Obligation for 2021/2022 and 2022/2023 Delivery Years https://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_Notice_RPM_Must_Offer_Obligations_20201229.pdf
January 29, 2021	Analysis of NJ Zero Emissions Credit(ZEC)Applications https://www.monitoringanalytics.com/reports/Reports/2021/IMM_Public_Report_Analysis_of_NJ_ZEC_Applications_20210129.pdf
February 19, 2021	Generation Capacity Resources in PJM Region Subject to RPM Must Offer Obligation for 2021/2022 and 2022/2023 Delivery Years https://www.monitoringanalytics.com/reports/Market_Messages/RPM_Material/IMM_RPM_Must_Offer_Obligations_20210219.pdf
March 4, 2021	Next Steps in Capacity Market Design https://www.monitoringanalytics.com/reports/Presentations/2021/IMM_Capacity_Market_Workshop_Session_2_Next_Steps_in_Capacity_Market_Design_20210304.pdf
March 5, 2021	IMM Comment re New Jersey FRR Docket No. E020030203 https://www.monitoringanalytics.com/filings/2021/IMM_Comment_Docket_No_E020030203_20210305.pdf
March 22, 2021	IMM Comments re ELCC Docket No. ER21-278-001 https://www.monitoringanalytics.com/filings/2021/IMM_Comments_Docket_No_ER21-278-001_20210322.pdf
March 31, 2021	IMM Answer re Jackson Complaint Docket No. EL21-62, et al https://www.monitoringanalytics.com/filings/2021/IMM_Answer_Docket_Nos_EL21-62_EL21-63_20210331.pdf

Installed Capacity

On January 1, 2021, RPM installed capacity was 184,270.0 MW (Table 5-3).³³ Over the next three months, new generation, unit deactivations, facility reratings, plus import and export shifts resulted in RPM installed capacity of 183,778.6 MW on March 31, 2021, a decrease of 491.4 MW or 0.3 percent from the January 1 level.^{34 35} The 491.4 MW decrease was the result of an increase in exports (49.1 MW), derates (63.1 MW), and deactivations (429.2 MW), offset by new or reactivated generation (50.0 MW).

At the beginning of the new delivery year on June 1, 2020, RPM installed capacity was 184,583.3 MW, a decrease of 1,069.2 MW or 0.6 percent from the May 31, 2020, level of 185,652.5 MW.

Table 5-3 Installed capacity (By fuel source): January 1, January 31, February 28, and March 31, 2021

	01-Jan-21		31-Jan-21		28-Feb-21		31-Mar-21	
	MW	Percent	MW	Percent	MW	Percent	MW	Percent
Coal	49,747.0	27.0%	49,631.5	26.9%	49,579.9	26.9%	49,342.0	26.8%
Gas	84,031.3	45.6%	84,025.5	45.6%	83,981.8	45.6%	83,912.6	45.7%
Hydroelectric	8,779.3	4.8%	8,779.3	4.8%	8,778.5	4.8%	8,778.5	4.8%
Nuclear	32,312.4	17.5%	32,312.4	17.5%	32,301.2	17.5%	32,301.2	17.6%
Oil	5,512.6	3.0%	5,512.6	3.0%	5,507.0	3.0%	5,507.0	3.0%
Solar	1,014.7	0.6%	1,014.7	0.6%	1,032.2	0.6%	1,032.2	0.6%
Solid waste	695.6	0.4%	695.6	0.4%	695.5	0.4%	695.5	0.4%
Wind	2,177.1	1.2%	2,209.6	1.2%	2,209.6	1.2%	2,209.6	1.2%
Total	184,270.0	100.0%	184,181.2	100.0%	184,085.7	100.0%	183,778.6	100.0%

Figure 5-1 shows the share of installed capacity by fuel source for the first day of each delivery year, from June 1, 2007, to June 1, 2020, as well as the expected installed capacity for the 2021/2022 delivery year, based on the

33 Percent values shown in Table 5-3 are based on unrounded, underlying data and may differ from calculations based on the rounded values in the tables.
 34 Unless otherwise specified, the capacity described in this section is the summer installed capacity rating of all PJM generation capacity resources, as entered into the Capacity Exchange system, regardless of whether the capacity cleared in the RPM auctions.
 35 Wind resources accounted for 2,209.6 MW, and solar resources accounted for 1,032.2 MW of installed capacity in PJM on March 31, 2021. PJM administratively reduces the capabilities of all wind generators to 14.7 percent for wind farms in mountainous terrain and 17.6 percent for wind farms in open terrain, and solar generators to 42.0 percent for ground mounted fixed panel, 60.0 percent for ground mounted tracking panel, and 38.0 percent for other than ground mounted solar arrays, of nameplate capacity when determining the installed capacity because wind and solar resources cannot be assumed to be available on peak and cannot respond to dispatch requests. As data become available, unforced capability of wind and solar resources will be calculated using actual data. There are additional wind and solar resources not reflected in total capacity because they are energy only resources and do not participate in the PJM Capacity Market. See "PJM Manual 21: Rules and Procedures for Determination of Generating Capability," Appendix B.3 Calculation Procedure, Rev. 14 (Aug. 1, 2019).

results of all auctions held through March 31, 2021.³⁶ On June 1, 2007, coal comprised 40.7 percent of the installed capacity, reached a maximum of 42.9 percent in 2012, decreased to 27.1 percent on June 1, 2020, and is projected to decrease to 25.5 percent by June 1, 2021. The share of gas increased from 29.1 percent on June 1, 2007, to 45.7 percent on June 1, 2020, and is projected to increase to 50.6 percent on June 1, 2021.

Figure 5-1 Percent of installed capacity (By fuel source): June 1, 2007 through June 1, 2021

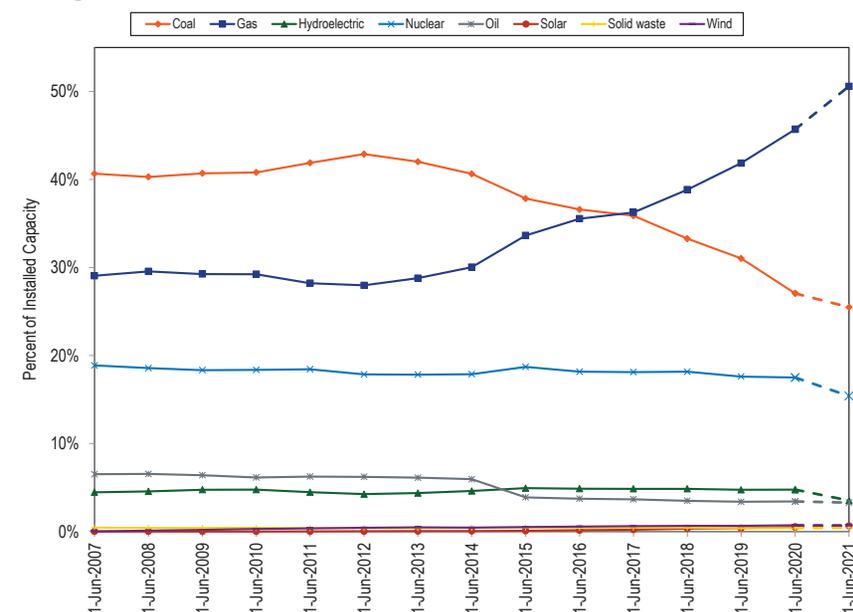


Table 5-4 shows the RPM installed capacity on January 1, 2021, through March 31, 2021, for the top five generation capacity resource owners, excluding FRR committed MW.

36 Due to EFORd values not being finalized for future delivery years, the projected installed capacity is based on cleared unforced capacity (UCAP) MW using the EFORd submitted with the offer.

Table 5-4 Installed capacity by parent company: January 1, January 31, February 28, and March 31, 2021

Parent Company	01-Jan-21			31-Jan-21			28-Feb-21			31-Mar-21		
	ICAP (MW)	Percent of Total ICAP	Rank	ICAP (MW)	Percent of Total ICAP	Rank	ICAP (MW)	Percent of Total ICAP	Rank	ICAP (MW)	Percent of Total ICAP	Rank
Exelon Corporation	20,843.6	12.2%	1	20,843.6	12.2%	1	20,842.1	12.2%	1	20,842.1	12.2%	1
Dominion Resources, Inc.	19,533.2	11.4%	2	19,533.2	11.4%	2	19,543.3	11.4%	2	19,505.1	11.4%	2
Vistra Energy Corp.	11,319.0	6.6%	3	11,319.0	6.6%	3	11,319.0	6.6%	3	11,319.0	6.6%	3
Talen Energy Corporation	10,941.4	6.4%	4	10,941.4	6.4%	4	10,935.7	6.4%	4	10,866.5	6.4%	4
LS Power Group	8,829.5	5.2%	5	8,829.5	5.2%	5	8,829.5	5.2%	5	8,829.5	5.2%	5

The sources of funding for generation owners can be categorized as one of two types: market and nonmarket. Market funding is from private investors bearing the investment risk without guarantees or support from any public sources, subsidies or guaranteed payment by ratepayers. Providers of market funding rely entirely on market revenues. Nonmarket funding is from guaranteed revenues, including cost of service rates for a regulated utility and subsidies. Table 5-5 shows the RPM installed capacity on January 1, 2021, to March 31, 2021, by funding type.

Table 5-5 Installed capacity by funding type: January 1, January 31, February 28, and March 31, 2021

Funding Type	01-Jan-21		31-Jan-21		28-Feb-21		31-Mar-21	
	ICAP (MW)	Percent of Total ICAP						
Market	152,436.7	82.7%	152,347.9	82.7%	152,246.0	82.7%	151,977.1	82.7%
Nonmarket	31,833.3	17.3%	31,833.3	17.3%	31,839.7	17.3%	31,801.5	17.3%
Total	184,270.0	100.0%	184,181.2	100.0%	184,085.7	100.0%	183,778.6	100.0%

Fuel Diversity

Figure 5-2 shows the fuel diversity index (FDI_c) for RPM installed capacity.³⁷ The FDI_c is defined as $1 - \sum_{i=1}^N s_i^2$, where s_i is the percent share of fuel type i . The minimum possible value for the FDI_c is zero, corresponding to all capacity from a single fuel type. The maximum possible value for the FDI_c is achieved when each fuel type has an equal share of capacity. For a capacity mix of eight fuel types, the maximum achievable index is 0.875. The fuel type categories used in the calculation of the FDI_c are the eight fuel sources in Table 5-3. The FDI_c is stable and does not exhibit any long-term trends. The only significant deviation occurred with the expansion of the PJM footprint. On April 1, 2002, PJM expanded with the addition of Allegheny Power System, which added about 12,000 MW of generation.³⁸ The reduction in the FDI_c resulted from an increase in coal capacity resources. A similar but more significant reduction occurred in 2004 with the expansion into the COMED, AEP, and DAY Control Zones.³⁹ The average FDI_c for the first quarter of 2021 decreased 0.4 percent compared to the first quarter of 2020. Figure 5-2 also includes the expected FDI_c through June 2021 based on cleared RPM auctions. The expected FDI_c is indicated in Figure 5-2 by the dashed orange line.

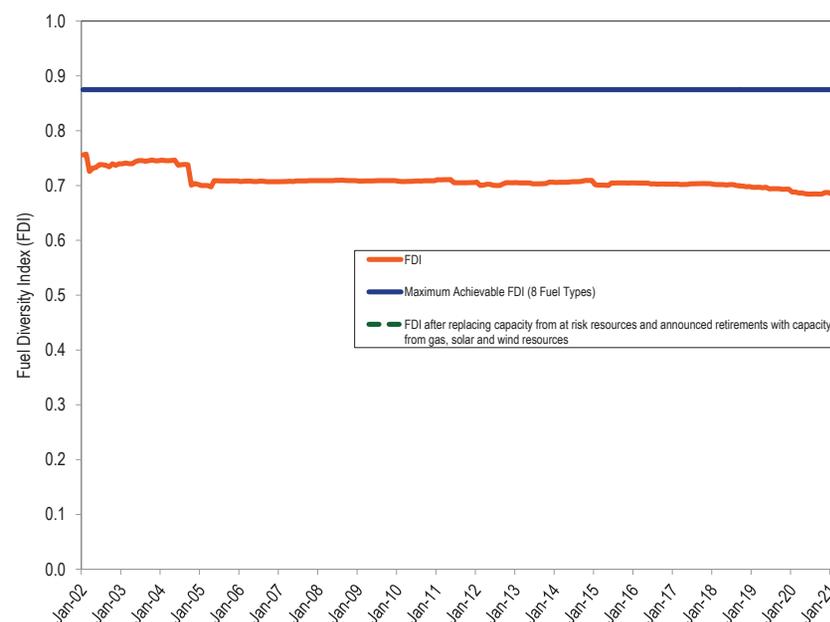
³⁷ Monitoring Analytics developed the FDI to provide an objective metric of fuel diversity. The FDI metric is similar to the HHI used to measure market concentration. The FDI is calculated separately for energy output and for installed capacity.

³⁸ On April 1, 2002, the PJM Region expanded with the addition of Allegheny Power System under a set of agreements known as "PJM-West." See page 4 in the 2002 *State of the Market Report for PJM* for additional details.

³⁹ See the 2019 *State of the Market Report for PJM*, Volume II, Appendix A, "PJM Geography" for an explanation of the expansion of the PJM footprint. The integration of the COMED Control Area occurred in May 2004 and the integration of the AEP and DAY control zones occurred in October 2004.

The FDI_c was used to measure the impact of potential retirements of resources that the MMU has identified as being at risk of retirement. A total of 4,763 MW of coal, CT and other capacity were identified as being at risk of retirement.⁴⁰ Generation owners that intend to retire a generator are required by the tariff to notify PJM at least 90 days in advance of the retirement.⁴¹ There are 4,622.5 MW of generation that have a requested retirement date after March 31, 2021.⁴² The dashed green line in Figure 5-2 shows the FDI_c calculated assuming that the capacity that cleared in an RPM auction from the at risk resources and other resources with deactivation notices is replaced by gas, wind and solar capacity.⁴³ ⁴⁴ The FDI_c under these assumptions would decrease by 0.3 percent on average from the expected FDI_c for the period April 1, 2021, through June 1, 2021.

Figure 5-2 Fuel Diversity Index for installed capacity: January 1, 2002 through June 1, 2021



RPM Capacity Market

The RPM Capacity Market, implemented June 1, 2007, is a forward-looking, annual, locational market, with a must offer requirement for Existing Generation Capacity Resources and mandatory participation by load, with performance incentives, that includes clear market power mitigation rules and that permits the direct participation of demand-side resources.

Annual base auctions are held in May for delivery years that are three years in the future. Effective January 31, 2010, First, Second, and Third Incremental Auctions are conducted 20, 10, and three months prior to the delivery year.⁴⁵

⁴⁰ See Table 7-47 in the 2020 State of the Market Report for PJM, Volume II, Section 7: Net Revenue.

⁴¹ See OATT Part V § 113.1.

⁴² See 2020 State of the Market Report for PJM, Volume II, Section 12: Generation and Transmission Planning, Table 12-11.

⁴³ It is assumed that 1,705.3 MW of replacement capacity is from solar units and 186.8 MW from wind units, with the remaining replacement capacity coming from gas units. This is the amount of derated wind and solar capacity needed to produce 2,295.2 GWh of generation over a three month period assuming the average capacity derate factors in the Planned Generation Additions subsection of Section 12 and the average capacity factors for wind and solar capacity resources in Table 8-27 and Table 8-30. This level of renewable generation represents the increase over first quarter 2021 levels of renewable generation that is required by RPS in the first quarter of 2022. The split between solar and wind is based on queue data.

⁴⁴ For this analysis resources for which PJM has received deactivation notifications were replaced with capacity beginning on the projected retirement date listed in the deactivation data. At risk resources that have not notified PJM regarding deactivation were replaced with capacity beginning on April 1, 2021.

⁴⁵ See Letter Order, Docket No. ER10-366-000 (January 22, 2010).

In the first three months of 2021, the 2021/2022 RPM Third Incremental Auction was conducted.⁴⁶

Market Structure

Supply

Table 5-6 shows generation capacity changes since the implementation of the Reliability Pricing Model through the 2019/2020 Delivery Year. The 21,993.1 MW increase was the result of new generation capacity resources (33,614.4 MW), reactivated generation capacity resources (1,362.8 MW), uprates (7,002.2 MW), integration of external zones (21,967.5 MW), a net decrease in capacity exports (1,905.2 MW), offset by a net decrease in capacity imports (1,013.6 MW), deactivations (39,400.0 MW) and derates (3,445.4 MW).

Table 5-7 shows the calculated RPM reserve margin and reserve in excess of the defined installed reserve margin (IRM) for June 1, 2016, through June 1, 2021, and accounts for cleared capacity, replacement capacity, and deficiency MW for all auctions held and the most recent peak load forecast for each delivery year. The completion of the replacement process using cleared buy bids from RPM incremental auctions includes two transactions. The first step is for the entity to submit and clear a buy bid in an RPM incremental auction. The next step is for the entity to complete a separate replacement transaction using the cleared buy bid capacity. Without an approved early replacement transaction requested for defined physical reasons, replacement capacity transactions can be completed only after the EFORds for the delivery year are finalized, on November 30 in the year prior to the delivery year, but before the start of the delivery day. The calculated reserve margins for June 1, 2021, does not account for cleared buy bids that have not been used in replacement capacity transactions. The projected reserve margin for June 1, 2021, accounts for projected replacement capacity using cleared buy bids by applying the rate at which historical buy bids have been used.

⁴⁶ FERC granted PJM's request for waiver of its Open Access Transmission Tariff to delay the 2022/2023 RPM Base Residual Auction from May 2019 to August 2019. See 164 FERC ¶ 61,153 (2018). FERC subsequently denied PJM's motion seeking clarification of the June 29, 2018, Order (163 FERC ¶ 61,236) and directed PJM not to run the 2022/2023 BRA in August 2019. See 168 FERC ¶ 61,051 (2019).

Future Changes in Generation Capacity⁴⁷

As shown in Table 5-6, for the period from the introduction of the RPM capacity market design in the 2007/2008 Delivery Year through the 2019/2020 Delivery Year, internal installed capacity decreased by 866.0 MW after accounting for new capacity resources, reactivations, and uprates (41,979.4 MW) and capacity deactivations and derates (42,845.4 MW).

For the current and future delivery years (2020/2021 through 2021/2022), new generation capacity is defined as capacity that cleared an RPM auction for the first time in the specified delivery year. Based on expected completion rates of cleared new generation capacity (2,372.1 MW) and pending deactivations (2,702.2 MW), PJM capacity is expected to decrease by 330.1 MW for the 2020/2021 through 2021/2022 Delivery Years.

⁴⁷ For more details on future changes in generation capacity, see "2020 PJM Generation Capacity and Funding Sources 2007/2008 through 2021/2022 Delivery Years," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf> (September 15, 2020).

Table 5-6 Generation capacity changes: 2007/2008 through 2019/2020^{48 49}

	ICAP (MW)									
	New	Reactivations	Upgrades	Integration	Net Change in Capacity Imports	Net Change in Capacity Exports	Deactivations	Derates	Net Change	
2007/2008	45.0	0.0	691.5	0.0	70.0	15.3	380.0	417.0	(5.8)	
2008/2009	815.4	238.3	987.0	0.0	473.0	(9.9)	609.5	421.0	1,493.1	
2009/2010	406.5	0.0	789.0	0.0	229.0	(1,402.2)	108.4	464.3	2,254.0	
2010/2011	153.4	13.0	339.6	0.0	137.0	367.7	840.6	223.5	(788.8)	
2011/2012	3,096.4	354.5	507.9	16,889.5	(1,183.3)	(1,690.3)	2,542.0	176.2	18,637.1	
2012/2013	1,784.6	34.0	528.1	47.0	342.4	84.0	5,536.0	317.8	(3,201.7)	
2013/2014	198.4	58.0	372.8	2,746.0	934.3	28.9	2,786.9	288.3	1,205.4	
2014/2015	2,276.8	20.7	530.2	0.0	2,335.7	177.3	4,915.6	360.3	(289.8)	
2015/2016	4,291.8	90.0	449.0	0.0	511.4	(117.8)	8,338.2	215.8	(3,094.0)	
2016/2017	3,679.3	532.0	419.2	0.0	575.6	722.9	659.4	206.7	3,617.1	
2017/2018	4,127.3	5.0	562.1	0.0	(1,025.1)	(695.1)	2,657.4	148.5	1,558.5	
2018/2019	8,127.5	4.0	330.9	2,120.0	(3,217.0)	212.7	6,730.0	89.2	333.5	
2019/2020	4,612.0	13.3	494.9	165.0	(1,196.6)	401.3	3,296.0	116.8	274.5	
Total	33,614.4	1,362.8	7,002.2	21,967.5	(1,013.6)	(1,905.2)	39,400.0	3,445.4	21,993.1	

Table 5-7 RPM reserve margin: June 1, 2016, to June 1, 2021^{50 51}

	Generation and DR RPM Committed Less				RPM Peak Load	Pool Wide Average EFORd	Generation and DR RPM Committed Less			Reserve Margin in Excess of IRM			Projected Replacement Capacity using Cleared Buy Bids	
	Deficiency UCAP (MW)	Forecast Peak Load	FRR Peak Load	PRD			Deficiency UCAP (MW)	Reserve Margin	Percent	ICAP (MW)	UCAP (MW)	Projected Reserve Margin		
01-Jun-16	160,883.3	152,356.6	12,511.6	0.0	139,845.0	16.4%	5.91%	170,988.7	22.3%	5.9%	8,209.2	0.0	22.3%	
01-Jun-17	163,872.0	153,230.1	12,837.5	0.0	140,392.6	16.6%	5.94%	174,220.7	24.1%	7.5%	10,522.9	0.0	24.1%	
01-Jun-18	161,242.6	152,407.9	12,732.9	0.0	139,675.0	16.1%	6.07%	171,662.5	22.9%	6.8%	9,499.8	0.0	22.9%	
01-Jun-19	162,276.1	151,643.5	12,284.2	0.0	139,359.3	16.0%	6.08%	172,781.2	24.0%	8.0%	11,124.4	0.0	24.0%	
01-Jun-20	159,560.4	148,355.3	11,488.3	558.0	136,309.0	15.5%	5.78%	169,348.8	24.2%	8.7%	11,911.9	0.0	24.2%	
01-Jun-21	162,699.3	149,482.9	11,717.7	510.0	137,255.2	14.7%	5.22%	171,659.9	25.1%	10.4%	14,228.2	4,609.2	21.5%	

Sources of Funding⁵²

Developers use a variety of sources to fund their projects, including Power Purchase Agreements (PPA), cost of service rates, and private funds (from internal sources or private lenders and investors). PPAs can be used for a variety of purposes and the use of a PPA does not imply a specific source of funding.

48 The capacity changes in this report are calculated based on June 1 through May 31.

49 The calculated export MW for 2012/2013 were revised from the 2020 Quarterly State of the Market Report for PJM: January through March.

50 The calculated reserve margins in this table do not include EE on the supply side or the EE add back on the demand side. The EE excluded from the supply side for this calculation includes annual EE and summer EE. This is how PJM calculates the reserve margin.

51 These reserve margin calculations do not consider Fixed Resource Requirement (FRR) load.

52 For more details on sources of funding for generation capacity, see "2020 PJM Generation Capacity and Funding Sources 2007/2008 through 2021/2022 Delivery Years," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf> (September 15, 2020).

New and reactivated generation capacity from the 2007/2008 Delivery Year through the 2019/2020 Delivery Year totaled 34,977.2 MW (83.3 percent of all additions), with 26,798.1 MW from market funding and 8,179.1 MW from nonmarket funding. Uprates to existing generation capacity from the 2007/2008 Delivery Year through the 2019/2020 Delivery Year totaled 7,002.2 MW (16.7 percent of all additions), with 5,550.8 MW from market funding and 1,451.4 MW from nonmarket funding. In summary, of the 41,979.4 MW of additional capacity from new, reactivated, and uprated generation that cleared in RPM auctions for the 2007/2008 through 2019/2020 Delivery Years, 32,348.9 MW (77.1 percent) were based on market funding.

Of the 3,032.2 MW of the additional generation capacity (new resources, reactivated resources, and uprates) that cleared in RPM auctions for the 2020/2021 through 2021/2022 delivery year, 2,169.3 MW are not yet in service. Of those 2,169.3 MW that have not yet gone into service, 2,150.3 MW have market funding and 19.0 MW have nonmarket funding. Applying the historical completion rates, 69.6 percent of all the projects in development are expected to go into service (1,496.0 MW of the 2,150.3 MW of market funded projects; 13.2 MW of the 19.0 MW of nonmarket funded projects). Together, 1,509.2 MW of the 2,169.3 MW of new generation capacity that cleared in RPM and are not yet in service are expected to go into service through the 2021/2022 Delivery Year.

Of the 862.9 MW of the additional generation capacity that cleared in RPM auctions for the 2020/2021 through 2021/2022 delivery years and are already in service, 592.5 MW (68.7 percent) are based on market funding and 270.4 MW (31.3 percent) are based on nonmarket funding. In summary, 2,742.8 MW (90.5 percent) of the additional generation capacity (592.5 MW in service and 2,150.3 MW not yet in service) that cleared in RPM auctions for the 2020/2021 through 2021/2022 Delivery Years are based on market funding. Capacity additions based on nonmarket funding are 289.4 MW (9.5 percent) of proposed generation that cleared at least one RPM auction for the 2020/2021 through 2021/2022 Delivery Years.

Demand

The MMU analyzed market sectors in the PJM Capacity Market to determine how they met their load obligations. The PJM Capacity Market was divided into the following sectors:

- **PJM EDC.** EDCs with a franchise service territory within the PJM footprint. This sector includes traditional utilities, electric cooperatives, municipalities and power agencies.
- **PJM EDC Generating Affiliate.** Affiliate companies of PJM EDCs that own generating resources.
- **PJM EDC Marketing Affiliate.** Affiliate companies of PJM EDCs that sell power and have load obligations in PJM, but do not own generating resources.
- **Non-PJM EDC.** EDCs with franchise service territories outside the PJM footprint.
- **Non-PJM EDC Generating Affiliate.** Affiliate companies of non-PJM EDCs that own generating resources.
- **Non-PJM EDC Marketing Affiliate.** Affiliate companies of non-PJM EDCs that sell power and have load obligations in PJM, but do not own generating resources.
- **Non-EDC Generating Affiliate.** Affiliate companies of non-EDCs that own generating resources.
- **Non-EDC Marketing Affiliate.** Affiliate companies of non-EDCs that sell power and have load obligations in PJM, but do not own generating resources.

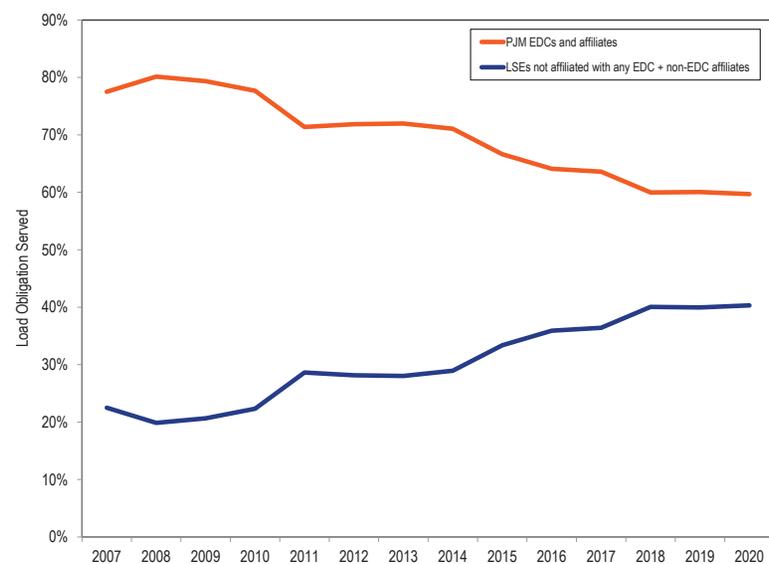
On June 1, 2020, PJM EDCs and their affiliates maintained a large market share of load obligations under RPM, together totaling 59.7 percent (Table 5-8), down from 60.1 percent on June 1, 2019. The combined market share of LSEs not affiliated with any EDC and of non-PJM EDC affiliates was 40.3 percent, up from 39.9 percent on June 1, 2019. The share of capacity market load obligation fulfilled by PJM EDCs and their affiliates, and LSEs not affiliated with any EDC and non-PJM EDC affiliates from June 1, 2007, to June 1, 2020,

is shown in Figure 5-3. PJM EDCs' and their affiliates' share of load obligation has decreased from 77.5 percent on June 1, 2007, to 59.7 percent on June 1, 2020. The share of load obligation held by LSEs not affiliated with any EDC and non-PJM EDC affiliates increased from 22.5 percent on June 1, 2007, to 40.3 percent on June 1, 2020. Prior to the 2012/2013 Delivery Year, obligation was defined as cleared and make whole MW in the Base Residual Auction and the Second Incremental Auction plus ILR forecast obligations. Effective with the 2012/2013 Delivery Year, obligation is defined as the sum of the unforced capacity obligations satisfied through all RPM auctions for the delivery year.

Table 5-8 Capacity market load obligation served: June 1, 2019 and June 1, 2020

	1-Jun-19		1-Jun-20		Change	
	Obligation (MW)	Percent of total obligation	Obligation (MW)	Percent of total obligation	Obligation (MW)	Percent of total obligation
PJM EDCs and Affiliates	113,416.3	60.1%	104,849.4	59.7%	(8,566.8)	(0.4%)
LSEs not affiliated with any EDC + non EDC Affiliates	75,445.0	39.9%	70,838.3	40.3%	(4,606.7)	0.4%
Total	188,861.3	100.0%	175,687.7	100.0%	(13,173.6)	0.0%

Figure 5-3 Capacity market load obligation served: June 1, 2007 through June 1, 2020



Capacity Transfer Rights (CTRs)

Capacity Transfer Rights (CTRs) are used to return capacity market congestion revenues to load. Load pays for the transmission system through firm transmission charges and pays congestion. Capacity market congestion revenues are the difference between the total dollars paid by load for capacity and the total dollars received by capacity market sellers. CTRs permit customers to receive the benefit of importing cheaper capacity using transmission capability. The MW of CTRs available for allocation to LSEs in an LDA are equal to the Unforced Capacity imported into the LDA, based on

the results of the Base Residual Auction and Incremental Auctions, less any MW of CETL paid for directly by market participants in the form of Qualifying Transmission Upgrades (QTUs) cleared in an RPM Auction, and Incremental Capacity Transfer Rights (ICTRs). There are two types of ICTRs, those allocated to a New Service Customer obligated to fund a

transmission facility or upgrade and those associated with Incremental Rights Eligible Required Transmission Enhancements.

For LDAs in which the RPM auctions for a delivery year resulted in a positive average weighted Locational Price Adder, an LSE with CTRs corresponding to the LDA is entitled to a payment or charge equal to the Locational Price Adder multiplied by the MW of the LSEs' CTRs.

In the 2021/2022 RPM Base Residual Auction, EMAAC had 4,352.6 MW of CTRs with a total value of \$40,877,295, PSEG had 4,990.5 MW of CTRs with a total value of \$70,238,159, ATSI had 6,402.8 MW of CTRs with a total value of \$73,219,252, COMED had 1,527.9 MW of CTRs with a total value of \$30,978,820, and BGE had 5,125.6 MW of CTRs with a total value of \$112,812,971.

EMAAC had 40.0 MW of customer funded ICTRs with a total value of \$375,658, PSEG had 41.0 MW of customer funded ICTRs with a total value of \$577,050, BGE had 65.7 MW of customer funded ICTRs with a total value of \$1,446,024,

and COMED had 1,097.0 MW of customer funded ICTRs with a total value of \$22,242,498.

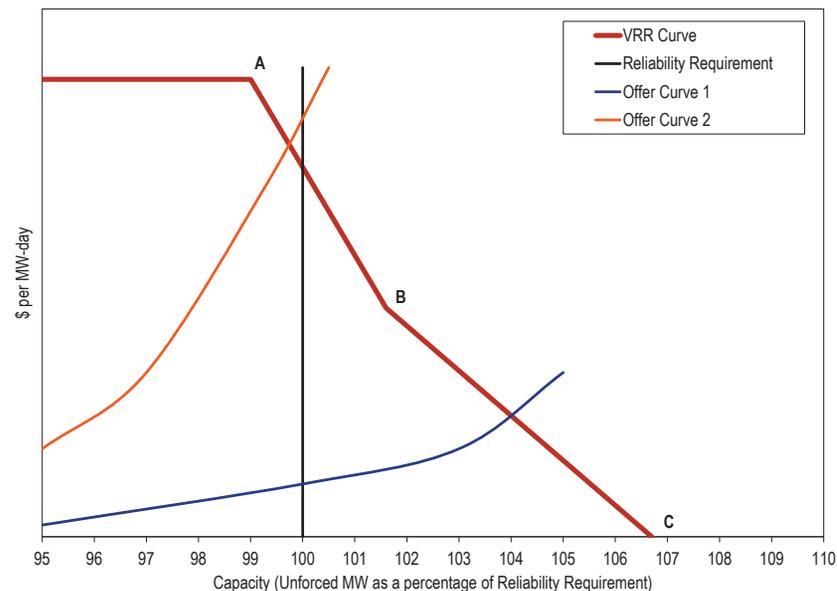
EMAAC had 948.0 MW of ICTRs due to Incremental Rights-Eligible Required Transmission Enhancements with a value of \$8,903,095. PSEG had 499.4 MW of ICTRs due to Incremental Rights-Eligible Required Transmission Enhancements with a value of \$7,028,755. BGE had 306.0 MW of ICTRs due to Incremental Rights-Eligible Required Transmission Enhancements with a value of \$6,734,907.

Demand Curve

Effective for the 2018/2019 and subsequent delivery years, PJM revised the variable resource requirement (VRR) curve. The starting MW point of the downward sloping demand curve is set at 99.0 percent of the reliability requirement. The highest MW point is set at 106.7 percent of the reliability requirement. Almost all of the downward sloping part of the VRR curve lies to the right side of the reliability requirement.

The PJM definition of the VRR curve means the clearing price and cleared quantity will be higher, almost without exception, using the current VRR curve than using a vertical demand curve at the reliability requirement. As a result, payments for capacity will be higher. Figure 5-4 shows the RTO VRR curve and RTO reliability requirement for the 2022/2023 RPM BRA. The clearing price and cleared quantity would be lower if a vertical VRR curve set at the reliability requirement were used in place of the existing VRR curve. This is the case if the supply curve intersects the VRR curve to the right side of the reliability requirement (Offer Curve 1). The only exception would be if the supply curve intersects the VRR curve to the left of the reliability requirement (Offer Curve 2). In that case, the clearing price and cleared quantity would be higher with the vertical demand curve than with the existing VRR curve. In almost all RPM auctions, the offer curve intersected the VRR curve to the right side of the vertical demand curve.

Figure 5-4 VRR curve relative to the reliability requirement: 2022/2023 Delivery Year



Market Concentration

Auction Market Structure

As shown in Table 5-9, in the 2021/2022 RPM Third Incremental Auction all participants in the total PJM market as well as the LDA RPM markets failed the three pivotal supplier (TPS) test.⁵³ Offer caps were applied to all sell offers for resources which were subject to mitigation when the capacity market seller did not pass the test, the submitted sell offer exceeded the defined offer cap, and the submitted sell offer, absent mitigation, increased the market clearing price.^{54 55 56}

⁵³ The market definition used for the TPS test includes all offers with costs less than or equal to 1.50 times the clearing price. See *MMU Technical Reference for PJM Markets*, at "Three Pivotal Supplier Test" for additional discussion.

⁵⁴ See OATT Attachment DD § 6.5.

⁵⁵ Prior to November 1, 2009, existing DR and EE resources were subject to market power mitigation in RPM Auctions. See 129 FERC ¶ 61,081 at P 30 (2009).

⁵⁶ Effective January 31, 2011, the RPM rules related to market power mitigation were changed, including revising the definition for planned generation capacity resource and creating a new definition for existing generation capacity resource for purposes of the must offer requirement and market power mitigation, and treating a proposed increase in the capability of a generation capacity resource the same in terms of mitigation as a planned generation capacity resource. See 134 FERC ¶ 61,065 (2011).

In applying the market structure test, the relevant supply for the RTO market includes all supply offered at less than or equal to 150 percent of the RTO cost-based clearing price. The relevant supply for the constrained LDA markets includes the incremental supply inside the constrained LDAs which was offered at a price higher than the unconstrained clearing price for the parent LDA market and less than or equal to 150 percent of the cost-based clearing price for the constrained LDA. The relevant demand consists of the MW needed inside the LDA to relieve the constraint.

Table 5-9 presents the results of the TPS test. A generation owner or owners are pivotal if the capacity of the owners' generation facilities is needed to meet the demand for capacity. The results of the TPS are measured by the residual supply index (RSI_x). The RSI_x is a general measure that can be used with any number of pivotal suppliers. The subscript denotes the number of pivotal suppliers included in the test. If the RSI_x is less than or equal to 1.0, the supply owned by the specific generation owner, or owners, is needed to meet market demand and the generation owners are pivotal suppliers with a significant ability to influence market prices. If the RSI_x is greater than 1.0, the supply of the specific generation owner or owners is not needed to meet market demand and those generation owners have a reduced ability to unilaterally influence market price.

Table 5-9 RSI results: 2019/2020 through 2021/2022 RPM Auctions⁵⁷

RPM Markets	$RSI_{1,06}$	RSI_x	Total Participants	Failed RSI_x Participants
2019/2020 Base Residual Auction				
RTO	0.81	0.66	131	131
EMAAC	0.79	0.23	6	6
ComEd	0.74	0.12	6	6
BGE	0.00	0.00	1	1
2019/2020 First Incremental Auction				
RTO	0.63	0.50	53	53
EMAAC	0.00	0.00	5	5
2019/2020 Second Incremental Auction				
RTO	0.61	0.48	38	38
BGE	0.00	0.00	1	1
2019/2020 Third Incremental Auction				
RTO	0.70	0.59	72	72
2020/2021 Base Residual Auction				
RTO	0.81	0.69	119	119
MAAC	0.67	0.77	24	24
EMAAC	0.45	0.18	21	21
ComEd	0.47	0.20	14	14
DEOK	0.00	0.00	1	1
2020/2021 First Incremental Auction				
RTO	0.47	0.42	47	47
2020/2021 Second Incremental Auction				
RTO	0.40	0.56	34	34
2020/2021 Third Incremental Auction				
RTO	0.54	0.72	59	59
MAAC	0.25	0.18	14	14
2021/2022 Base Residual Auction				
RTO	0.80	0.68	122	122
EMAAC	0.71	0.22	14	14
PSEG	0.20	0.01	5	5
ATSI	0.01	0.00	2	2
ComEd	0.08	0.02	5	5
BGE	0.23	0.00	3	3
2021/2022 First Incremental Auction				
RTO	0.57	0.48	26	26
EMAAC	0.00	0.82	5	3
PSEG	0.00	0.00	1	1
PSEG North	0.00	0.00	2	2
BGE	0.00	0.00	1	1
2021/2022 Second Incremental Auction				
RTO	0.19	0.12	19	19
EMAAC	0.05	0.23	7	5
PSEG	0.00	0.00	2	2
BGE	0.00	0.00	0	0
2021/2022 Third Incremental Auction				
RTO	0.57	0.41	59	59
EMAAC	1.00	0.19	6	6
PSEG	0.00	0.00	1	1
BGE	0.00	-0.00	2	2

⁵⁷ The RSI shown is the lowest RSI in the market.

Locational Deliverability Areas (LDAs)

Under the PJM Tariff, PJM determines, in advance of each BRA, whether defined Locational Deliverability Areas (LDAs) will be modeled in the auction. Effective with the 2012/2013 Delivery Year, an LDA is modeled as a potentially constrained LDA for a delivery year if the Capacity Emergency Transfer Limit (CETL) is less than 1.15 times the Capacity Emergency Transfer Objective (CETO), such LDA had a locational price adder in one or more of the three immediately preceding BRAs, or such LDA is determined by PJM in a preliminary analysis to be likely to have a locational price adder based on historic offer price levels. The rules also provide that starting with the 2012/2013 Delivery Year, EMAAC, SWMAAC, and MAAC LDAs are modeled as potentially constrained LDAs regardless of the results of the above three tests.⁵⁸ In addition, PJM may establish a constrained LDA even if it does not qualify under the above tests if PJM finds that “such is required to achieve an acceptable level of reliability.”⁵⁹ A reliability requirement and a Variable Resource Requirement (VRR) curve are established for each modeled LDA. Effective for the 2014/2015 through 2016/2017 Delivery Years, a Minimum Annual and a Minimum Extended Summer Resource Requirement are established for each modeled LDA. Effective for the 2017/2018 Delivery Year, Sub-Annual and Limited Resource Constraints, replacing the Minimum Annual and a Minimum Extended Summer Resource Requirements, are established for each modeled LDA.⁶⁰ Effective for the 2018/2019 through the 2019/2020 Delivery Years, Base Capacity Demand Resource Constraint and a Base Capacity Resource Constraint, replacing the Sub-Annual and Limited Resource Constraints, are established for each modeled LDA.

Locational Deliverability Areas are shown in Figure 5-5, Figure 5-6 and Figure 5-7.

Figure 5-5 Map of locational deliverability areas

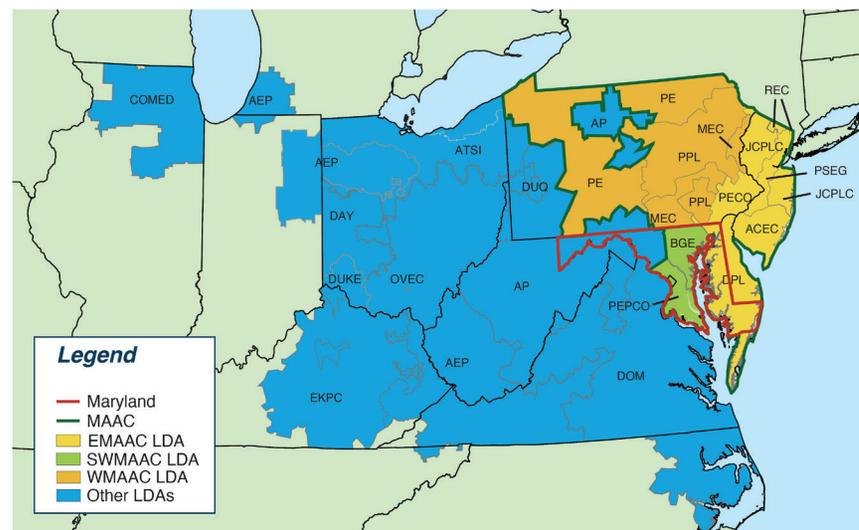
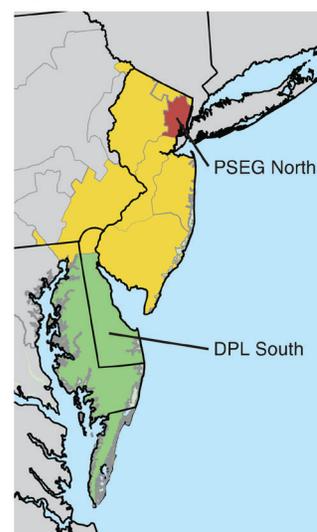


Figure 5-6 Map of RPM EMAAC subzonal LDAs



58 Prior to the 2012/2013 Delivery Year, an LDA with a CETL less than 1.05 times CETO was modeled as a constrained LDA in RPM. No additional criteria were used in determining modeled LDAs.

59 OAT Attachment DD § 5.10 (a) (ii).

60 146 FERC ¶ 61,052 (2014).

Figure 5-7 Map of RPM ATSI subzonal LDA



Imports and Exports

Units external to the metered boundaries of PJM can qualify as PJM capacity resources if they meet the requirements to be capacity resources. Generators on the PJM system that do not have a commitment to serve PJM loads in the given delivery year as a result of RPM auctions, FRR capacity plans, locational UCAP transactions, and/or are not designated as a replacement resource, are eligible to export their capacity from PJM.⁶¹

The PJM market rules should not create inappropriate barriers to either the import or export of capacity. The market rules in other balancing authorities should also not create inappropriate barriers to the import or export of capacity. The PJM market rules should ensure that the definition of capacity is enforced including physical deliverability, recallability and the obligation to make competitive offers into the PJM Day-Ahead Energy Market equal to ICAP MW. Physical deliverability can only be assured by requiring that all imports are deliverable to PJM load to ensure that they are full substitutes for internal capacity resources. Selling capacity into the PJM Capacity Market but making energy offers daily of \$999 per MWh would not fulfill the requirements of a capacity resource to make a competitive offer, but would constitute economic withholding. This is one of the reasons that the rules governing the obligation to make a competitive offer in the day-ahead energy market should be clarified for both internal and external resources.

⁶¹ OATT Attachment DD § 5.6.6(b).

For the 2017/2018 through the 2019/2020 Delivery Years, Capacity Import Limits (CILs) are established for each of the five external source zones and the overall PJM region to account for the risk that external generation resources may not be able to deliver energy during the relevant delivery year due to the curtailment of firm transmission by third parties.⁶² Capacity market sellers may request an exception to the CIL for an external generation resource by committing that the resource will be pseudo tied prior to the start of the relevant delivery year, by demonstrating that it has long-term firm transmission service confirmed on the complete transmission path from the resource to PJM, and by agreeing to be subject to the same RPM must offer requirement as internal PJM generation resources.

Effective June 9, 2015, an external generation capacity resource must obtain an exception to the CILs to be eligible to offer as a Capacity Performance Resource, which means that effective with the 2020/2021 Delivery Year, CILs are no longer defined as an RPM parameter.⁶³

Effective May 9, 2017, enhanced pseudo tie requirements for external generation capacity resources were implemented, including a transition period with deliverability requirements for existing pseudo tie resources that have previously cleared an RPM auction.⁶⁴ The rule changes include: defining coordination with other Balancing Authorities when conducting pseudo tie studies; establishing an electrical distance requirement; establishing a market to market flowgate test to establish limits on the number of coordinated flowgates PJM must add in order to accommodate a new pseudo tie; a model consistency requirement; the requirement for the capacity market seller to provide written acknowledgement from the external Balancing Authority Areas that such pseudo tie does not require tagging and that firm allocations associated with any coordinated flowgates applicable to the external Generation Capacity Resource under any agreed congestion management process then in effect between PJM and such Balancing Authority Area will be allocated to PJM; the requirement for the capacity market seller to obtain long-term firm point to point transmission service for transmission outside PJM with rollover

⁶² 147 FERC ¶ 61,060 (2014).

⁶³ 151 FERC ¶ 61,208 (2015).

⁶⁴ 161 FERC ¶ 61,197 (2017), *order denying reh'g*, 170 FERC ¶ 61,217 (2020).

rights and to obtain network external designated transmission service for transmission within PJM; establishing an operationally deliverable standard; and modifying the nonperformance penalty definition for external generation capacity resources to assess performance at subregional transmission organization granularity.

As shown in Table 5-10, of the 4,470.4 MW of imports offered in the 2021/2022 RPM Base Residual Auction, 4,051.8 MW cleared. Of the cleared imports, 1,909.9 MW (47.1 percent) were from MISO.

Table 5-10 RPM imports: 2007/2008 through 2021/2022 RPM Base Residual Auctions

Base Residual Auction	UCAP (MW)					
	MISO		Non-MISO		Total Imports	
	Offered	Cleared	Offered	Cleared	Offered	Cleared
2007/2008	1,073.0	1,072.9	547.9	547.9	1,620.9	1,620.8
2008/2009	1,149.4	1,109.0	517.6	516.8	1,667.0	1,625.8
2009/2010	1,189.2	1,151.0	518.8	518.1	1,708.0	1,669.1
2010/2011	1,194.2	1,186.6	539.8	539.5	1,734.0	1,726.1
2011/2012	1,862.7	1,198.6	3,560.0	3,557.5	5,422.7	4,756.1
2012/2013	1,415.9	1,298.8	1,036.7	1,036.7	2,452.6	2,335.5
2013/2014	1,895.1	1,895.1	1,358.9	1,358.9	3,254.0	3,254.0
2014/2015	1,067.7	1,067.7	1,948.8	1,948.8	3,016.5	3,016.5
2015/2016	1,538.7	1,538.7	2,396.6	2,396.6	3,935.3	3,935.3
2016/2017	4,723.1	4,723.1	2,770.6	2,759.6	7,493.7	7,482.7
2017/2018	2,624.3	2,624.3	2,320.4	1,901.2	4,944.7	4,525.5
2018/2019	2,879.1	2,509.1	2,256.7	2,178.8	5,135.8	4,687.9
2019/2020	2,067.3	1,828.6	2,276.1	2,047.3	4,343.4	3,875.9
2020/2021	2,511.8	1,671.2	2,450.0	2,326.0	4,961.8	3,997.2
2021/2022	2,308.4	1,909.9	2,162.0	2,141.9	4,470.4	4,051.8

Demand Resources

There are two basic demand products incorporated in the RPM market design:⁶⁵

- **Demand Resources (DR).** Interruptible load resource that is offered into an RPM Auction as capacity and receives the relevant LDA or RTO resource clearing price.
- **Energy Efficiency (EE) Resources.** Load resources that are offered into an RPM auction as capacity and receive the relevant LDA or RTO resource clearing price. The EE resource type was eligible to be offered in RPM auctions starting with the 2012/2013 Delivery Year and in incremental auctions in the 2011/2012 Delivery Year.⁶⁶

Effective for the 2018/2019 and the 2019/2020 Delivery Years, there are two types of demand resource and energy efficiency resource products included in the RPM market design:^{67 68}

- **Base Capacity Resources**
 - **Base Capacity Demand Resources.** A demand resource that is required to be available on any day from June through September for an unlimited number of interruptions. Base capacity DR is required to be capable of maintaining each interruption for at least 10 hours only during the hours of 10:00 a.m. to 10:00 p.m. EPT.
 - **Base Capacity Energy Efficiency Resources.** A project designed to achieve a continuous (during summer peak periods) reduction in electric energy consumption that is not reflected in the peak load forecast for the delivery year for which the base capacity energy efficiency resource is proposed, and that is fully implemented at all times during the relevant delivery year, without any requirement of notice, dispatch, or operator intervention. The peak period definition for the base capacity energy efficiency resource type includes the period from the hour ending 15:00 EPT and the hour ending 18:00 EPT from June through August, excluding weekends and federal holidays.

⁶⁵ Effective June 1, 2007, the PJM active load management (ALM) program was replaced by the PJM load management (LM) program. Under ALM, providers had received a MW credit which offset their capacity obligation. With the introduction of LM, qualifying load management resources can be offered into RPM auctions as capacity resources and receive the clearing price.

⁶⁶ Letter Order, Docket No. ER10-366-000 (January 22, 2010).

⁶⁷ 151 FERC ¶ 61,208.

⁶⁸ PJM Reliability Assurance Agreement Article 1.

- **Capacity Performance Resources**

- **Annual Demand Resources.** A demand resource that is required to be available on any day in the relevant delivery year for an unlimited number of interruptions. Annual DR is required to be capable of maintaining each interruption for only 10 hours during the hours of 10:00 a.m. to 10:00 p.m. EPT for the period May through October and 6:00 a.m. to 9:00 p.m. EPT for the period November through April unless there is an Office of the Interconnection approved maintenance outage during October through April.
- **Annual Energy Efficiency Resources.** A project designed to achieve a continuous (during summer and winter peak periods) reduction in electric energy consumption during peak periods that is not reflected in the peak load forecast for the delivery year for which the energy efficiency resource is proposed, and that is fully implemented at all times during the relevant delivery year, without any requirement of notice, dispatch, or operator intervention. The peak period definition for the annual energy efficiency resource type includes the period from the hour ending 15:00 EPT and the hour ending 18:00 EPT from June through August, and the period from the hour ending 8:00 EPT and the hour ending 9:00 EPT and the period from the hour ending 19:00 EPT and the hour ending 20:00 EPT from January through February, excluding weekends and federal holidays.

Effective with the 2020/2021 Delivery Year, the Capacity Performance Product will be the only capacity product type, with two possible season types, annual and summer.

- **Annual Capacity Performance Resources**

- Annual Demand Resources
- Annual Energy Efficiency Resources

- **Seasonal Capacity Performance Resources**

- **Summer-Period Demand Resources.** A demand resource that is required to be available on any day from June through October and the following May of the delivery year for an unlimited number of interruptions.

Summer period DR is required to be capable of maintaining each interruption between the hours of 10:00 a.m. to 10:00 p.m. EPT.

- **Summer-Period Energy Efficiency Resources.** A project designed to achieve a continuous (during summer peak periods) reduction in electric energy consumption during peak periods that is not reflected in the peak load forecast for the delivery year for which the energy efficiency resource is proposed, and that is fully implemented at all times during the relevant delivery year, without any requirement of notice, dispatch, or operator intervention. The peak period definition for the summer-period efficiency resource type includes the period from the hour ending 15:00 EPT and the hour ending 18:00 EPT from June through August, excluding weekends and federal holidays.

As shown in Table 5-11, Table 5-12, and Table 5-13, capacity in the RPM load management programs was 10,586.0 MW for June 1, 2020, as a result of cleared capacity for demand resources and energy efficiency resources in RPM auctions for the 2020/2021 Delivery Year (13,015.2 MW) less replacement capacity (2,429.2 MW).

Table 5-11 RPM load management statistics by LDA: June 1, 2018 to June 1, 2021^{69 70 71}

	UCAP (MW)															
	RTO	MAAC	EMAAC	SWMAAC	DPL South	PSEG	PSEG		ATSI					DAY	DEOK	
							North	Pepco	ATSI	Cleveland	ComEd	BGE	PPL			
01-Jun-18	DR cleared	11,435.4	4,361.9	1,707.2	1,226.4	86.8	389.9	139.2	559.3	1,034.3	287.2	1,895.2	667.1	716.2		
	EE cleared	2,296.3	706.8	315.9	317.6	9.2	102.0	45.2	186.1	184.4	33.2	807.4	131.5	43.1		
	DR net replacements	(3,182.4)	(1,268.4)	(584.3)	(199.5)	(52.4)	(150.9)	(43.6)	(25.6)	(261.0)	(136.7)	(430.0)	(173.9)	(220.0)		
	EE net replacements	248.8	163.0	45.5	107.6	1.1	22.4	9.1	(8.9)	14.7	4.7	29.0	116.5	5.4		
	RPM load management	10,798.1	3,963.3	1,484.3	1,452.1	44.7	363.4	149.9	710.9	972.4	188.4	2,301.6	741.2	544.7		
01-Jun-19	DR cleared	10,703.1	3,878.9	1,659.2	817.0	91.3	381.2	176.5	554.6	1,047.0	333.9	1,759.9	262.4	741.4		
	EE cleared	2,528.5	821.4	395.3	301.7	7.8	134.5	52.8	170.0	204.8	41.7	792.9	131.7	72.7		
	DR net replacements	(2,138.8)	(1,004.2)	(468.8)	(129.0)	(40.9)	(141.5)	(86.6)	(74.8)	(130.3)	(123.1)	(143.0)	(54.2)	(208.9)		
	EE net replacements	(50.0)	(24.1)	4.7	3.3	(0.2)	2.7	9.1	2.2	3.4	0.0	0.0	1.1	(20.4)		
	RPM load management	11,042.8	3,672.0	1,590.4	993.0	58.0	376.9	151.8	652.0	1,124.9	252.5	2,409.8	341.0	584.8		
01-Jun-20	DR cleared	9,445.7	2,829.1	1,168.9	485.8	72.6	339.0	152.7	236.3	951.7	231.9	1,657.3	249.5	616.6	241.5	184.7
	EE cleared	3,569.5	1,288.8	700.3	394.5	28.8	246.1	111.3	196.2	356.0	72.9	852.0	198.3	111.4	79.5	105.6
	DR net replacements	(2,399.5)	(858.7)	(369.0)	(176.5)	(29.7)	(136.5)	(89.0)	(53.3)	(121.1)	(36.2)	(314.5)	(123.2)	(171.0)	(66.1)	(27.5)
	EE net replacements	(29.7)	(0.5)	(0.3)	5.9	0.0	(6.3)	12.0	(0.6)	(0.2)	0.0	(0.1)	6.5	(5.2)	0.0	(5.0)
	RPM load management	10,586.0	3,258.7	1,499.9	709.7	71.7	442.3	187.0	378.6	1,186.4	268.6	2,194.7	331.1	551.8	254.9	257.8
01-Jun-21	DR cleared	11,427.7	3,454.1	1,381.5	624.9	66.3	410.5	188.6	345.9	1,196.8	272.8	2,073.7	279.0	697.7	227.7	220.5
	EE cleared	4,806.2	1,810.5	979.1	501.1	42.0	353.1	136.0	275.9	420.5	95.7	982.7	225.2	186.7	111.0	135.5
	DR net replacements	(1,195.2)	(591.8)	(190.7)	(81.5)	(10.0)	(100.9)	(49.9)	(37.9)	(102.6)	(13.0)	(259.2)	(43.6)	(83.7)	(7.3)	(62.2)
	EE net replacements	(7.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(7.0)
	RPM load management	15,031.7	4,672.8	2,169.9	1,044.5	98.3	662.7	274.7	583.9	1,514.7	355.5	2,797.2	460.6	800.7	331.4	286.8

69 See OATT Attachment DD § 8.4. The reported DR cleared MW may reflect reductions in the level of committed MW due to relief from Capacity Resource Deficiency Charges.

70 Pursuant to OA § 15.1.6(c), PJM Settlement shall attempt to close out and liquidate forward capacity commitments for PJM Members that are declared in collateral default. The reported replacement transactions may include transactions associated with PJM members that were declared in collateral default.

71 See OATT Attachment DD § 5.14E. The reported DR cleared MW for the 2016/2017, 2017/2018, and 2018/2019 Delivery Years reflect reductions in the level of committed MW due to the Demand Response Legacy Direct Load Control Transition Provision.

Table 5-12 RPM commitments, replacements, and registrations for demand resources: June 1, 2007 to June 1, 2021^{72 73 74}

	UCAP (MW)						Registered DR		
	RPM Cleared	Adjustments to Cleared	Net Replacements	RPM Commitments	RPM Commitment Shortage	RPM Commitments Less Commitment Shortage	ICAP (MW)	UCAP Conversion Factor	UCAP (MW)
01-Jun-07	127.6	0.0	0.0	127.6	0.0	127.6	0.0	1.033	0.0
01-Jun-08	559.4	0.0	(40.0)	519.4	(58.4)	461.0	488.0	1.034	504.7
01-Jun-09	892.9	0.0	(474.7)	418.2	(14.3)	403.9	570.3	1.033	589.2
01-Jun-10	962.9	0.0	(516.3)	446.6	(7.7)	438.9	572.8	1.035	592.6
01-Jun-11	1,826.6	0.0	(1,052.4)	774.2	0.0	774.2	1,117.9	1.035	1,156.5
01-Jun-12	8,752.6	(11.7)	(2,253.6)	6,487.3	(34.9)	6,452.4	7,443.7	1.037	7,718.4
01-Jun-13	10,779.6	0.0	(3,314.4)	7,465.2	(30.5)	7,434.7	8,240.1	1.042	8,586.8
01-Jun-14	14,943.0	0.0	(6,731.8)	8,211.2	(219.4)	7,991.8	8,923.4	1.042	9,301.2
01-Jun-15	15,774.8	(321.1)	(4,829.7)	10,624.0	(61.8)	10,562.2	10,946.0	1.038	11,360.0
01-Jun-16	13,284.7	(19.4)	(4,800.7)	8,464.6	(455.4)	8,009.2	8,961.2	1.042	9,333.4
01-Jun-17	11,870.7	0.0	(3,870.8)	7,999.9	(30.3)	7,969.6	8,681.4	1.039	9,016.3
01-Jun-18	11,435.4	0.0	(3,182.4)	8,253.0	(1.0)	8,252.0	8,512.0	1.091	9,282.4
01-Jun-19	10,703.1	0.0	(2,138.8)	8,564.3	(0.4)	8,563.9	9,229.9	1.090	10,056.0
01-Jun-20	9,445.7	0.0	(2,399.5)	7,046.2	(0.1)	7,046.1	7,867.6	1.088	8,561.5
01-Jun-21	11,427.7	0.0	(1,195.2)	10,232.5	0.0	10,232.5	609.2	1.087	662.3

Table 5-13 RPM commitments and replacements for energy efficiency resources: June 1, 2007 to June 1, 2021^{75 76}

	UCAP (MW)				RPM	
	RPM Cleared	Adjustments to Cleared	Net Replacements	RPM Commitments	RPM Commitment Shortage	RPM Commitments Less Commitment Shortage
01-Jun-07	0.0	0.0	0.0	0.0	0.0	0.0
01-Jun-08	0.0	0.0	0.0	0.0	0.0	0.0
01-Jun-09	0.0	0.0	0.0	0.0	0.0	0.0
01-Jun-10	0.0	0.0	0.0	0.0	0.0	0.0
01-Jun-11	76.4	0.0	0.2	76.6	0.0	76.6
01-Jun-12	666.1	0.0	(34.9)	631.2	(5.1)	626.1
01-Jun-13	904.2	0.0	120.6	1,024.8	(13.5)	1,011.3
01-Jun-14	1,077.7	0.0	204.7	1,282.4	(0.2)	1,282.2
01-Jun-15	1,189.6	0.0	335.9	1,525.5	(0.9)	1,524.6
01-Jun-16	1,723.2	0.0	61.1	1,784.3	(0.5)	1,783.8
01-Jun-17	1,922.3	0.0	195.6	2,117.9	(7.4)	2,110.5
01-Jun-18	2,296.3	0.0	248.8	2,545.1	0.0	2,545.1
01-Jun-19	2,528.5	0.0	(50.0)	2,478.5	0.0	2,478.5
01-Jun-20	3,569.5	0.0	(29.7)	3,539.8	(0.1)	3,539.7
01-Jun-21	4,806.2	0.0	(7.0)	4,799.2	0.0	4,799.2

72 See OATT Attachment DD § 8.4. The reported DR adjustments to cleared MW include reductions in the level of committed MW due to relief from Capacity Resource Deficiency Charges.

73 See OATT Attachment DD § 5.14C. The reported DR adjustments to cleared MW for the 2015/2016 and 2016/2017 Delivery Years include reductions in the level of committed MW due to the Demand Response Operational Resource Flexibility Transition Provision.

74 See OATT Attachment DD § 5.14E. The reported DR adjustments to cleared MW for the 2016/2017, 2017/2018, and 2018/2019 Delivery Years include reductions in the level of committed MW due to the Demand Response Legacy Direct Load Control Transition Provision.

75 Pursuant to the OA § 15.1.6(c), PJM Settlement shall close out and liquidate all forward positions of PJM members that are declared in default. The replacement transactions reported for the 2014/2015 Delivery Year included transactions associated with RTP Controls, Inc., which was declared in collateral default on March 9, 2012.

76 Effective with the 2019/2020 Delivery Year, available capacity from an EE Resource can be used to replace only EE Resource commitments. This rule change and related EE add back rule changes were endorsed at the December 17, 2015, meeting of the PJM Markets and Reliability Committee.

Market Conduct

Offer Caps and Offer Floors

Market power mitigation measures were applied to capacity resources such that the sell offer was set equal to the defined offer cap when the capacity market seller failed the market structure test for the auction, the submitted sell offer exceeded the defined offer cap, and the submitted sell offer, absent mitigation, would have increased the market clearing price.^{77 78 79} For Base Capacity, offer caps are defined in the PJM Tariff as avoidable costs less PJM market revenues, or opportunity costs based on the potential sale of capacity in an external market. For Capacity Performance Resources, offer caps are defined in the PJM Tariff as the applicable zonal net Cost of New Entry (CONE) times (B) where B is the average of the Balancing Ratios (B) during the Performance Assessment Hours in the three consecutive calendar years that precede the base residual auction for such delivery year, unless net avoidable costs exceed this level, or opportunity costs based on the potential sale of capacity in an external market exceed this level. For RPM Third Incremental Auctions, capacity market sellers may elect, for Base Capacity offers, an offer cap equal to 1.1 times the BRA clearing price for the relevant LDA and delivery year or, for Capacity Performance offers, an offer cap equal to the greater of the net CONE for the relevant LDA and delivery year or 1.1 times the BRA clearing price for the relevant LDA and delivery year.

Avoidable costs are the costs that a generation owner would not incur if the generating unit did not operate for one year, in particular the delivery year.⁸⁰ In the calculation of avoidable costs, there is no presumption that the unit would retire as the alternative to operating, although that possibility could be reflected if the owner documented that retirement was the alternative. Avoidable costs may also include annual capital recovery associated with investments required to maintain a unit as a generation capacity resource,

⁷⁷ See OATT Attachment DD § 6.5.

⁷⁸ Prior to November 1, 2009, existing DR and EE resources were subject to market power mitigation in RPM Auctions. See 129 FERC ¶ 61,081 at P 30 (2009).

⁷⁹ Effective January 31, 2011, the RPM rules related to market power mitigation were changed, including revising the definition for Planned Generation Capacity Resource and creating a new definition for Existing Generation Capacity Resource for purposes of the must offer requirement and market power mitigation, and treating a proposed increase in the capability of a Generation Capacity Resource the same in terms of mitigation as a Planned Generation Capacity Resource. See 134 FERC ¶ 61,065 (2011).

⁸⁰ OATT Attachment DD § 6.8 (b).

termed Avoidable Project Investment Recovery (APIR). Avoidable cost based offer caps are defined to be net of revenues from all other PJM markets and unit-specific bilateral contracts. For Capacity Performance Resources, avoidable cost based offer caps are defined to be net of revenues from all other PJM markets and unit-specific bilateral contracts and expected bonus performance payments/nonperformance charges.⁸¹ Capacity resource owners could provide ACR data by providing their own unit-specific data or, for delivery years prior to 2020/2021, by selecting the default ACR values. The specific components of avoidable costs are defined in the PJM Tariff.⁸²

Effective for the 2018/2019 and subsequent delivery years, the ACR definition includes two additional components, Avoidable Fuel Availability Expenses (AFAE) and Capacity Performance Quantifiable Risk (CPQR).⁸³ AFAE is available for Capacity Performance Resources. AFAE is defined to include expenses related to fuel availability and delivery. CPQR is available for Capacity Performance Resources and, for the 2018/2019 and 2019/2020 Delivery Years, Base Capacity Resources. CPQR is defined to be the quantifiable and reasonably supported cost of mitigating the risks of nonperformance associated with submission of an offer.

The opportunity cost option allows capacity market sellers to offer based on a documented price available in a market external to PJM, subject to export limits. If the relevant RPM market clears above the opportunity cost, the generation capacity resource is sold in the RPM market. If the opportunity cost is greater than the clearing price and the generation capacity resource does not clear in the RPM market, it is available to sell in the external market.

Calculation of Offer Caps

The competitive offer of a Capacity Performance resource is based on a market seller's expectations of a number of variables, some of which are resource specific: the resource's net going forward costs (Net ACR); and the resource's

⁸¹ For details on the competitive offer of a capacity performance resource, see "Analysis of the 2021/2022 RPM Base Residual Auction—Revised," <http://www.monitoringanalytics.com/reports/Reports/2018/IMM_Analysis_of_the_2021/2022_RPM_BRA_Revised_20180824.pdf> (August 24, 2018).

⁸² OATT Attachment DD § 6.8(a).

⁸³ 151 FERC ¶ 61,208.

performance during performance assessment intervals (A) in the delivery year.⁸⁴

The competitive offer of a Capacity Performance resource is also based on a market seller's expectations of system level variables: the number of performance assessment intervals (PAI) in a delivery year (H) where the resource is located; the level of performance required to meet its capacity obligation during those performance assessment intervals, measured as the average Balancing Ratio (B); and the level of the bonus performance payment rate (CPBR) compared to the nonperformance charge rate (PPR). The level of bonus performance payment rate depends on the level of underperforming MW net of the underperforming MW excused by PJM during performance assessment hours for reasons defined in the PJM OATT.⁸⁵

The default offer cap defined in the PJM tariff, Net CONE times the average Balancing Ratio, is based on a number of assumptions:

1. The Net ACR of a resource is less than its expected energy only bonuses:

$$ACR \leq \sum_{i=1}^H (CPBR_i \times A_i)$$

$$\text{or } ACR \leq \left(\frac{1}{12}\right) (CPBR \times H \times \bar{A})$$

2. The expected number of performance assessment intervals equals 360. (H = 360 intervals, or 12 hours)
3. The expected value of the bonus performance payment rate (CPBR) is equal to the nonperformance charge rate (PPR)
4. The average expected performance of the resource during performance assessment hours (\bar{A})

The competitive offer of such a resource is:

$$p = \left(\frac{1}{12}\right) (CPBR \times H \times \bar{A} + PPR \times H \times (\bar{B} - \bar{A}))$$

⁸⁴ The model is only applicable to generation resources and storage resources that have an annual obligation to perform with very limited specific excuses as defined in the PJM OATT.

⁸⁵ OATT Attachment DD S 10A (d).

In other words, the competitive offer of such a resource is the opportunity cost of taking on the capacity obligation which equals the sum of the energy only bonuses it would have earned $(CPBR \times H \times \bar{A})/12$ and the net nonperformance charges it would incur by taking on the capacity obligation $(PPR \times H \times (\bar{B} - \bar{A})/12$). Both the components are proportional to the expected number of performance assessment intervals. If the expected number of performance assessment intervals (H) is significantly lower than the value used to determine the nonperformance charge rate (PPR), the opportunity of earning bonuses as an energy only resource, as well as the net nonperformance charges incurred by taking on a capacity obligation are lower. Under such a scenario, the likelihood that that the resource's Net ACR is lower than the expected energy only bonuses is reduced. For resources whose Net ACR is greater than the expected energy only bonuses, the competitive offer is the Net ACR adjusted with any capacity performance bonuses or nonperformance charges they expect to incur during the delivery year.

This means that when the expected number of performance assessment intervals are lower than the value used to determine the nonperformance charge rate (360 intervals, or 30 hours), the current default offer cap of Net CONE times B overstates the competitive offer and the market seller offer cap.

The recent history of a low number of emergency actions in PJM reflect the improvements to generator performance with the capacity performance design, the reduction in actual and expected pool wide outage rates as a result of new units added to the system and the retirement of old units, the upward biased peak load forecasts used in RPM, and the high reserve margins in capacity.^{86 87} Given these developments, the assumption that there would be 30 hours of emergency actions in a year that would trigger performance assessment intervals is unsupported. Since the nonperformance charge rate is defined in the tariff as net CONE divided by 30 hours, the adjusted default offer cap to reflect a lower estimate for the number of PAIs is much lower than net CONE times B.

⁸⁶ PJM experienced only one emergency event since April 2014 that triggered a PAI in an area that at least encompasses a PJM transmission zone. On October 2, 2019, PJM declared a pre-emergency load management action that triggered PAIs in four zones for a period of two hours or 24 five minute intervals.

⁸⁷ See Table 5-7.

In the 2021/2022 RPM Base Residual Auction, net CONE times B exceeded the actual competitive offer level of a Low ACR resource that the default offer cap is based on.⁸⁸ While most participants offered in the 2021/2022 RPM Base Residual Auction at competitive levels based on their expectation of the number of performance assessment hours and projected net revenues, some market participants did not offer competitively and affected the market clearing prices.

MOPR

Effective April 12, 2011, the RPM Minimum Offer Price Rule (MOPR) was changed.⁸⁹ The changes to the MOPR included updating the calculation of the net Cost of New Entry (CONE) for Combined Cycle (CC) and Combustion Turbine (CT) plants which is used as a benchmark value in assessing the competitiveness of a sell offer, increasing the percentage value used in the screen to 90 percent for CC and CT plants, eliminating the net-short requirement as a prerequisite for applying the MOPR, eliminating the impact screen, revising the process for reviewing proposed exceptions to the defined minimum sell offer price, and clarifying which resources are subject to the MOPR along with the duration of mitigation. Subsequent FERC Orders revised the MOPR, including clarification on the duration of mitigation, which resources are subject to MOPR, and the MOPR review process.⁹⁰

Effective May 3, 2013, the RPM Minimum Offer Price Rule (MOPR) was changed again.⁹¹ The changes to the MOPR included establishing Competitive Entry and Self Supply Exemptions while also retaining the unit specific exception process for those that do not qualify for the Competitive Entry or Self Supply Exemptions; changing the applicability of MOPR to include only combustion turbine, combined cycle, integrated gasification combined cycle (IGCC) technologies while excluding units primarily fueled with landfill gas or cogeneration units which are certified or self-certified as Qualifying Facilities (QFs); changing the applicability to increases in installed capacity of 20.0

MW or more combined for all units at a single point of interconnection to the transmission system; changing the applicability to include the full capability of repowering of plants based on combustion turbine, combined cycle, IGCC technology; increasing the screen from 90 percent to 100 percent of the applicable net CONE values; and broadening the region subject to MOPR to the entire RTO from modeled LDAs only.

Effective December 8, 2017, FERC issued an order on remand rejecting PJM's MOPR proposal in Docket No. ER13-535, and as a result, the rules that were in effect prior to PJM's December 7, 2012, MOPR filing were reinstated. These changes include eliminating the Competitive Entry and Self Supply Exemptions and retaining only the Unit Specific Exception request; narrowing the region subject to MOPR from the entire RTO to only modeled LDAs; eliminating the 20.0 MW threshold for applicability; decreasing the screen from 90 percent to 100 percent of the applicable net CONE values; redefining the applicability criteria to exclude nuclear, coal, IGCC, hydroelectric, wind and solar facilities; modifying the duration of mitigation criteria from clearing in a prior delivery year to clearing in any delivery year; and changing the procedural deadlines.⁹²

By order issued December 19, 2019, the RPM Minimum Offer Price Rule (MOPR) was modified.⁹³ The rules applying to natural gas fired capacity resources without state subsidies were retained. The changes include expanding the MOPR to new or existing state subsidized capacity resources; establishing a competitive exemption for new and existing resources other than natural gas fired resources while also allowing a resource specific exception process for those that do not qualify for the competitive exemption; defining limited categorical exemptions for renewable resources participating in renewable portfolio standards (RPS) programs, self supply, DR, EE, and capacity storage; defining the region subject to MOPR for capacity resources with state subsidy as the entire RTO; and defining the default offer price floor for capacity resources with state subsidies as 100 percent of the applicable net CONE or net ACR values. The Commission approved PJM's proposed revisions to the PJM market rules to implement a forward looking EAS offset to include forward

⁸⁸ See Monitoring Analytics, LLC "Analysis of the 2021/2022 RPM Base Residual Auction—Revised," at Attachment B <http://www.monitoringanalytics.com/reports/Reports/2018/IMM_Analysis_of_the_20212022_RPM_BRA_Revised_20180824.pdf> (August 24, 2018).

⁸⁹ 135 FERC ¶ 61,022 (2011).

⁹⁰ 135 FERC ¶ 61,022 (2011), *order on reh'g*, 137 FERC ¶ 61,145 (2011).

⁹¹ 143 FERC ¶ 61,090 (2013).

⁹² 161 FERC ¶ 61,252 (2017).

⁹³ 169 FERC ¶ 61,239 (2019), *order denying reh'g*, 171 FERC ¶ 61,035 (2020).

looking energy and ancillary services revenues rather than historical.⁹⁴ The MMU has recommended such an approach. The change in the offset will affect MOPR floor prices and the results of unit specific reviews under MOPR. The 2022/2023 BRA is scheduled to be run in May 2021.⁹⁵ The Commission convened a Technical Conference on March 23, 2021, in order to consider whether MOPR should be retained and to consider possible alternative approaches.⁹⁶

Issues addressed during the MOPR unit specific review process in 2021 for the 2022/2023 BRA included documentation of asset life greater than 20 years, degradation of resource performance, operating and maintenance expenses, required capital expenditures, tax assumptions, documentation of forward net revenues, and the use of retail savings as a source of net revenue offset to EE gross CONE.

2021/2022 RPM Third Incremental Auction

As shown in Table 5-14, 481 generation resources submitted Capacity Performance offers in the 2021/2022 RPM Third Incremental Auction. Unit specific offer caps were calculated for zero generation resources (0.0 percent). Of the 481 generation resources, 415 generation resources had the net CONE times B offer cap (86.3 percent), 28 generation resources elected the offer cap option of 1.1 times the BRA clearing price (5.8 percent), 11 Planned Generation Capacity Resources had uncapped offers (2.3 percent), and the remaining 27 generation resources were price takers (5.6 percent). Market power mitigation was applied to the Capacity Performance sell offers of zero generation resources, including 0.0 MW.

MOPR Statistics

Market power mitigation measures are applied to MOPR Screened Generation Resources such that the sell offer is set equal to the MOPR Floor Offer Price when the submitted sell offer is less than the MOPR Floor Offer Price and an exemption or exception was not granted, or the sell offer is set equal to the agreed upon minimum level of sell offer when the sell offer is less than the agreed upon minimum level of sell offer based on a Unit-Specific Exception.

As shown in Table 5-15, of the 838.5 ICAP MW of MOPR Unit-Specific Exception requests for the 2021/2022 RPM Third Incremental Auction, requests for 838.5 MW were granted.

⁹⁴ 173 FERC ¶ 61,134 (2020).

⁹⁵ 174 FERC ¶ 61,036 (2021).

⁹⁶ Technical Conference regarding Resource Adequacy in the Evolving Electricity Sector, Docket No. AD21-10 (March 23, 2021).

Table 5-14 ACR statistics: 2021/2022 RPM auctions

Offer Cap/Mitigation Type	2021/2022 Base Residual Auction		2021/2022 First Incremental Auction		2021/2022 Second Incremental Auction		2021/2022 Third Incremental Auction	
	Number of Generation Resources	Percent of Generation Resources Offered	Number of Generation Resources	Percent of Generation Resources Offered	Number of Generation Resources	Percent of Generation Resources Offered	Number of Generation Resources	Percent of Generation Resources Offered
Default ACR	NA	NA	NA	NA	NA	NA	NA	NA
Unit specific ACR (APIR)	3	0.3%	0	0.0%	0	0.0%	0	0.0%
Unit specific ACR (APIR and CPQR)	5	0.4%	0	0.0%	0	0.0%	0	0.0%
Unit specific ACR (non-APIR)	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Unit specific ACR (non-APIR and CPQR)	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Opportunity cost input	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Default ACR and opportunity cost	NA	NA	NA	NA	NA	NA	NA	NA
Net CONE times B	953	84.2%	285	94.7%	241	87.3%	415	86.3%
Offer cap of 1.1 times BRA clearing price elected	NA	NA	NA	NA	NA	NA	28	5.8%
Uncapped planned uprate and default ACR	NA	NA	NA	NA	NA	NA	NA	NA
Uncapped planned uprate and opportunity cost	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Uncapped planned uprate and Net CONE times B	31	2.7%	4	1.3%	20	7.2%	0	0.0%
Uncapped planned uprate and price taker	0	0.0%	1	0.3%	0	0.0%	0	0.0%
Uncapped planned uprate and 1.1 times BRA clearing price elected	NA	NA	NA	NA	NA	NA	0	0.0%
Uncapped planned generation resources	11	1.0%	9	3.0%	10	3.6%	11	2.3%
Existing generation resources as price takers	129	11.4%	2	0.7%	5	1.8%	27	5.6%
Total Generation Capacity Resources offered	1,132	100.0%	301	100.0%	276	100.0%	481	100.0%

Table 5-15 MOPR statistics: RPM auctions conducted in first quarter, 2021⁹⁷

	Number of Requests (Company-Plant Level)	ICAP (MW)			UCAP (MW)		
		Requested	Granted	Offered	Offered	Cleared	
2021/2022 Third Incremental Auction	Unit-Specific Exception	32	838.5	838.5	248.2	246.5	103.9
	Other MOPR Screened Generation Resources	0	0.0	0.0	82.1	81.4	0.0
	Total	32	838.5	838.5	330.3	327.9	103.9

Replacement Capacity⁹⁸

When a capacity resource is not available for a delivery year, the owner of the capacity resource may purchase replacement capacity. Replacement capacity is the vehicle used to offset any reduction in capacity from a resource which is not available for a delivery year. But the replacement capacity mechanism may also be used to manipulate the market.

Table 5-16 shows the committed and replacement capacity for all capacity resources for June 1 of each year from 2007 through 2021. The 2021 numbers are not final.

⁹⁷ There were additional MOPR Screened Generation Resources for which no exceptions or exemptions were requested and to which the MOPR floor was applied. Some numbers are not reported as a result of PJM confidentiality rules.

⁹⁸ For more details on replacement capacity, see "Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2019," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Analysis_of_Replacement_Capacity_for_RPM_Commitments_June_1_2007_to_June_1_2019_20190913.pdf> (September 13, 2019).

Sellers of demand resources in RPM auctions disproportionately replace those commitments on a consistent basis compared to sellers of other resource types. External generation and internal generation not in service had high rates of replacement in some years and those are also of concern.

The dynamic that can result is that the speculative DR suppresses prices in the BRA and displaces physical generation assets. Those generation assets then have an incentive to offer at a low price, including offers at zero and below cost, in IAs in order to ensure some capacity market revenue for long lived physical resources which the owners expect to maintain for multiple years. The result is lower IA prices which permit the buyback of the speculative DR at prices below the BRA prices which encourages the greater use of speculative DR.

PJM's sale of capacity in IAs at very low prices, given that PJM announces the MW quantity and the sell offer price in advance of the auctions, further reduces IA prices and increases the incentive of DR sellers to speculate in the BRAs. The MMU recommends that if PJM sells capacity in incremental auctions, PJM should offer the capacity for sale at the BRA clearing price in order to avoid suppressing the IA price below the competitive level. If the PJM sell offer price is not the BRA clearing price, PJM should not reveal its proposed sell offer price or the MW quantity to be sold prior to the auction.

It has been asserted that selling at a high price in the BRA and buying back at a low price in the IA is just a market transaction and therefore does not constitute a problem. But permitting DR to be an option in the BRA rather than requiring DR to be a commitment to provide a physical asset gives DR an unfair advantage and creates a self fulfilling dynamic that incents more of the same behavior. Only DR is permitted to be an option in the BRA. Generation resources must have met physical milestones in order to offer in the BRA. It is not reasonable to permit DR capacity resources to have a different product definition than generation capacity resources. Even if DR is treated as an annual product, this unique treatment as an option makes DR an inferior resource and not a complete substitute for generation resources. The current approach to DR is also inconsistent with the history of the definition

of capacity in PJM, which has always been that capacity is physical and unit specific. The current approach to DR effectively makes DR a virtual participant in the PJM Capacity Market. That option should be eliminated.

The definition of demand side resources in PJM capacity markets is flawed in a variety of ways. The current demand side definition should be replaced with a definition that includes demand on the demand side of the market. There are ways to ensure and enhance the vibrancy of demand side without negatively affecting markets for generation. There are other price formation issues in the capacity market that should also be examined and addressed.⁹⁹

Table 5-16 RPM commitments and replacements for all Capacity Resources: June 1, 2007 to June 1, 2021

	UCAP (MW)					RPM
	RPM Cleared	Adjustments to Cleared	Net Replacements	RPM Commitments	RPM Commitment Shortage	Commitments Less Commitment Shortage
01-Jun-07	129,409.2	0.0	0.0	129,409.2	(8.1)	129,401.1
01-Jun-08	130,629.8	0.0	(766.5)	129,863.3	(246.3)	129,617.0
01-Jun-09	134,030.2	0.0	(2,068.2)	131,962.0	(14.7)	131,947.3
01-Jun-10	134,036.2	0.0	(4,179.0)	129,857.2	(8.8)	129,848.4
01-Jun-11	134,182.6	0.0	(6,717.6)	127,465.0	(79.3)	127,385.7
01-Jun-12	141,295.6	(11.7)	(9,400.6)	131,883.3	(157.2)	131,726.1
01-Jun-13	159,844.5	0.0	(12,235.3)	147,609.2	(65.4)	147,543.8
01-Jun-14	161,214.4	(9.4)	(13,615.9)	147,589.1	(1,208.9)	146,380.2
01-Jun-15	173,845.5	(326.1)	(11,849.4)	161,670.0	(1,822.0)	159,848.0
01-Jun-16	179,773.6	(24.6)	(16,157.5)	163,591.5	(924.4)	162,667.1
01-Jun-17	180,590.5	0.0	(13,982.7)	166,607.8	(625.3)	165,982.5
01-Jun-18	175,996.0	0.0	(12,057.8)	163,938.2	(150.5)	163,787.7
01-Jun-19	177,064.2	0.0	(12,300.3)	164,763.9	(9.3)	164,754.6
01-Jun-20	174,023.8	(335.3)	(10,582.7)	163,105.8	(5.7)	163,100.1
01-Jun-21	174,713.0	0.0	(7,214.5)	167,498.5	0.0	167,498.5

⁹⁹ See Monitoring Analytics, LLC, "Analysis of the 2021/2022 RPM Base Residual Auction - Revised," <http://www.monitoringanalytics.com/reports/Reports/2018/MM_Analysis_of_the_20212022_RPM_BRA_Revised_20180824.pdf> (August 24, 2008).

Market Performance

Figure 5-8 shows cleared MW weighted average capacity market prices on a delivery year basis including base and incremental auctions for each delivery year, and the weighted average clearing prices by LDA in each Base Residual Auction for the entire history of the PJM capacity markets.

Table 5-17 shows RPM clearing prices for all RPM auctions held through the first three months of 2021, and Table 5-18 shows the RPM cleared MW for all RPM auctions held through the first three months of 2021.

Figure 5-9 shows the RPM cleared MW weighted average prices for each LDA from the 2018/2019 Delivery Year to the current delivery year, and all results for auctions for future delivery years that have been held through the first three months of 2021. A summary of these weighted average prices is given in Table 5-19.

Table 5-20 shows RPM revenue by delivery year for all RPM auctions held through the first three months of 2021 based on the unforced MW cleared and the resource clearing prices. In the 2019/2020 Delivery Year RPM revenue was \$7.1 billion. In the 2020/2021 Delivery Year, RPM revenue was \$7.0 billion.

Table 5-21 shows RPM revenue by calendar year for all RPM auctions held through the first three months of 2021. In 2019, RPM revenue was \$8.7 billion. In 2020, RPM revenue was \$7.1 billion.

Table 5-22 shows the RPM annual charges to load. For the 2019/2020 Delivery Year, RPM annual charges to load were \$7.0 billion. For the 2020/2021 Delivery Year, annual charges to load are \$7.0 billion.

Table 5-17 Capacity market clearing prices: 2019/2020 through 2021/2022 RPM Auctions¹⁰⁰

		RPM Clearing Price (\$ per MW-day)												
	Product Type	RTO	MAAC	APS	PPL	EMAAC	SWMAAC	DPL South	PSEG	PSEG North	PEPCO	ATSI	COMED	BGE
2019/2020 BRA	Base Capacity	\$80.00	\$80.00	\$80.00	\$80.00	\$99.77	\$80.00	\$99.77	\$99.77	\$99.77	\$80.00	\$80.00	\$182.77	\$80.30
2019/2020 BRA	Base Capacity DR/EE	\$80.00	\$80.00	\$80.00	\$80.00	\$99.77	\$80.00	\$99.77	\$99.77	\$99.77	\$0.01	\$80.00	\$182.77	\$80.30
2019/2020 BRA	Capacity Performance	\$100.00	\$100.00	\$100.00	\$100.00	\$119.77	\$100.00	\$119.77	\$119.77	\$119.77	\$100.00	\$100.00	\$202.77	\$100.30
2019/2020 First Incremental Auction	Base Capacity	\$15.00	\$15.00	\$15.00	\$15.00	\$22.22	\$15.00	\$22.22	\$22.22	\$22.22	\$15.00	\$15.00	\$15.00	\$15.00
2019/2020 First Incremental Auction	Base Capacity DR/EE	\$15.00	\$15.00	\$15.00	\$15.00	\$22.22	\$15.00	\$22.22	\$22.22	\$22.22	\$15.00	\$15.00	\$15.00	\$15.00
2019/2020 First Incremental Auction	Capacity Performance	\$51.33	\$51.33	\$51.33	\$51.33	\$58.55	\$51.33	\$58.55	\$58.55	\$58.55	\$51.33	\$51.33	\$51.33	\$51.33
2019/2020 Second Incremental Auction	Base Capacity	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$32.14
2019/2020 Second Incremental Auction	Base Capacity DR/EE	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$10.01	\$32.14
2019/2020 Second Incremental Auction	Capacity Performance	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$32.87	\$55.00
2019/2020 Third Incremental Auction	Base Capacity	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35
2019/2020 Third Incremental Auction	Base Capacity DR/EE	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$21.35	\$20.00	\$21.35	\$21.35	\$21.35
2019/2020 Third Incremental Auction	Capacity Performance	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35	\$28.35
2020/2021 BRA	Capacity Performance	\$76.53	\$86.04	\$76.53	\$86.04	\$187.87	\$86.04	\$187.87	\$187.87	\$187.87	\$86.04	\$76.53	\$188.12	\$86.04
2020/2021 First Incremental Auction	Capacity Performance	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90	\$42.90
2020/2021 Second Incremental Auction	Capacity Performance	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25	\$20.25
2020/2021 Third Incremental Auction	Capacity Performance	\$10.00	\$15.25	\$10.00	\$15.25	\$15.25	\$15.25	\$15.25	\$15.25	\$15.25	\$15.25	\$10.00	\$10.00	\$15.25
2021/2022 BRA	Capacity Performance	\$140.00	\$140.00	\$140.00	\$140.00	\$165.73	\$140.00	\$165.73	\$204.29	\$204.29	\$140.00	\$171.33	\$195.55	\$200.30
2021/2022 First Incremental Auction	Capacity Performance	\$23.00	\$23.00	\$23.00	\$23.00	\$25.00	\$23.00	\$25.00	\$45.00	\$219.00	\$23.00	\$23.00	\$23.00	\$60.00
2021/2022 Second Incremental Auction	Capacity Performance	\$10.26	\$10.26	\$10.26	\$10.26	\$15.37	\$10.26	\$15.37	\$125.00	\$125.00	\$10.26	\$10.26	\$10.26	\$70.00
2021/2022 Third Incremental Auction	Capacity Performance	\$20.55	\$20.55	\$20.55	\$20.55	\$26.36	\$20.55	\$26.36	\$31.00	\$31.00	\$20.55	\$20.55	\$20.55	\$39.00

¹⁰⁰ See the 2019 State of the Market Report for PJM, Volume II, Section 5: Capacity Market

Table 5-18 Capacity market cleared MW: 2019/2020 through 2021/2022 RPM Auctions¹⁰¹

Delivery Year	Auction	UCAP (MW)													TOTAL
		RTO	MAAC	APS	PPL	EMAAC	DPL South	PSEG	PSEG North	PEPCO	ATSI	COMED	BGE		
2019/2020	BASE	60,061.8	9,996.2	9,066.6	12,754.9	20,382.4	1,598.5	5,583.1	3,228.9	6,971.7	10,291.1	22,971.4	4,422.9	167,329.5	
2019/2020	FIRST	784.5	249.4	39.3	157.7	78.7	11.7	10.6	28.8	43.6	147.5	711.4	31.9	2,295.1	
2019/2020	SECOND	442.9	160.4	30.1	146.2	210.1	21.2	38.1	44.8	41.9	263.6	105.8	107.5	1,612.6	
2019/2020	THIRD	1,608.0	440.9	429.4	1,216.6	265.7	2.4	180.4	23.2	83.6	454.2	867.4	255.2	5,827.0	
2020/2021	BASE	56,012.4	11,413.2	8,990.6	14,398.2	19,978.5	1,647.2	5,041.2	2,975.4	6,410.0	9,925.9	23,960.3	4,021.1	164,773.9	
2020/2021	FIRST	1,265.6	331.0	144.2	83.4	76.2	38.9	105.8	32.0	97.8	666.9	644.4	38.7	3,524.8	
2020/2021	SECOND	447.2	206.9	53.0	30.7	302.9	28.4	29.5	48.8	35.4	366.2	194.6	160.3	1,903.8	
2020/2021	THIRD	1,106.6	569.7	118.7	89.0	194.1	33.1	423.0	137.0	93.1	554.3	127.7	39.8	3,486.0	
2021/2022	BASE	55,642.6	12,565.1	10,136.1	15,368.6	19,857.3	1,673.8	4,667.2	3,134.1	6,546.1	8,010.5	22,358.1	3,667.8	163,627.3	
2021/2022	FIRST	281.7	200.4	45.9	27.2	119.0	15.3	18.3	79.1	207.9	739.3	360.4	48.7	2,143.2	
2021/2022	SECOND	1,307.8	335.8	30.3	55.4	129.9	39.3	97.0	98.1	75.7	1,216.8	205.9	115.5	3,707.5	
2021/2022	THIRD	1,797.6	168.7	231.6	127.8	911.0	18.3	227.7	244.8	67.2	942.7	221.7	275.9	5,235.0	

Table 5-19 Weighted average clearing prices by zone: 2018/2019 through 2021/2022

LDA	Weighted Average Clearing Price (\$ per MW-day)			
	2018/2019	2019/2020	2020/2021	2021/2022
RTO				
AEP	\$158.20	\$93.63	\$74.42	\$133.80
APS	\$158.20	\$93.63	\$74.42	\$133.80
ATSI	\$148.42	\$92.97	\$69.75	\$142.59
Cleveland	\$158.68	\$89.17	\$68.93	\$90.81
COMED	\$199.02	\$188.90	\$182.15	\$189.54
DAY	\$158.20	\$93.63	\$72.42	\$132.69
DUKE	\$158.20	\$93.63	\$121.24	\$127.66
DUQ	\$158.20	\$93.63	\$74.42	\$133.80
DOM	\$158.20	\$93.63	\$74.42	\$133.80
EKPC	\$158.20	\$93.63	\$74.42	\$133.80
MAAC				
EMAAC				
ACEC	\$214.31	\$112.48	\$182.04	\$158.72
DPL	\$214.31	\$112.48	\$182.04	\$158.72
DPL South	\$211.38	\$115.95	\$178.65	\$159.65
JCPLC	\$214.31	\$112.48	\$182.04	\$158.72
PECO	\$214.31	\$112.48	\$182.04	\$158.72
PSEG	\$210.92	\$110.56	\$165.74	\$184.82
PSEG North	\$211.71	\$116.03	\$176.45	\$190.48
REC	\$214.31	\$112.48	\$182.04	\$158.72
SWMAAC				
BGE	\$141.58	\$88.20	\$80.71	\$174.43
PEPCO	\$144.90	\$90.59	\$84.24	\$133.37
WMAAC				
MEC	\$152.65	\$93.81	\$81.85	\$134.56
PE	\$152.65	\$93.81	\$81.85	\$134.56
PPL	\$147.90	\$88.53	\$85.07	\$138.51

101 The MW values in this table refer to rest of LDA or RTO values, which are net of nested LDA values.

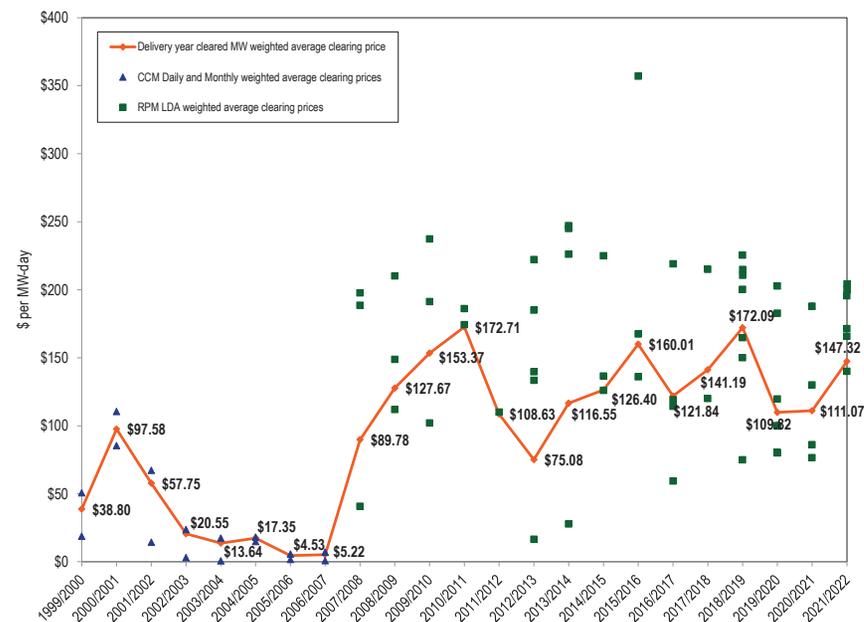
Table 5-20 RPM revenue by delivery year: 2007/2008 through 2021/2022¹⁰²

Delivery Year	Weighted Average RPM Price (\$ per MW-day)	Weighted Average Cleared UCAP (MW)	Days	RPM Revenue
2007/2008	\$89.78	129,409.2	366	\$4,252,287,381
2008/2009	\$127.67	130,629.8	365	\$6,087,147,586
2009/2010	\$153.37	134,030.2	365	\$7,503,218,157
2010/2011	\$172.71	134,036.2	365	\$8,449,652,496
2011/2012	\$108.63	134,182.6	366	\$5,335,087,023
2012/2013	\$75.08	141,283.9	365	\$3,871,714,635
2013/2014	\$116.55	159,844.5	365	\$6,799,778,047
2014/2015	\$126.40	161,205.0	365	\$7,437,267,646
2015/2016	\$160.01	173,519.4	366	\$10,161,726,902
2016/2017	\$121.84	179,749.0	365	\$7,993,888,695
2017/2018	\$141.19	180,590.5	365	\$9,306,676,719
2018/2019	\$172.09	175,996.0	365	\$11,054,943,851
2019/2020	\$109.82	177,064.2	366	\$7,116,815,360
2020/2021	\$111.07	173,688.5	365	\$7,041,524,517
2021/2022	\$147.32	174,713.0	365	\$9,394,577,868

Table 5-21 RPM revenue by calendar year: 2007 through 2022¹⁰³

Year	Weighted Average RPM Price (\$ per MW-day)	Weighted Average Cleared UCAP (MW)	Effective Days	RPM Revenue
2007	\$89.78	75,665.5	214	\$2,486,310,108
2008	\$111.93	130,332.1	366	\$5,334,880,241
2009	\$142.74	132,623.5	365	\$6,917,391,702
2010	\$164.71	134,033.7	365	\$8,058,113,907
2011	\$135.14	133,907.1	365	\$6,615,032,130
2012	\$89.01	138,561.1	366	\$4,485,656,150
2013	\$99.39	152,166.0	365	\$5,588,442,225
2014	\$122.32	160,642.2	365	\$7,173,539,072
2015	\$146.10	168,147.0	365	\$9,018,343,604
2016	\$137.69	177,449.8	366	\$8,906,998,628
2017	\$133.19	180,242.4	365	\$8,763,578,112
2018	\$159.31	177,896.7	365	\$10,331,688,133
2019	\$135.58	176,338.6	365	\$8,734,613,179
2020	\$110.55	175,368.7	366	\$7,084,072,778
2021	\$132.32	174,289.2	365	\$8,421,122,920
2022	\$147.32	72,278.5	151	\$3,886,523,995

Figure 5-8 History of capacity prices: 1999/2000 through 2021/2022¹⁰⁴



¹⁰⁴ The 1999/2000 through 2006/2007 capacity prices are CCM combined market, weighted average prices. The 2007/2008 through 2021/2022 capacity prices are RPM weighted average prices. The CCM data points plotted are cleared MW weighted average prices for the daily and monthly markets by delivery year. The RPM data points plotted are RPM LDA clearing prices. For the 2014/2015 and subsequent delivery years, only the prices for Annual Resources or Capacity Performance Resources are plotted.

¹⁰² The results for the ATSI Integration Auctions are not included in this table.
¹⁰³ The results for the ATSI Integration Auctions are not included in this table.

Figure 5-9 Map of RPM capacity prices: 2018/2019 through 2021/2022

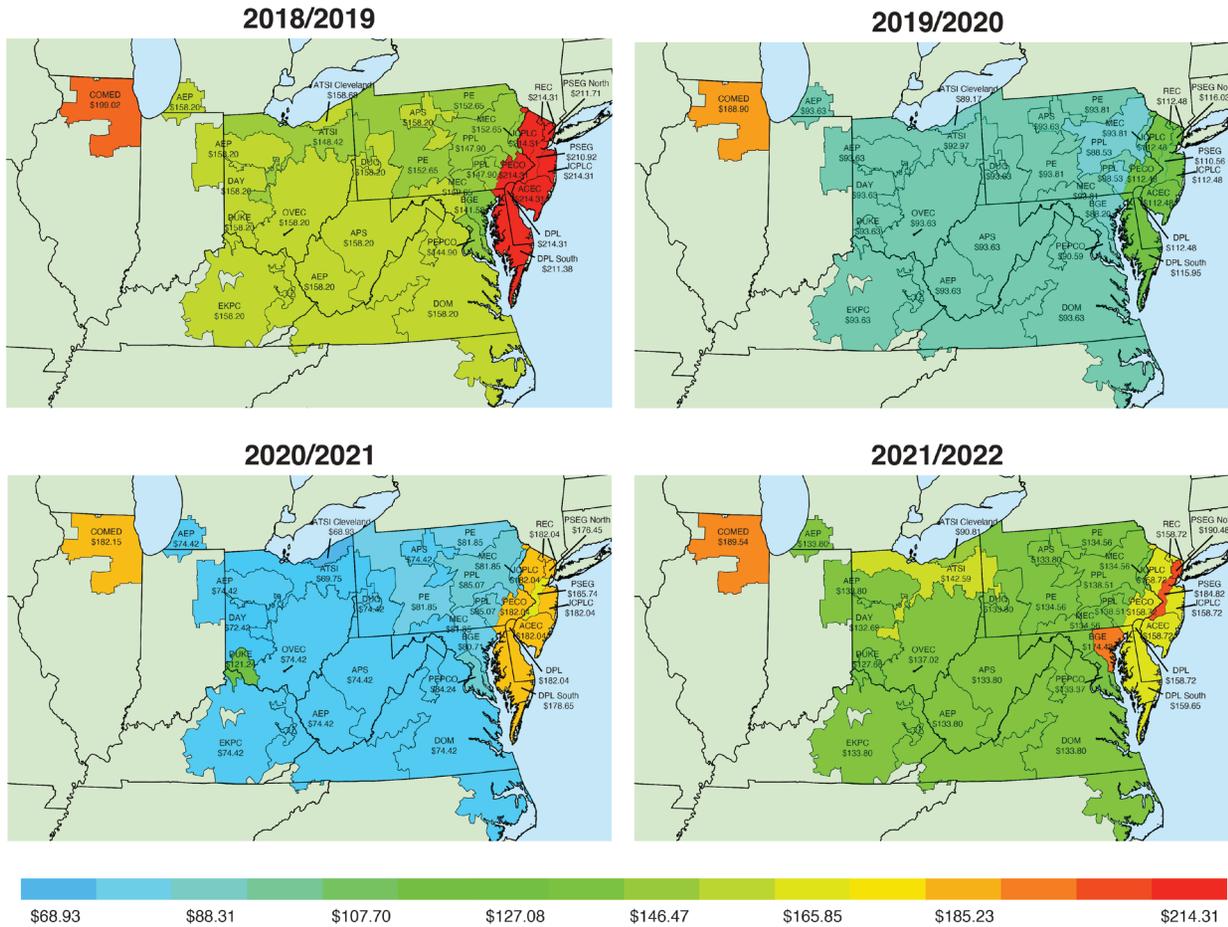


Table 5-22 RPM cost to load: 2019/2020 through 2021/2022 RPM Auctions^{105 106 107}

	Net Load Price (\$ per MW-day)	UCAP Obligation (MW)	Annual Charges
2019/2020			
Rest of RTO	\$98.07	89,185.9	\$3,201,364,940
Rest of EMAAC	\$115.58	24,415.1	\$1,032,810,556
BGE	\$97.79	7,595.2	\$271,828,430
COMED	\$192.56	24,985.1	\$1,760,892,086
PEPCO	\$92.90	7,330.3	\$249,230,694
PSEG	\$115.83	11,281.1	\$478,247,326
Total		164,792.8	\$6,994,374,033
2020/2021			
Rest of RTO	\$77.31	69,073.7	\$1,949,098,489
Rest of MAAC	\$87.06	29,555.9	\$939,246,366
EMAAC	\$174.32	35,740.4	\$2,274,098,760
COMED	\$189.92	23,744.7	\$1,645,988,210
DUKE	\$104.50	5,072.0	\$193,459,838
Total		163,186.7	\$7,001,891,663
2021/2022			
Rest of RTO	\$142.16	82,768.3	\$4,294,838,410
Rest of EMAAC	\$164.73	23,719.9	\$1,426,178,211
ATSI	\$160.21	13,995.4	\$818,411,597
BGE	\$163.50	7,491.2	\$447,049,048
COMED	\$198.43	22,721.2	\$1,645,630,168
PSEG	\$188.46	10,987.4	\$755,803,998
Total		161,683.4	\$9,387,911,433

MOPR and FRR

The states have authority over their generation resources and can choose to remain in PJM capacity markets or to create FRR entities. The existing FRR approach remains an option for utilities with regulated revenues based on cost of service rates, including both privately and publicly owned (including public power entities and electric cooperatives) utilities. Such regulated utilities have had and continue to have the ability to opt out of the capacity market and provide their own capacity. As made clear in recent analyses of FRR options in Illinois, Maryland, New Jersey and Ohio, the FRR approach is likely to lead to

¹⁰⁵ The RPM annual charges are calculated using the rounded, net load prices as posted in the PJM RPM auction results.

¹⁰⁶ There is no separate obligation for DPL South as the DPL South LDA is completely contained within the DPL Zone. There is no separate obligation for PSEG North as the PSEG North LDA is completely contained within the PSEG Zone. There is no separate obligation for ATSI Cleveland as the ATSI Cleveland LDA is completely contained within the ATSI Zone.

¹⁰⁷ The net load prices and obligation MW for 2021/2022 are not finalized.

significant increases in payments by customers when it replaces participation in the PJM markets.¹⁰⁸ The existing FRR rules were created in 2007 primarily for the specific circumstances of AEP as part of the original RPM capacity market design settlement. The MMU recommends that the FRR rules be revised and updated to ensure that the rules reflect current market realities and that FRR entities do not unfairly take advantage of those customers paying for capacity in the PJM capacity market.

Recent FRR proposals in Illinois for the COMED Zone and in New Jersey are primarily nuclear subsidy programs that would increase nuclear subsidies well beyond the ZECs rules currently in place in both states while also providing for payments to some renewable resources at above market prices.¹⁰⁹ The MMU has prepared reports with analysis on the potential impacts of states pursuing the FRR option. In separate reports for Illinois, Maryland, New Jersey and Ohio, the cost impacts of the state choosing the FRR option are computed under different FRR capacity price assumptions and different assumptions regarding the composition of the FRR service area.^{110 111 112 113} Additionally, the impact on the remaining PJM capacity market footprint is computed for each scenario. In all but a few scenarios the MMU finds that the FRR leads to higher costs for load included in the FRR service area. In all scenarios the MMU finds that prices in what remains of the PJM Capacity Market would be significantly lower.

¹⁰⁸ The MMU has posted several reports regarding the creation of FRRs. "Potential Impacts of the Creation of a ComEd FRR," (December 18, 2019). <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Potential_Impacts_of_the_Creation_of_a_ComEd_FRR_20191218.pdf>. "Potential Impacts of the Creation of Maryland FRRs," (April 16, 2020). <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_Maryland_FRRs_20200416.pdf>. "Potential Impacts of the Creation of New Jersey FRRs," (May 13, 2020). <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_New_Jersey_FRRs_20200513.pdf>. "Potential Impacts of the Creation of Ohio FRRs," (July 17, 2020). <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_Ohio_FRRs_20200717.pdf>.

¹⁰⁹ *In the Matter of the Investigation of Resource Adequacy Alternatives*, New Jersey Board of Public Utilities, Docket No. E020030203. Monitoring Analytics, LLC Comments. <http://www.monitoringanalytics.com/filings/2020/IMM_Comments_Docket_No_E020030203_20200520.pdf> (May 20, 2020). Monitoring Analytics, LLC, Reply Comments <http://www.monitoringanalytics.com/filings/2020/IMM_Reply_Comments_Docket_No_E020030203_20200624.pdf>. (June 24, 2020). Monitoring Analytics, Answer to Exelon and PSEG. <http://www.monitoringanalytics.com/filings/2020/IMM_Answer_to_Exelon_PSEG_Docket_No_E020030203_20200715.pdf> (July 15, 2020).

¹¹⁰ See Monitoring Analytics, LLC, "Potential Impacts of the Creation of a ComEd FRR," <http://www.monitoringanalytics.com/reports/Reports/2019/IMM_Potential_Impacts_of_the_Creation_of_a_ComEd_FRR_20191218.pdf> (December 18, 2020).

¹¹¹ See Monitoring Analytics, LLC, "Potential Impacts of the Creation of Maryland FRRs," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_Maryland_FRRs_20200416.pdf> (April 16, 2020).

¹¹² See Monitoring Analytics, LLC, "Potential Impacts of the Creation of New Jersey FRRs," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_New_Jersey_FRRs_20200513.pdf> (May 13, 2020).

¹¹³ See Monitoring Analytics, LLC, "Potential Impacts of the Creation of Ohio FRRs," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_Potential_Impacts_of_the_Creation_of_Ohio_FRRs_20200717.pdf> (July 17, 2020).

The MMU recognizes that both FERC and the states have significant and overlapping authority affecting wholesale power markets. While the FERC MOPR approach was designed to ensure that subsidies did not affect the wholesale power markets, the states have ultimate authority over the generation choices made in the states. The FRR explorations by multiple states illustrated a possible path forward. Under that path, the FERC market would be unaffected by subsidies but many states would withdraw from the FERC regulated markets and create higher cost nonmarket solutions rather than be limited by MOPR. That would not be an efficient outcome and would not serve the interests of customers or generators.

With the expected elimination of the current MOPR rules, the capacity market design must accommodate the choices made by states to subsidize renewable or clean resources in a way that maximizes the role of competition to ensure that customers pay the lowest amount possible, consistent with state goals and the costs of providing the desired resources. Such an approach can take several forms, but none require the dismantling of the PJM capacity market design. The PJM capacity market design can adapt to a wide range of state supported resources and state programs. As a simple starting point, states can continue to support selected resources using a range of payment structures and those resources could participate in the capacity auctions. As a broader and more comprehensive option, PJM could create a demand curve for clean resources based on the quantity of such resources identified by one or more states and clear a market for clean resources as part of the capacity market clearing process.

Given that states have increasingly aggressive renewable energy targets, a core goal of a competitive market design should be to ensure that the resources required to provide reliability receive appropriate competitive market incentives for entry and for ongoing investment and for exit when uneconomic. A significant level of renewable resources, operating with zero or near zero marginal costs, will result in very low energy prices. Since renewable resources are intermittent, the contribution of renewables to meeting reliability targets must be analyzed carefully to ensure that the capacity value is calculated correctly.

PJM has proposed a flawed Effective Load Carrying Capability (ELCC) approach to defining the capacity contribution of intermittent resources.¹¹⁴ Implementing PJM's flawed ELCC approach, based on static average rather than dynamic, market defined marginal values, and locking in values for old technology for long periods regardless of market realities, and basing the results on incorrect assumptions about the dispatch of some resource types, would be a significant mistake and create new issues for the PJM capacity markets. The results could degrade reliability, impede innovation and the introduction of new technologies, and inefficiently displace thermal resources. It is essential to not build in a bad market design from the beginning as such designs gain momentum and gain entrenched supporters among the beneficiaries. If done correctly, ELCC would be an advance over the current approach to discounting the reliability contribution of intermittent resources, but only if done correctly and only if all the required assumptions are made explicit and decided explicitly.¹¹⁵

In order to attract and retain adequate resources for the reliable operation of the energy market, revenues from PJM energy, ancillary services and capacity markets must be adequate for those resources. That adequacy requires a capacity market. The capacity market plays the essential role of equilibrating the revenues necessary to incent competitive entry and exit of the resources needed for reliability, with the revenues from the energy market that are directly affected by nonmarket sources.

Price suppression below the competitive level in the capacity market should not be acceptable and is not consistent with a competitive market design. Harmonizing means that the integrity of each paradigm is maintained and respected. Harmonizing permits nonmarket resources to have an unlimited impact on energy markets and energy prices. Harmonizing means designing a capacity market to account for these energy market impacts, clearly limiting the impact of nonmarket revenues on the capacity market and ensuring **competitive outcomes in the capacity market and thus in the entire market.**

¹¹⁴ *PJM Interconnection L.L.C.*, Docket No. ER21-278 *Effective Load Carrying Capability Construct* (October 30, 2020).

¹¹⁵ Comments and Motions of the Independent Market Monitor for PJM, Docket No. ER21-278 and EL19-100 (November 20, 2020). Answer and Motion for Leave to Answer and Alternative Motion for Consolidation of the Independent Market Monitor for PJM, Docket No. ER21-278 (December 10, 2020). Answer and Motion for Leave to Answer of the Independent Market Monitor for PJM, Docket No. ER21-278 (December 18, 2020). Comments and Motions of the Independent Market Monitor for PJM, ER21-278-001 (March 22, 2021). Answer and Motion for Leave to Answer of the Independent Market Monitor for PJM, Docket No. ER21-278 (April 28, 2021).

To the extent that there are shared broader goals related to PJM markets, they should also be addressed, but this can happen with a slightly longer lead time. If a shared goal is to reduce carbon output, a price on carbon is the market based solution. If a shared goal is increased renewables in addition to their carbon attributes, a common approach to RECs would be a market based solution. Fuel diversity has also been mentioned as an issue. Current fuel diversity is higher than ever in PJM. If there is an issue, the real issue is fuel security and not fuel diversity. Significant reliance on specific fuels, including nuclear, coal and gas means that markets are at risk from a significant disruption in any one fuel. If fuel security for gas is a concern, a number of issues should be considered including the reliability of the pipelines, the compatibility of the gas pipeline and the merchant generator business models, the degree to which electric generators have truly firm gas service and the need for a gas RTO/ISO to help ensure reliability. PJM should require firm fuel as a condition of being a capacity resource.

CRF Issue¹¹⁶

As a result of the significant changes to the federal tax code in December 2017, the capital recovery factor (CRF) tables in PJM OATT Attachment DD § 6.8(a) and Schedule 6A are not correct. These tables should have been updated in 2018 and should be updated prior to the next capacity market auction. Correct CRFs will ensure that offer caps and offer floors in the capacity market are correct. The required changes are clear and unambiguous. An immediate filing to change the table based only on the known changes to the tax code would avoid potential uncertainty and confusion among market participants and would avoid any potential delay in running or finalizing the results of the capacity auctions. PJM could file the changes under FPA Section 205. The MMU issued a public statement on these issues.¹¹⁷

The current CRF table includes tax rates and depreciation provisions in the tax code that are no longer correct. The result is that the current tariff CRF values are significantly too high. A combination of modified depreciation rules and

a reduction of the corporate tax rate has reduced the calculated CRF values required to provide the same return on and of capital as provided by the prior CRF values when the prior tax provisions were in effect. A reduced amount of revenue is required in order to provide full recovery on and of the relevant capital investment. Table 5-23 includes the new CRF values based solely on changes to the federal tax code.

Table 5-23 Levelized CRF requests: 2022 through 2027

Age of Existing Units (Years)	Remaining Life of Plant (Years)	Levelized CRF					
		2022	2023	2024	2025	2026	2027
1 to 5	30	0.089	0.091	0.094	0.096	0.099	0.101
6 to 10	25	0.093	0.096	0.098	0.101	0.104	0.106
11 to 15	20	0.101	0.104	0.107	0.110	0.113	0.115
16 to 20	15	0.116	0.119	0.122	0.126	0.129	0.132
21 to 25	10	0.147	0.152	0.158	0.164	0.169	0.175
25 Plus	5	0.246	0.258	0.271	0.283	0.296	0.308
Mandatory CapEx	4	0.296	0.312	0.328	0.345	0.361	0.377
40 Plus Alternative	1	1.100	1.100	1.100	1.100	1.100	1.100

Timing of Unit Retirements

Generation owners that want to deactivate a unit, either to mothball or permanently retire, must provide notice to PJM and the MMU at least 90 days prior to the proposed deactivation date. Generation owners seeking a capacity market must offer exemption for a delivery year must submit their deactivation request no later than the December 1 preceding the Base Residual Auction or 120 days before the start of an Incremental Auction for that delivery year.¹¹⁸ If no reliability issues are found during PJM's analysis of the retirement's impact on the transmission system, and the MMU finds no market power issues associated with the proposed deactivation, the unit may deactivate at any time thereafter.¹¹⁹

Table 5-24 shows the timing of actual deactivation dates and the initially requested deactivation date, for all deactivation requests submitted from January 2018 through March 2021. Of the 78 deactivation requests submitted, 17 units (21.8 percent) deactivated an average of 232 days earlier than their

¹¹⁶ See related filing on CRF issue in black start: Comments of the Independent Market Monitor for PJM, Docket No. ER21-1635 (April 28, 2021).

¹¹⁷ See "CRF issues in the capacity market," December 4, 2020 <http://www.monitoringanalytics.com/reports/Market_Messages/IMM_CRF_Issues_in_the_Capacity_Market_20201204.pdf>.

¹¹⁸ OATT Attachment DD § 6.6(g).

¹¹⁹ OATT Part V §113

initially requested date; 12 units (15.4 percent) deactivated an average of 95 days later than the originally requested deactivation date; and 27 units (34.6 percent) deactivated on their initially requested date. Twelve (15.4 percent) of the unit deactivations were cancelled an average of 435 days before their scheduled deactivation date, and 10 (12.8 percent) of the unit deactivations have not yet reached their target retirement date.

Table 5-24 Timing of actual unit deactivations compared to requested deactivation date: Requests submitted January 2018 through March 2021

	Number of		Average Days Deviation from Originally Requested Date
	Units	Percent	
Early	17	21.8%	(232)
Late	12	15.4%	95
On time	27	34.6%	0
Cancelled	12	15.4%	(435)
Pending	10	12.8%	-
Total	78	100.0%	-

Reliability Must Run (RMR) Service

PJM must make out of market payments to units for Reliability Must Run (RMR) service during periods when a unit that would otherwise have been deactivated is needed for reliability.¹²⁰ The need for RMR service reflects a flawed market design and/or planning process problems. If a unit is needed for reliability, the market should reflect a locational value consistent with that need which would result in the unit remaining in service or being replaced by a competitor unit. The planning process should evaluate the impact of the loss of units at risk and determine in advance whether transmission upgrades are required.¹²¹

When notified of an intended deactivation, the MMU performs a market power study to ensure that the deactivation is economic, not an exercise of

¹²⁰ OATT Part V §114

¹²¹ See, e.g., 140 FERC ¶ 61,237 at P 36 (2012) (“The evaluation of alternatives to an SSR designation is an important step that deserves the full consideration of MISO and its stakeholders to ensure that SSR Agreements are used only as a ‘limited, last-resort measure.’”); 118 FERC ¶ 61,243 at P 41 (2007) (“the market participants that pay for the agreements pay out-of-market prices for the service provided under the RMR agreements, which broadly hinders market development and performance.[footnote omitted] As a result of these factors, we have concluded that RMR agreements should be used as a last resort.”); 110 FERC ¶ 61,315 at P 40 (2005) (“The Commission has stated on several occasions that it shares the concerns . . . that RMR agreements not proliferate as an alternative pricing option for generators, and that they are used strictly as a last resort so that units needed for reliability receive reasonable compensation.”).

market power through withholding, and consistent with competition.¹²² PJM performs a system study to determine whether the system can accommodate the deactivation on the desired date, and if not, when it could.¹²³ If PJM determines that it needs a unit for a period beyond the intended deactivation date, PJM will request a unit to provide RMR service.¹²⁴ The PJM market rules do not require an owner to provide RMR service, but owners must provide 90 days advance notice of a proposed deactivation.¹²⁵ The owner of a generation capacity resource must provide notice of a proposed deactivation in order to avoid a requirement to offer in RPM auctions.¹²⁶ In order to avoid submitting an offer for a unit in the next three-year forward RPM base residual auction, an owner must show “a documented plan in place to retire the resource,” including a notice of deactivation filed with PJM, 120 days prior to such auction.¹²⁷

Under the current rules, a unit providing RMR service can recover its costs under either the deactivation avoidable cost rate (DACR), which is a formula rate, or the cost of service recovery rate. The deactivation avoidable cost rate is designed to permit the recovery of the costs of the unit’s “continued operation,” termed “avoidable costs,” plus an incentive adder.¹²⁸ Avoidable costs are defined to mean “incremental expenses directly required for the operation of a generating unit.”¹²⁹ The incentives escalate for each year of service (first year, 10 percent; second year, 20 percent; third year, 35 percent; fourth year, 50 percent).¹³⁰ The rules provide terms for early termination of RMR service and for the repayment of project investment by owners of units that choose to keep units in service after the RMR period ends.¹³¹ Project investment is capped at \$2 million, above which FERC approval is required.¹³² The cost of service rate is designed to permit the recovery of the unit’s “cost of

¹²² OATT § 113.2; OATT Attachment M § IV.1.

¹²³ OATT § 113.2.

¹²⁴ *Id.*

¹²⁵ OATT § 113.1.

¹²⁶ OATT Attachment DD § 6.6(g).

¹²⁷ *Id.*

¹²⁸ OATT § 114 (Deactivation Avoidable Credit = ((Deactivation Avoidable Cost Rate + Applicable Adder) * MW capability of the unit * Number of days in the month) – Actual Net Revenues).

¹²⁹ OATT § 115.

¹³⁰ *Id.*

¹³¹ OATT § 118.

¹³² OATT §§ 115, 117.

service rate to recover the entire cost of operating the generating unit” if the generation owner files a separate rate schedule at FERC.¹³³

Table 5-25 shows units that have provided RMR service to PJM.

Table 5-25 RMR service summary

Unit Names	Owner	ICAP		Docket Numbers	Start of Term	End of Term
		(MW)	Cost Recovery Method			
B.L. England 2	RC Cape May Holdings, LLC	150.0	Cost of Service Recovery Rate	ER17-1083	01-May-17	30-Apr-19
Yorktown 1	Dominion Virginia Power	159.0	Deactivation Avoidable Cost Rate	ER17-750	06-Jan-17	08-Mar-19
Yorktown 2	Dominion Virginia Power	164.0	Deactivation Avoidable Cost Rate	ER17-750	06-Jan-17	08-Mar-19
B.L. England 3	RC Cape May Holdings, LLC	148.0	Cost of Service Recovery Rate	ER17-1083	01-May-17	24-Jan-18
Ashtabula	FirstEnergy Service Company	210.0	Deactivation Avoidable Cost Rate	ER12-2710	01-Sep-12	11-Apr-15
Eastlake 1	FirstEnergy Service Company	109.0	Deactivation Avoidable Cost Rate	ER12-2710	01-Sep-12	15-Sep-14
Eastlake 2	FirstEnergy Service Company	109.0	Deactivation Avoidable Cost Rate	ER12-2710	01-Sep-12	15-Sep-14
Eastlake 3	FirstEnergy Service Company	109.0	Deactivation Avoidable Cost Rate	ER12-2710	01-Sep-12	15-Sep-14
Lakeshore	FirstEnergy Service Company	190.0	Deactivation Avoidable Cost Rate	ER12-2710	01-Sep-12	15-Sep-14
Elrama 4	GenOn Power Midwest, LP	171.0	Cost of Service Recovery Rate	ER12-1901	01-Jun-12	01-Oct-12
Niles 1	GenOn Power Midwest, LP	109.0	Cost of Service Recovery Rate	ER12-1901	01-Jun-12	01-Oct-12
Cromby 2 and Diesel	Exelon Generation Company, LLC	203.7	Cost of Service Recovery Rate	ER10-1418	01-Jun-11	01-Jan-12
Eddystone 2	Exelon Generation Company, LLC	309.0	Cost of Service Recovery Rate	ER10-1418	01-Jun-11	01-Jun-12
Brunot Island CT2A, CT2B, CT3 and CC4	Orion Power MidWest, LP.	244.0	Cost of Service Recovery Rate	ER06-993	16-May-06	05-Jul-07
Hudson 1	PSEG Energy Resources Et Trade LLC and PSEG Fossil LLC	355.0	Cost of Service Recovery Rate	ER05-644, ER11-2688	25-Feb-05	08-Dec-11
Sewaren 1-4	PSEG Energy Resources Et Trade LLC and PSEG Fossil LLC	453.0	Cost of Service Recovery Rate	ER05-644	25-Feb-05	01-Sep-08

Only two of seven owners have used the deactivation avoidable cost rate approach. The other five owners used the cost of service recovery rate, despite the greater administrative expense.

In each of the cost of service recovery rate filings for RMR service, the scope of recovery permitted under the cost of service approach defined in Section 119 has been a significant issue. Owners have sought to recover fixed costs, incurred prior to the noticed deactivation date, in addition to the cost of operating the generating unit. Owners have cited the cost of service reference to mean that the unit is entitled to file to recover costs that it was unable to recover in the competitive markets, in addition to recovery of costs of actually providing the RMR service.

The cost of service recovery rate approach has been interpreted by the companies using that approach to allow the company to establish a rate base including investment in the existing plant and new investment necessary to provide RMR service and to earn a return on that rate base and receive depreciation of that rate base. Companies developing the cost of service recovery rate have ignored the tariff's limitation to the costs of operating the unit during the RMR service period and have included costs incurred prior to the decision to deactivate and costs associated with closing the unit that would have been incurred regardless of the RMR service period.¹³⁴ In one cost of service recovery rate, the filing included costs that already had been written off on the company's public books.¹³⁵ Unit owners have filed for revenues under the cost of service method that substantially exceed the actual incremental costs of providing RMR service.

¹³³ OATT § 119.

¹³⁴ See, e.g., FERC Dockets Nos. ER10-1418-000, ER12-1901-000 and ER17-1083-000.

¹³⁵ See GenOn Filing, Docket No. ER12-1901-000 (May 31, 2012) at Exh. No. GPM-1 at 9:16-21.

Because an RMR unit is needed by PJM for reliability reasons, and the provision of RMR service is voluntary in PJM, owners of RMR service have significant market power in establishing the terms of RMR service.

RMR service should be provided to PJM customers at reasonable rates, which reflect the riskless nature of providing such service to owners, the reliability need for such service and the opportunity for owners to be guaranteed recovery of 100 percent of the actual incremental costs incurred to provide the service plus an incentive markup.

The cost of service recovery rates have been excessive compared to the actual incremental costs of providing RMR service. The DACR method also provides excessive incentives for service longer than a year, given that customers bear the risks.

The MMU recommends elimination of the cost of service recovery rate in OATT Section 119, and that RMR service should be provided under the deactivation avoidable cost rate in Part V.

The MMU also recommends, based in part on its experience with application of the deactivation avoidable cost rate and proceedings filed under Section 119, the following improvements to the DACR provisions:

- Revise the applicable adders in Section 114 to be 15 percent for the second year of RMR service and 20 percent for the provision of RMR service in excess of two years.
- Add true up provisions that ensure that the RMR service provider is reimbursed for, and consumers pay for, the actual incremental costs associated with the RMR service, plus the applicable adder.
- Eliminate the \$2 million cap on project investment expenditures.
- Clearly distinguish operating expenses and project investment costs.
- Clarify the tariff language in Section 118 regarding the refund of project investment in the event the RMR unit continues operation beyond the RMR term.

Generator Performance

Generator performance results from the interaction between the physical characteristics of the units and the level of expenditures made to maintain the capability of the units, which in turn is a function of incentives from energy, ancillary services and capacity markets. Generator performance indices include those based on total hours in a period (generator performance factors) and those based on hours when units are needed to operate by the system operator (generator forced outage rates).

Capacity Factor

Capacity factor measures the actual output of a power plant over a period of time compared to the potential output of the unit had it been running at full nameplate capacity for every hour during that period. Table 5-26 shows the capacity factors by unit type for January through March, 2020 through 2021. In the first three months of 2021, nuclear units had a capacity factor of 93.5 percent, compared to 93.4 percent in the first three months of 2020; combined cycle units had a capacity factor of 50.7 percent in the first three months of 2021, compared to a capacity factor of 56.0 percent in the first three months of 2020; all steam units had a capacity factor of 31.3 percent in the first three months of 2021, compared to 21.3 percent in the first three months of 2020; coal units had a capacity factor of 35.1 percent in the first three months of 2021, compared to 23.7 percent in the first three months of 2020.

Table 5-26 Capacity factor (By unit type (GWh)): January through March, 2020 and 2021^{136 137}

Unit Type	2020 (Jan-Mar)		2021 (Jan-Mar)		Change in 2021 from 2020
	Generation (GWh)	Capacity Factor	Generation (GWh)	Capacity Factor	
Battery	8.0	1.0%	9.2	1.2%	0.2%
Combined Cycle	77,192.5	56.0%	70,022.8	50.7%	(5.4%)
Single Fuel	66,268.7	58.0%	63,155.2	55.3%	(2.7%)
Dual Fuel	10,923.8	46.5%	6,867.5	28.5%	(17.9%)
Combustion Turbine	1,922.6	2.6%	1,932.1	2.6%	0.0%
Single Fuel	1,536.5	2.9%	1,446.5	2.7%	(0.1%)
Dual Fuel	386.1	1.8%	485.6	2.3%	0.5%
Diesel	39.5	3.5%	58.9	5.3%	1.8%
Single Fuel	39.4	4.2%	56.5	6.1%	1.9%
Dual Fuel	0.1	0.0%	2.4	1.3%	1.2%
Diesel (Landfill gas)	451.8	48.3%	380.1	43.1%	(5.2%)
Fuel Cell	57.3	82.2%	54.5	78.9%	(3.2%)
Nuclear	69,142.2	93.4%	68,475.8	93.5%	0.1%
Pumped Storage Hydro	1,169.7	8.1%	1,253.1	8.7%	0.7%
Run of River Hydro	3,352.8	38.5%	3,211.1	37.3%	(1.2%)
Solar	678.9	15.1%	1,128.6	13.4%	(1.7%)
Steam	39,117.1	21.3%	54,654.0	31.3%	10.0%
Biomass	1,457.6	55.2%	1,365.8	54.2%	(1.0%)
Coal	37,071.1	23.7%	52,432.7	35.1%	11.4%
Single Fuel	36,665.4	24.6%	50,740.3	35.4%	10.8%
Dual Fuel	405.7	5.5%	1,692.4	27.4%	21.9%
Natural Gas	570.8	35.7%	855.3	32.7%	(3.0%)
Single Fuel	100.3	42.1%	109.8	40.3%	(1.8%)
Dual Fuel	470.5	18.9%	745.5	13.0%	(5.9%)
Oil	17.6	0.2%	0.3	0.0%	(0.1%)
Wind	7,892.4	34.4%	8,480.7	34.2%	(0.2%)
Total	201,026.0	38.4%	209,662.7	40.4%	2.0%

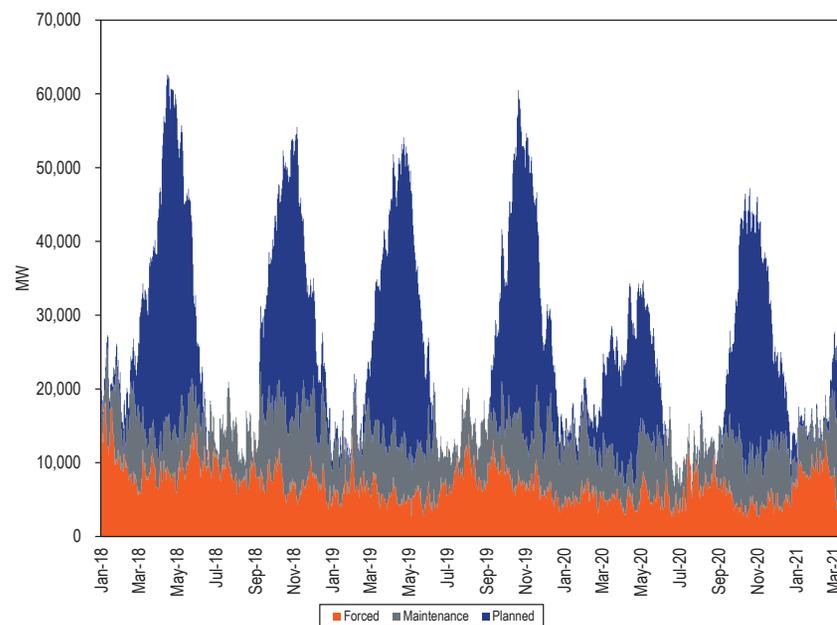
Generator Performance Factors

Generator outages fall into three categories: planned, maintenance, and forced. The MW on outage vary throughout the year. For example, the MW on planned outage are generally highest in the spring and fall, as shown in Figure 5-10, due to restrictions on planned outages during the winter and summer. The effect of the seasonal variation in outages can be seen in the monthly generator performance metrics in Figure 5-14.

¹³⁶ The capacity factors in this table are based on nameplate capacity values, and are calculated based on when the units come on line.

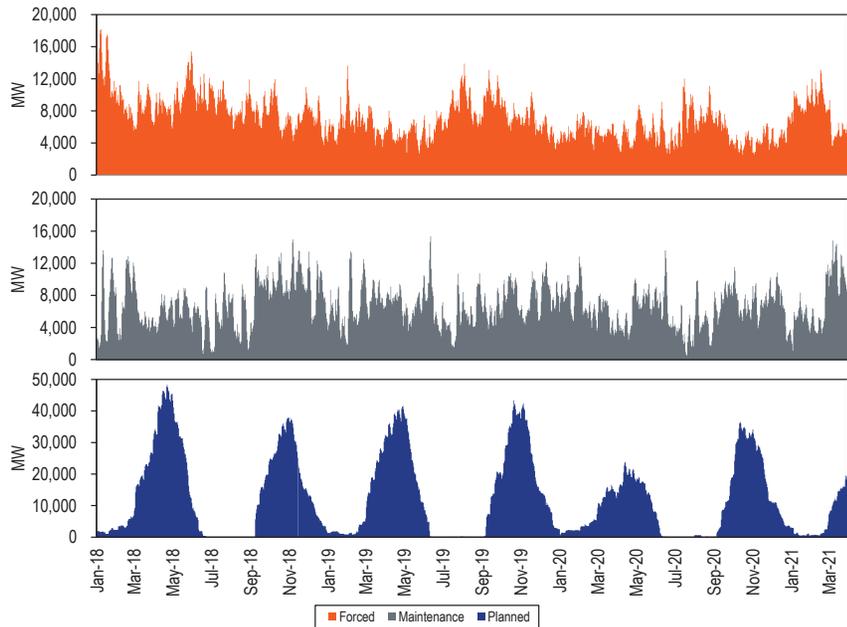
¹³⁷ The subcategories of steam units are consolidated consistent with confidentiality rules. Coal is comprised of coal and waste coal. Natural gas is comprised of natural gas and propane. Oil is comprised of both heavy and light oil. Biomass is comprised of biomass, landfill gas, and municipal solid waste.

Figure 5-10 Outages (MW): 2012 through March 2021



In 2020, forced and planned outages were lower than in 2018 and 2019 (Figure 5-11). The MWh of planned outages in 2020 were 26 percent lower than in 2019 and the MWh of forced outages were 20 percent lower than in 2019. The MWh of maintenance outages were 7 percent lower than in 2019. In 2021, planned outages were 18 percent lower, maintenance outages were 5 percent higher, and forced outages were 45 percent higher in the first three months of 2021 than in the first three months of 2020.

Figure 5-11 Outages (MW): Forced, maintenance and planned outages 2018 through March 2021



Performance factors include the equivalent availability factor (EAF), the equivalent maintenance outage factor (EMOF), the equivalent planned outage factor (EPOF) and the equivalent forced outage factor (EFOF). These four factors add to 100 percent for any generating unit. The EAF is the proportion of hours in a year when a unit is available to generate at full capacity while the three outage factors include all the hours when a unit is unavailable. The EMOF is the proportion of hours in a year when a unit is unavailable because of maintenance outages and maintenance deratings. The EPOF is the proportion of hours in a year when a unit is unavailable because of planned outages and planned deratings. The EFOF is the proportion of hours in a year when a unit is unavailable because of forced outages and forced deratings.

The PJM aggregate EAF, EFOF, EPOF, and EMOF are shown in Figure 5-12. Metrics by unit type are shown in Table 5-27.

Figure 5-12 Equivalent outage and availability factors: January through March, 2007 to 2021

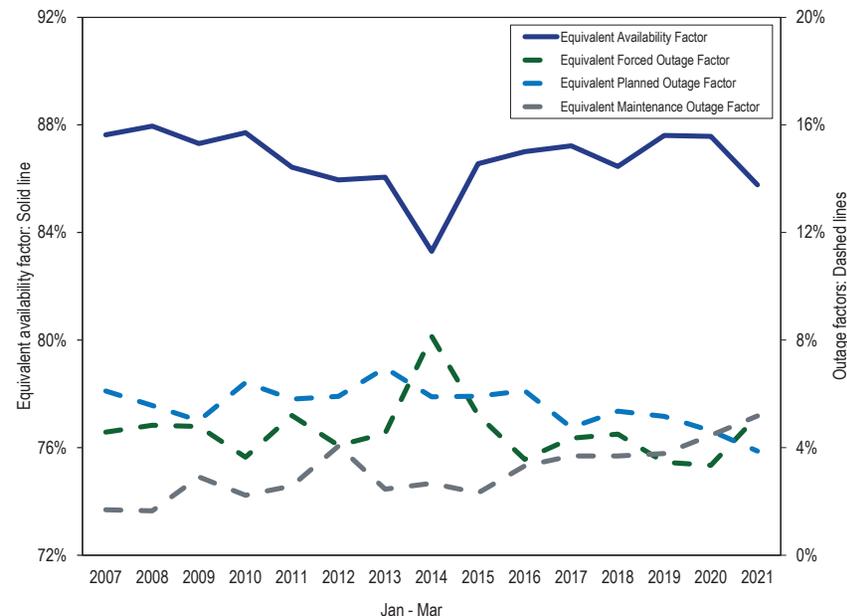


Table 5-27 EFOF, EPOF, EMOF and EAF by unit type: January through March, 2007 through 2021

Jan- Mar	Coal				Combined Cycle				Combustion Turbine				Diesel				Hydroelectric				Nuclear				Other			
	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF	EFOF	EPOF	EMOF	EAF
2007	6.7%	8.3%	2.0%	83.0%	1.5%	6.4%	1.1%	91.0%	5.8%	2.3%	2.5%	89.4%	8.0%	0.3%	1.6%	90.2%	1.2%	7.8%	2.0%	89.0%	0.4%	5.0%	0.3%	94.2%	7.8%	4.4%	2.6%	85.2%
2008	8.2%	5.3%	2.1%	84.3%	1.8%	2.5%	1.4%	94.3%	3.5%	4.1%	1.3%	91.1%	10.1%	0.2%	0.9%	88.8%	1.3%	9.2%	0.6%	88.8%	1.5%	7.3%	0.6%	90.5%	3.9%	7.1%	3.0%	86.1%
2009	6.7%	5.7%	3.4%	84.2%	3.6%	5.3%	3.3%	87.9%	1.9%	2.8%	1.9%	93.4%	6.6%	0.2%	1.7%	91.5%	1.6%	10.5%	1.3%	86.6%	4.0%	3.4%	1.1%	91.5%	5.1%	6.0%	6.7%	82.2%
2010	6.3%	7.5%	3.6%	82.5%	1.3%	5.7%	2.3%	90.7%	2.5%	1.7%	1.3%	94.5%	4.1%	0.7%	0.7%	94.5%	0.7%	9.8%	1.3%	88.2%	0.7%	7.1%	0.4%	91.8%	3.8%	7.1%	1.7%	87.4%
2011	9.5%	7.4%	4.1%	79.1%	3.1%	7.6%	1.9%	87.4%	1.7%	2.6%	1.6%	94.1%	2.5%	0.0%	3.6%	93.9%	1.8%	10.0%	0.8%	87.4%	1.6%	3.3%	0.7%	94.3%	4.0%	5.2%	3.0%	87.8%
2012	7.4%	7.7%	7.7%	77.3%	1.8%	5.6%	1.9%	90.8%	1.6%	2.2%	1.4%	94.8%	1.9%	0.0%	0.8%	97.3%	1.7%	4.0%	1.5%	92.8%	0.8%	6.0%	0.6%	92.7%	4.4%	5.4%	3.7%	86.4%
2013	6.4%	9.8%	4.0%	79.8%	2.2%	9.9%	3.2%	84.7%	5.6%	2.9%	0.8%	90.8%	3.7%	0.1%	1.1%	95.1%	0.5%	3.7%	2.4%	93.4%	0.2%	3.4%	0.2%	96.2%	8.9%	6.4%	2.5%	82.1%
2014	10.4%	5.2%	4.0%	80.4%	4.1%	10.2%	1.6%	84.1%	15.1%	3.4%	1.2%	80.3%	14.9%	0.0%	2.3%	82.7%	1.1%	9.5%	5.9%	83.5%	0.9%	4.6%	0.3%	94.2%	10.9%	8.0%	4.8%	76.3%
2015	8.1%	5.3%	3.7%	82.8%	2.6%	6.8%	1.6%	89.0%	3.7%	4.1%	1.1%	91.1%	10.0%	0.3%	1.9%	87.8%	2.1%	10.0%	1.4%	86.5%	1.6%	4.6%	0.6%	93.2%	9.2%	10.8%	3.9%	76.1%
2016	6.7%	6.8%	6.5%	80.0%	2.1%	4.2%	1.5%	92.2%	2.3%	2.6%	1.6%	93.5%	5.8%	0.0%	2.9%	91.2%	2.3%	5.3%	3.9%	88.5%	0.5%	5.0%	0.5%	94.0%	4.3%	15.4%	3.7%	76.6%
2017	10.3%	6.0%	7.4%	76.3%	2.2%	4.3%	1.5%	91.9%	1.0%	2.5%	1.8%	94.7%	4.5%	0.2%	1.4%	93.9%	2.7%	5.6%	3.5%	88.2%	0.4%	4.8%	0.5%	94.3%	2.5%	4.6%	4.8%	88.1%
2018	9.9%	7.0%	7.6%	75.4%	1.7%	4.0%	1.1%	93.1%	1.9%	3.1%	1.6%	93.5%	6.2%	0.7%	2.8%	90.4%	3.5%	4.3%	2.1%	90.1%	0.3%	4.9%	0.3%	94.5%	4.5%	7.6%	6.4%	81.6%
2019	8.1%	4.0%	7.1%	80.9%	1.3%	6.1%	1.5%	91.0%	1.6%	4.5%	2.3%	91.6%	6.1%	1.1%	2.9%	90.0%	1.0%	5.5%	3.4%	90.1%	0.3%	5.4%	0.7%	93.7%	3.2%	8.2%	6.8%	81.7%
2020	4.1%	3.7%	10.8%	81.4%	5.2%	5.8%	1.4%	87.6%	4.9%	4.0%	1.4%	89.7%	7.7%	0.3%	2.7%	89.3%	4.3%	3.7%	1.9%	90.2%	2.3%	4.2%	0.8%	92.6%	2.6%	8.1%	4.3%	85.0%
2021	9.1%	4.9%	10.6%	75.4%	2.4%	2.8%	3.8%	91.0%	1.4%	3.8%	3.3%	91.4%	5.7%	0.0%	3.2%	91.1%	16.2%	0.6%	2.3%	80.9%	0.2%	3.8%	1.6%	94.5%	12.8%	4.7%	3.1%	79.4%

Generator Forced Outage Rates

The most fundamental forced outage rate metric is the equivalent demand forced outage rate (EFORD). EFORD is a measure of the probability that a generating unit will fail, either partially or totally, to perform when it is needed to operate. EFORD measures the forced outage rate during periods of demand, and does not include planned or maintenance outages. A period of demand is a period during which a generator is running or needed to run. EFORD calculations use historical performance data, including equivalent forced outage hours, service hours, average forced outage duration, average run time, average time between unit starts, available hours and period hours.¹³⁸ The EFORD metric includes all forced outages, regardless of the reason for those outages.

¹³⁸ Equivalent forced outage hours are the sum of all forced outage hours in which a generating unit is fully inoperable and all partial forced outage hours in which a generating unit is partially inoperable prorated to represent full hours.

The average PJM EFORD in the first three months of 2021 was 8.1 percent, an increase from 4.5 percent in the first three months of 2020. Figure 5-13 shows the average EFORD since 1999 for all units in PJM.¹³⁹

Figure 5-13 Trends in the equivalent demand forced outage rate (EFORD): January through March, 1999 through 2021

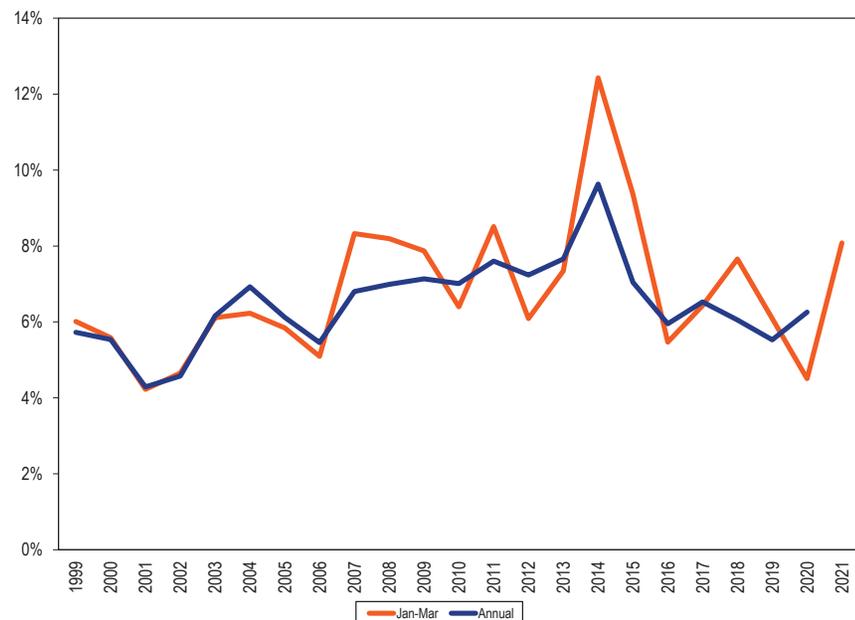


Table 5-28 shows the class average EFORD by unit type.

Table 5-28 EFORD by unit type: January through March, 2007 through 2021

	Jan-Mar														
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Coal	7.4%	8.9%	7.7%	7.8%	11.1%	9.3%	7.8%	11.5%	9.3%	8.3%	12.8%	12.4%	10.8%	5.8%	12.5%
Combined Cycle	9.3%	5.2%	5.3%	3.6%	4.1%	2.3%	2.9%	7.1%	4.7%	2.8%	2.6%	3.2%	2.9%	5.2%	3.0%
Combustion Turbine	21.5%	17.6%	15.2%	14.0%	12.8%	8.9%	18.3%	31.5%	20.1%	8.2%	6.0%	10.4%	8.9%	4.9%	4.8%
Diesel	9.0%	10.0%	8.1%	6.2%	5.1%	2.7%	3.8%	15.6%	11.1%	6.9%	5.9%	6.6%	6.6%	7.7%	6.2%
Hydroelectric	1.7%	3.1%	2.1%	0.9%	2.2%	2.8%	0.7%	1.5%	2.5%	3.4%	3.4%	3.9%	1.3%	4.3%	16.9%
Nuclear	0.4%	1.6%	4.0%	0.8%	1.7%	0.8%	0.2%	1.1%	1.6%	0.5%	0.5%	0.4%	0.3%	2.3%	0.2%
Other	10.8%	10.2%	10.6%	5.6%	13.2%	4.5%	11.4%	19.5%	17.5%	6.9%	6.3%	12.3%	6.5%	2.6%	27.7%
Total	8.3%	8.2%	7.9%	6.4%	8.5%	6.1%	7.3%	12.4%	9.4%	5.5%	6.4%	7.7%	6.1%	4.5%	8.1%

¹³⁹ The universe of units in PJM changed as the PJM footprint expanded and as units retired from and entered PJM markets. See the 2020 State of the Market Report for PJM, Appendix A: "PJM Overview" for details.

Other Forced Outage Rate Metrics

Under the capacity performance modifications to RPM, effective with the 2018/2019 Delivery Year, neither XEFORd nor EFORp are relevant.

Forced Outage Analysis

The MMU analyzed the causes of forced outages for the entire PJM system. The metric used was lost generation, which is the product of the duration of the outage and the size of the outage reduction. Lost generation can be converted into lost system equivalent availability.¹⁴⁰ On a system wide basis, the resultant lost equivalent availability from the forced outages is equal to the equivalent forced outage factor (EFOF).

PJM EFOF was 5.2 percent in the first three months of 2021. This means there was 5.2 percent lost availability because of forced outages. Table 5-29 shows that forced outages for boiler tube leaks, at 9.7 percent of the systemwide EFOF, were the fourth largest single contributor to EFOF.

Table 5-29 Contribution to EFOF by unit type by cause: January through March, 2021

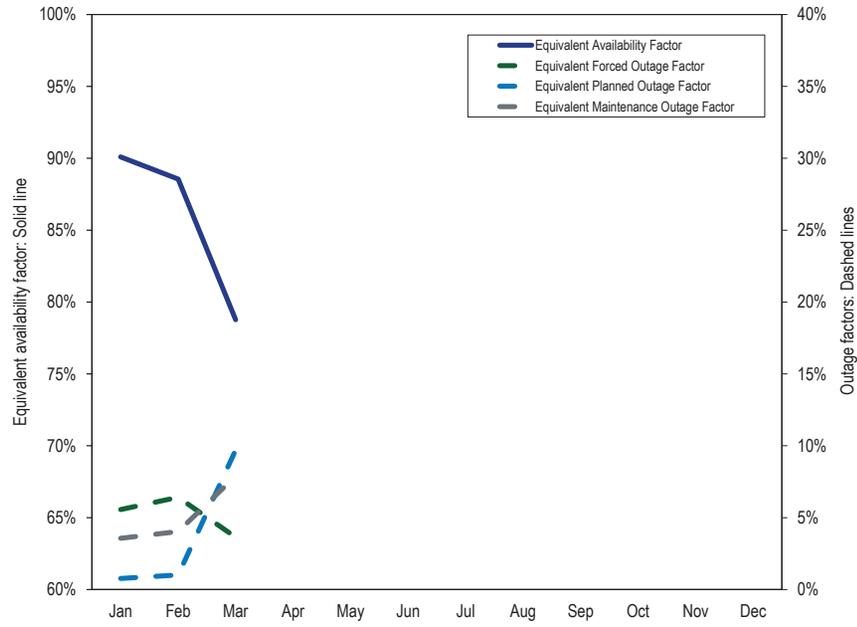
	Combined		Combustion		Hydroelectric	Nuclear	Other	System
	Coal	Cycle	Turbine	Diesel				
Feedwater System	21.8%	0.0%	0.0%	0.0%	0.0%	79.2%	0.0%	12.9%
Turbine	0.0%	0.1%	15.5%	0.0%	95.7%	0.0%	0.0%	11.7%
Controls	0.3%	3.0%	2.1%	10.2%	0.0%	0.0%	61.9%	11.4%
Boiler Tube Leaks	15.9%	1.9%	0.0%	0.0%	0.0%	0.0%	2.7%	9.7%
Generator	7.7%	43.9%	0.0%	2.4%	0.3%	0.0%	0.0%	8.1%
Miscellaneous (Steam Turbine)	6.5%	10.9%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%
Boiler Air and Gas Systems	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	4.4%
Economic	0.4%	1.3%	3.4%	5.1%	0.8%	0.0%	19.0%	3.9%
Electrical	4.2%	0.2%	22.9%	1.5%	0.0%	0.0%	0.0%	3.5%
Valves	4.9%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	2.9%
High Pressure Turbine	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%
Auxiliary Systems	1.3%	14.3%	10.7%	0.0%	0.0%	0.0%	0.1%	2.5%
Miscellaneous (Generator)	3.6%	0.1%	1.6%	0.9%	0.0%	0.0%	0.0%	2.2%
Unit Testing	1.0%	0.9%	21.8%	29.6%	1.4%	0.0%	1.3%	2.2%
Boiler Piping System	3.1%	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	1.8%
Condensing System	2.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	1.5%
Fuel Quality	2.1%	0.0%	0.0%	13.7%	0.0%	0.0%	0.3%	1.3%
Personnel or Procedure Errors	2.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	1.2%
Slag and Ash Removal	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%	1.1%
All Other Causes	9.1%	21.9%	22.0%	36.5%	1.6%	20.8%	10.6%	10.3%
Total	100.0%							

¹⁴⁰ For any unit, lost generation can be converted to lost equivalent availability by dividing lost generation by the product of the generating units' capacity and period hours. This can also be done on a systemwide basis.

Performance by Month

On a monthly basis, unit availability as measured by the equivalent availability factor is shown in Figure 5-14.

Figure 5-14 Monthly generator performance factors: January through March, 2021



Demand Response

Markets require both a supply side and a demand side to function effectively. The demand side of wholesale electricity markets is underdeveloped. Wholesale power markets will be more efficient when the demand side of the electricity market becomes fully functional without depending on special programs as a proxy for full participation.

Overview

- **Demand Response Activity.** Demand response activity includes economic demand response (economic resources), emergency and pre-emergency demand response (demand resources), synchronized reserves and regulation. Economic demand response participates in the energy market. Emergency and pre-emergency demand response participates in the capacity market and energy market.¹ Demand response resources participate in the synchronized reserve market. Demand response resources participate in the regulation market.

Total demand response revenue decreased by \$8.5 million, 9.4 percent, from \$94.0 million in the first three months of 2020 to \$85.1 million in the first three months of 2021. Emergency demand response revenue accounted for 98.4 percent of all demand response revenue, economic demand response for 0.1 percent, demand response in the synchronized reserve market for 1.1 percent and demand response in the regulation market for 0.4 percent.

Total emergency demand response revenue decreased by \$9.6 million, 10.2 percent, from \$93.3 million in the first three months of 2020 to \$83.8 million in the first three months of 2021. This decrease consisted entirely of capacity market revenue.²

Economic demand response revenue increased by \$0.03 million, 96.8 percent, from \$0.03 million in the first three months of 2020 to \$0.07 million in the first three months of 2021.³ Demand response revenue in

the synchronized reserve market increased by \$0.6 million, 220.9 percent, from \$0.3 million in the first three months of 2020 to \$0.9 million in the first three months of 2021. Demand response revenue in the regulation market increased by \$0.05 million, 15.5 percent, from \$0.3 million in the first three months of 2020 to \$0.4 million in the first three months of 2021.

- **Demand Response Energy Payments are Uplift.** Energy payments to emergency and economic demand response resources are uplift. LMP does not cover energy payments although emergency and economic demand response can and does set LMP. Energy payments to emergency demand resources are paid by PJM market participants in proportion to their net purchases in the real-time market. Energy payments to economic demand resources are paid by real-time exports from PJM and real-time loads in each zone for which the load-weighted, average real-time LMP for the hour during which the reduction occurred is greater than or equal to the net benefits test price for that month.⁴
- **Demand Response Market Concentration.** The ownership of economic load response resources was highly concentrated in 2020 and the first three months of 2021. The HHI for economic resource reductions decreased by 1048 points from 9065 in the first three months of 2020 to 8017 in the first three months of 2021. The ownership of emergency load response resources was highly concentrated in 2020. The HHI for emergency load response committed MW was 1840 for the 2019/2020 Delivery Year. In the 2019/2020 Delivery Year, the four largest CSPs owned 79.1 percent of all committed demand response UCAP MW. The HHI for emergency demand response committed MW was 2171 for the 2020/2021 Delivery Year. In the 2020/2021 Delivery Year, the four largest CSPs owned 85.6 percent of all committed demand response UCAP MW.
- **Limited Locational Dispatch of Demand Resources.** With full implementation of the Capacity Performance rules in the capacity market in the 2020/2021 Delivery Year, PJM should be able to individually dispatch any capacity performance resource, including demand resources. But PJM cannot dispatch demand resources by node with the current rules because

¹ Emergency demand response refers to both emergency and pre-emergency demand response. With the implementation of the Capacity Performance design, there is no functional difference between the emergency and pre-emergency demand response resource.

² The total credits and MWh numbers for demand resources were calculated as of January 12, 2021 and may change as a result of continued PJM billing updates.

³ Economic credits are synonymous with revenue received for reductions under the economic load response program.

⁴ "PJM Manual 28: Operating Agreement Accounting," § 11.2.2, Rev. 84 (Dec. 17 2020).

demand resources are not registered to a node. Demand resources can be dispatched by subzone only if the subzone is defined before dispatch. Aggregation rules allow a demand resource that incorporates many small end use customers to span an entire zone, which is inconsistent with nodal dispatch.

Recommendations

- The MMU recommends, as a preferred alternative to including demand resources as supply in the capacity market, that demand resources be on the demand side of the markets, that customers be able to avoid capacity and energy charges by not using capacity and energy at their discretion, that customer payments be determined only by metered load, and that PJM forecasts immediately incorporate the impacts of demand side behavior. (Priority: High. First reported 2014. Status: Not adopted.)
- The MMU recommends that the option to specify a minimum dispatch price (strike price) for demand resources be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the demand resources be treated as economic resources, responding to economic price signals like other capacity resources. The MMU recommends that demand resources not be treated as emergency resources, not trigger a PJM emergency and not trigger a Performance Assessment Interval. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Emergency Program Energy Only option be eliminated because the opportunity to receive the appropriate energy market incentive is already provided in the economic program. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends that, if demand resources remain in the capacity market, a daily energy market must offer requirement apply to demand resources, comparable to the rule applicable to generation capacity resources.⁵ (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that demand resources be required to provide their nodal location, comparable to generation resources. (Priority: High. First reported 2011. Status: Not adopted.)
- The MMU recommends that PJM require nodal dispatch of demand resources with no advance notice required or, if nodal location is not required, subzonal dispatch of demand resources with no advance notice required. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM eliminate the measurement of compliance across zones within a compliance aggregation area (CAA). The multiple zone approach is less locational than the zonal and subzonal approach and creates larger mismatches between the locational need for the resources and the actual response. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that measurement and verification methods for demand resources be modified to reflect compliance more accurately. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that operators have the necessary information for reliability and that market payments to demand resources

⁵ See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

be calculated based on interval meter data at the site of the demand reductions.⁶ (Priority: Medium. First reported 2013. Status: Not adopted.)

- The MMU recommends limited, extended summer and annual demand response event compliance be calculated on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that shutdown cost be defined as the cost to curtail load for a given period that does not vary with the measured reduction or, for behind the meter generators, be the start cost defined in Manual 15 for generators. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Net Benefits Test be eliminated and that demand response resources be paid LMP less any generation component of the applicable retail rate. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the tariff rules for demand response clarify that a resource and its CSP, if any, must notify PJM of material changes affecting the capability of the resource to perform as registered and must terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at defined levels because load has been reduced or eliminated, as in the case of bankrupt and/or out of service facilities. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that there be only one demand response product in the capacity market, with an obligation to respond when called for any hour of the delivery year. (Priority: High. First reported 2011. Status: Partially adopted.⁷)

⁶ See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

⁷ PJM's Capacity Performance design requires resources to respond when called for any hour of the delivery year, but demand resources still have a limited mandatory compliance window.

- The MMU recommends that the lead times for demand resources be shortened to 30 minutes with an hour minimum dispatch for all resources. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends setting the baseline for measuring capacity compliance under winter compliance at the customers' PLC, similar to GLD, to avoid double counting. (Priority: High. First reported 2010. Status: Partially adopted.)
- The MMU recommends the Relative Root Mean Squared Test be required for all demand resources with a CBL. (Priority: Low. First reported 2017. Status: Partially adopted.)
- The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that the limits imposed on the pre-emergency and emergency demand response share of the synchronized reserve market be eliminated. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that 30 minute pre-emergency and emergency demand response be considered to be 30 minute reserves. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that energy efficiency MW not be included in the PJM Capacity Market and that PJM should ensure that the impact of EE measures on the load forecast is incorporated immediately rather than with the existing lag. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that all demand resources register as Pre-Emergency Load Response and that the Emergency Load Response Program be eliminated. (Priority: High. First reported Q1 2020. Status: Not adopted.)

Conclusion

A fully functional demand side of the electricity market means that end use customers or their designated intermediaries will have the ability to see real-time energy price signals in real time, will have the ability to react to real-time prices in real time and will have the ability to receive the direct benefits or costs of changes in real-time energy use. In addition, customers or their designated intermediaries will have the ability to see current capacity prices, will have the ability to react to capacity prices and will have the ability to receive the direct benefits or costs of changes in the demand for capacity in the same year in which demand for capacity changes. A functional demand side of these markets means that customers will have the ability to make decisions about levels of power consumption based both on how customers value the power and on the actual cost of that power.

In the energy market, if there is to be a demand side program, demand resources should be paid the value of energy, which is LMP less any generation component of the applicable retail rate. There is no reason to have the net benefits test. The necessity for the net benefits test is an illustration of the illogical approach to demand side compensation embodied in paying full LMP to demand resources. The benefit of demand side resources is not that they suppress market prices, but that customers can choose not to consume at the current price of power, that individual customers benefit from their choices and that the choices of all customers are reflected in market prices. If customers face the market price, customers should have the ability to not purchase power and the market impact of that choice does not require a test for appropriateness.

If demand resources are to continue competing directly with generation capacity resources in the PJM Capacity Market, the product must be defined such that it can actually serve as a substitute for generation. This is a prerequisite to a functional market design. Demand resources do not have a must offer requirement into the day-ahead energy market, are able to offer above \$1,000 per MWh without providing a fuel cost policy, or any rationale for the offer. PJM automatically, and inappropriately, triggers a PAI when

demand resources are dispatched and demand resources do not have telemetry requirements similar to other Capacity Performance resources.

In order to be a substitute for generation, demand resources should be defined in PJM rules as an economic resource, as generation is defined. Demand resources should be required to offer in the day-ahead energy market and should be called when the resources are required and prior to the declaration of an emergency. Demand resources should be available for every hour of the year. The fact that PJM currently defines demand resources as emergency resources and the fact that calling on demand resources triggers a performance assessment interval (PAI) under the Capacity Performance design, both serve as a significant disincentive to calling on demand resources and mean that demand resources are underused. Demand resources should be treated as economic resources like any other capacity resource. Demand resources should be called when economic and paid the LMP rather than an inflated strike price up to \$1,849 per MWh that is set by the seller.

In order to be a substitute for generation, demand resources (DR) should be subject to robust measurement and verification techniques to ensure that transitional DR programs incent the desired behavior. The methods used in PJM programs today are not adequate to determine and quantify deliberate actions taken to reduce consumption.

In order to be a substitute for generation, demand resources should provide a nodal location and should be dispatched nodally to enhance the effectiveness of demand resources and to permit the efficient functioning of the energy market. Both subzonal and multi-zone compliance should be eliminated because they are inconsistent with an efficient nodal market.

In order to be a substitute for generation, compliance by demand resources with PJM dispatch instructions should include both increases and decreases in load. The current method applied by PJM simply ignores increases in load and thus artificially overstates compliance.

In order to be a substitute for generation, reductions should be calculated hourly for dispatched DR. The current rules use the average reduction for the duration of an event. The average reduction across multiple hours does not provide an accurate metric for each hour of the event and is inconsistent with the measurement of generation resources. Measuring compliance hourly would provide accurate information to the PJM system. Under the new CP rules, the performance of demand response during Performance Assessment Interval (PAI) will be measured on a five-minute basis.

In order to be a substitute for generation, any demand resource and its Curtailment Service Provider (CSP), should be required to notify PJM of material changes affecting the capability of the resource to perform as registered and to terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at the specified level, such as in the case of bankrupt and out of service facilities. Generation resources are required to inform PJM of any change in availability status, including outages and shutdown status.

As a preferred alternative to being a substitute for generation in the capacity and energy markets, demand response resources should be on the demand side of the capacity market rather than on the supply side. Rather than detailed demand response programs with their attendant complex and difficult to administer rules, customers would be able to avoid capacity and energy charges by not using capacity and energy at their discretion and the level of usage paid for would be defined by metered usage rather than a complex and inaccurate measurement protocol.

The MMU peak shaving proposal at the Summer-Only Demand Response Senior Task Force (SODRSTF) is an example of how to create a demand side product that is on the demand side of the market and not on the supply side.⁸ The MMU proposal was based on the BGE load forecasting program and the Pennsylvania Act 129 Utility Program.⁹ ¹⁰ Under the MMU proposal,

⁸ See the MMU package within the *SODRSTF Matrix*, <<http://www.pjm.com/-/media/committees-groups/task-forces/sodrستf/20180802/20180802-item-04-sodrستf-matrix.ashx>>.

⁹ *Advance signals that can be used to foresee demand response days*, BGE, <<https://www.pjm.com/-/media/committees-groups/task-forces/sodrستf/20180309/20180309-item-05-bge-load-curtailment-programs.ashx>> (Accessed March 6, 2019).

¹⁰ *Pennsylvania ACT 129 Utility Program*, CPower, <<https://www.pjm.com/-/media/committees-groups/task-forces/sodrستf/20180413/20180413-item-03-pa-act-129-program.ashx>> (Accessed March 6, 2019).

participating load would inform PJM prior to an RPM auction of the MW participating, the months and hours of participation and the temperature humidity index (THI) threshold at which load would be reduced. PJM would reduce the load forecast used in the RPM auction based on the designated reductions. Load would agree to curtail demand to at or below a defined FSL, less than the customer PLC, when the THI exceeds a defined level or load exceeds a specified threshold. By relying on metered load and the PLC, load can reduce its demand for capacity and that reduction can be verified without complicated and inaccurate metrics to estimate load reductions. Under PJM's weakened version of the program, performance will be measured under the current economic demand response CBL rules which means relying on load estimates rather than actual metered load.¹¹ PJM's proposal includes only a THI curtailment trigger and not an overall load curtailment trigger.

The long term appropriate end state for demand resources in the PJM markets should be comparable to the demand side of any market. Customers should use energy as they wish, accounting for market prices in any way they like, and that usage will determine the amount of capacity and energy for which each customer pays. There would be no counterfactual measurement and verification.

Under this approach, customers that wish to avoid capacity payments would reduce their load during expected high load hours. Capacity costs would be assigned to LSEs and by LSEs to customers, based on actual load on the system during these critical hours. Customers wishing to avoid high energy prices would reduce their load during high price hours. Customers would pay for what they actually use, as measured by meters, rather than relying on flawed measurement and verification methods. No measurement and verification estimates are required. No promises of future reductions which can only be verified by inaccurate and biased measurement and verification methods are required. To the extent that customers enter into contracts with CSPs or LSEs to manage their payments, measurement and verification can be negotiated as part of a bilateral commercial contract between a customer and its CSP or LSE.

¹¹ The PJM proposal from the SODRSTF weakened the proposal but was approved at the October 25, 2018 Members Committee meeting and PJM filed Tariff changes on December 7, 2018. See "Peak Shaving Adjustment Proposal," Docket No. ER19-511-000 (December 7, 2018).

But the system would be paid for actual, metered usage, regardless of which contractual party takes that obligation.

This approach provides more flexibility to customers to limit usage at their discretion. There is no requirement to be available year round or every hour of every day. There is no 30 minute notice requirement. There is no requirement to offer energy into the day-ahead market. All decisions about interrupting are up to the customers only and they may enter into bilateral commercial arrangements with CSPs at their sole discretion. Customers would pay for capacity and energy depending solely on metered load.

A transition to this end state should be defined in order to ensure that appropriate levels of demand side response are incorporated in PJM's load forecasts and thus in the demand curve in the capacity market. That transition should be defined by the PRD rules, modified as proposed by the MMU.

This approach would work under the CP design in the capacity market. This approach is entirely consistent with the Supreme Court decision in *EPSA* as it does not depend on whether FERC has jurisdiction over the demand side.¹² This approach will allow FERC to more fully realize its overriding policy objective to create competitive and efficient wholesale energy markets. The decision of the Supreme Court addressed jurisdictional issues and did not address the merits of FERC's approach. The Supreme Court's decision has removed the uncertainty surrounding the jurisdictional issues and created the opportunity for FERC to revisit its approach to demand side.

PJM Demand Response Programs

All PJM demand response programs can be grouped into economic, emergency and pre-emergency programs, or Price Responsive Demand (PRD). Table 6-1 provides an overview of the key features of PJM demand response programs.

Demand response activity includes economic demand response (economic resources), emergency and pre-emergency demand response (demand resources), synchronized reserves and regulation. Economic demand response

¹² 577 U.S. 260 (2016).

participates in the energy market. Emergency and pre-emergency demand response participate in the capacity market and energy market.¹³ Demand response resources participate in the synchronized reserve market. Demand response resources participate in the regulation market.

FERC Order No. 719 required PJM and other RTOs to amend their market rules to accept bids from aggregators of retail customers of utilities unless the laws or regulations of the relevant electric retail regulatory authority ("RERRA") do not permit the customers aggregated in the bid to participate.¹⁴ PJM implemented rules that require PJM to verify with EDCs that no law or regulation of a RERRA prohibits end use customers' participation.¹⁵ EDCs and their end use customers are categorized as small and large based on whether the EDC distributed more or less than 4 million MWh in the previous fiscal year. End use customers within a large EDC must provide verification of any other contractual obligations or laws or regulations that prohibit participation, but end use customers within a small EDC do not need to provide additional verification.¹⁶ RERRAs have permitted EDCs, in a number of cases, to participate in the PJM Economic Load Response Program.

¹³ Emergency demand response refers to both emergency and pre-emergency demand response. With the implementation of the Capacity Performance design, there is no functional difference between the emergency and pre-emergency demand response resource.

¹⁴ *Wholesale Competition in Regions with Organized Electric Markets*, Order No. 719, FERC Stats. & Regs. ¶ 31,281 at P 154 (2008), *order on reh'g*, Order No. 719-A, FERC Stats. & Regs. ¶ 31,292, *order on reh'g*, Order No. 719-B, 129 FERC ¶ 61,252 (2009).

¹⁵ The evidence supplied by LDCs must take the form of an order, resolution or ordinance of the RERRA, an opinion of the RERRA's legal counsel attesting to existence of an order, resolution, or ordinance, or an opinion of the state attorney general on behalf of the RERRA attesting to existence of an order, resolution or ordinance.

¹⁶ PJM Operating Agreement Schedule 1 § 1.5A.3.1.

Table 6-1 Overview of demand response programs

	Emergency and Pre-Emergency Load Response Program			Economic Load Response Program	Price Responsive Demand
	Load Management (LM)			Economic Demand Response	
Product Types	Limited, Annual, Base, Capacity Performance, Summer-Period Capacity Performance OATT Attachment DD § 5.5A	Limited, Annual, Base, Capacity Performance, Summer-Period Capacity Performance OATT Attachment DD § 5.5A		OATT Attachment K § 1.5A	
Market	Capacity Only OATT Attachment K § 8.1	Full Program Option (Capacity and Energy) OATT Attachment K § 8.1	Energy Only OATT Attachment K § 8.1	Energy Only	Capacity Only
Capacity Market	DR cleared in RPM	DR cleared in RPM	Not included in RPM	Not included in RPM	PRD cleared in RPM
Dispatch Requirement	Mandatory Curtailment	Mandatory Curtailment	Voluntary Curtailment	Dispatched Curtailment	Price Threshold
Capacity Payments	Capacity payments based on RPM clearing price	Capacity payments based on RPM clearing price	NA	NA	LSE PRD Credit RAA Schedule 6.1.G
Capacity Measurement and Verification	Firm Service Level Guaranteed Load Drop	Firm Service Level Guaranteed Load Drop	NA	NA	Firm Service Level
CBL	NA	Yes, as described OATT Attachment K § 3.3A	Yes, as described OATT Attachment K § 3.3A	Yes, as described OATT Attachment K § 3.3A	NA
Energy Payments	No energy payment	Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment during PJM declared Emergency Event mandatory curtailments.	Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment only for voluntary curtailments.	Energy payment based on full LMP. Energy payment for hours of dispatched curtailment. OATT Attachment K § 3.3A	NA
Penalties	RPM event OATT Attachment DD § 10A RAA Schedule 6.K Test compliance penalties OATT Attachment DD § 11A	RPM event OATT Attachment DD § 10A RAA Schedule 6.K Test compliance penalties OATT Attachment DD § 11A	NA	NA	RPM event RAA Schedule 6.1.G Test compliance penalties RAA Schedule 6.1.L
Associate Manuals	Manual 18	Manual 11 Manual 18	Manual 11 Manual 18	Manual 11	Manual 18

Non-PJM Demand Response Programs

Within the PJM footprint, states may have additional demand response programs as part of a Renewable Portfolio Standard (RPS) or a separate program. Indiana, Ohio, Pennsylvania and North Carolina include demand response in their RPS. If demand response is dispatched by a state run program, the demand response resources are ineligible to receive payments from PJM during the state dispatch.

PJM Demand Response Programs

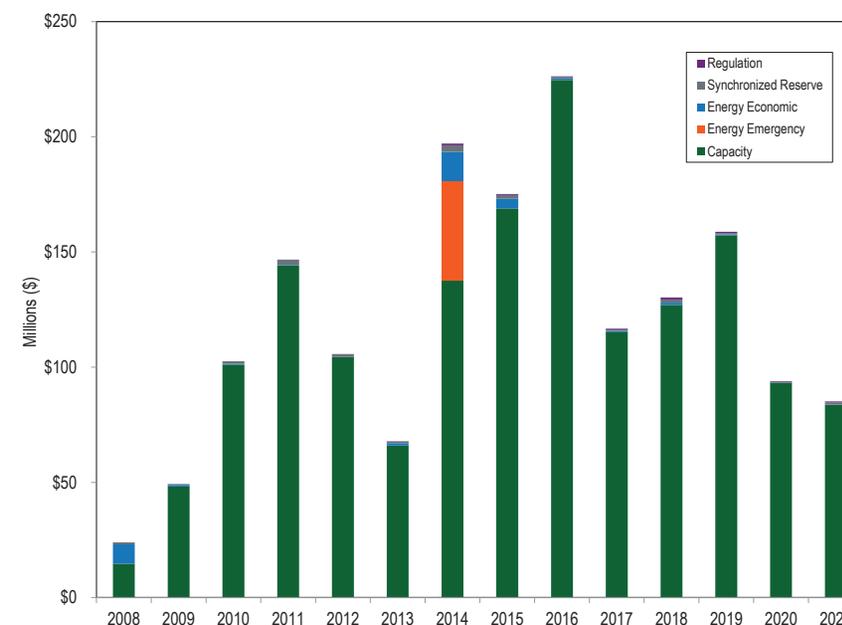
Figure 6-1 shows all revenue from PJM demand response programs by market for January 2008 through March 2021. Since the implementation of the RPM Capacity Market on June 1, 2007, the capacity market (demand resources) has been the primary source of demand response revenue.¹⁷ In the first three months of 2021, total demand response revenue decreased by \$8.8 million, 9.4 percent, from \$94.0 million in the first three months of 2020 to \$85.1 million in the first three months of 2021. Total emergency demand response revenue decreased by \$9.6 million, 10.2 percent, from \$93.3 million in the first three months of 2020 to \$83.8 million in the first three months of 2021. This decrease consisted of capacity market revenue.¹⁸ In 2020, emergency demand response revenue, which includes capacity and emergency energy revenue, accounted for 98.4 percent of all revenue received by demand response providers, the economic program for 0.1 percent, synchronized reserve for 1.1 percent and the regulation market for 0.4 percent.

Economic demand response revenue increased by \$0.03 million, 96.8 percent, from \$0.03 million in the first three months of 2020 to \$0.07 million in the first three months of 2021.¹⁹ Demand response revenue in the synchronized reserve market increased by \$0.6 million, 220.9 percent, from \$0.3 million in the first three months of 2020 to \$0.9 million in the first three months of 2021. Demand response revenue in the regulation market increased by \$0.05

million, 15.5 percent, from \$0.3 million in the first three months of 2020 to \$0.4 million in the first three months of 2021.

Lower demand resource revenues were in part a result of lower capacity market prices in the 2019/2020 RPM and 2020/2021 RPM auctions. The annual RTO capacity market prices decreased \$23.47 per MW-day from \$100.00 in the 2019/2020 Delivery Year to \$76.53 in the 2020/2021 Delivery Year, a 23.5 percent decrease.

Figure 6-1 Demand response revenue by market: January 2008 through March 2021



¹⁷ This includes both capacity market revenue and emergency energy revenue for capacity resources.

¹⁸ The total credits and MWh for demand resources were calculated as of April 21, 2021 and may change as a result of continued PJM billing updates.

¹⁹ Economic credits are synonymous with revenue received for reductions under the economic load response program.

Emergency and Pre-Emergency Load Response Programs

Demand resources participate in the capacity market within the Emergency and Pre-Emergency Load Response Programs.

All demand resources must register as pre-emergency unless the participant relies on behind the meter generation and the resource has environmental restrictions that limit the resource's ability to operate only in emergency conditions.²⁰ Under current rules, PJM will declare an emergency if pre-emergency or emergency demand response is dispatched. In all demand response programs, CSPs are companies that sign up customers that have the ability to reduce load. CSPs satisfy cleared RPM commitments registering customers as Nominated MW. After a demand response event occurs, PJM compensates CSPs for their participants' load reductions and CSPs in turn compensate their participants. Only CSPs are eligible to participate in the PJM demand response programs, but a participant can register as a PJM special member and become a CSP without any additional cost.

The emergency and pre-emergency load response programs consist of the base and capacity performance demand response products. Full implementation of the Capacity Performance design in the 2020/2021 Delivery Year requires all emergency or pre-emergency demand resources to be registered as annual capacity resources. Summer period demand response resources are allowed to aggregate with winter period capacity resources to fulfill the annual requirement of the CP design.²¹

All capacity resources must respond during a Performance Assessment Interval (PAI). Demand resources are the only capacity performance resource that create a PAI when dispatched by PJM. PJM eliminated any substantive difference between pre-emergency and emergency by making the dispatch of either type trigger a PAI.

²⁰ OA Schedule 1 § 8.5.

²¹ Summer period demand response has the same obligations as extended summer demand response. It must be available for June through October and the following May between 10:00AM and 10:00PM. See PJM OATT RAA Article 1.

The rules applied to demand resources in the current market design do not treat demand resources in a manner comparable to generation capacity resources, even though demand resources are sold in the same capacity market, are treated as a substitute for other capacity resources and displace other capacity resources in RPM auctions. PJM will not measure compliance for DR, and the resources will not face penalties, in a PAI unless the product type and lead time type are dispatched by PJM. PJM will not measure compliance for DR, and the resources will not face penalties, in a PAI if the area dispatched is not a defined subzone or control zone. Demand resources are not required to meet the same requirements as other capacity resources for the PAI.

Demand resources are also not required to meet the same must offer requirements as other capacity resources. All other capacity resources must offer daily into the day-ahead energy market.

The MMU recommends that if demand resources remain on the supply side of the capacity market, a daily must offer requirement in the day-ahead energy market apply to demand resources, comparable to the rule applicable to generation capacity resources. This will help to ensure comparability and consistency for demand resources.

The MMU recommends that the option to specify a minimum dispatch price under the Emergency and Pre-Emergency Program Full option be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate.²²

Market Structure

The HHI for demand resources showed that ownership was highly concentrated for the 2019/2020 Delivery Year, with an HHI value of 1840. In the 2019/2020 Delivery Year, the four largest companies contributed 79.1 percent of all committed demand resources UCAP MW in the 2019/2020 Delivery Year. The HHI for demand resources showed that ownership was highly concentrated for the 2020/2021 Delivery Year, with an HHI value of 2171. In the 2020/2021

²² See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 28, 2014), "Comments of the Independent Market Monitor for PJM," Docket No. ER15-852-000 (February 13, 2015).

Delivery Year, the four largest companies owned 85.6 percent of all committed demand response UCAP MW.

Table 6-2 shows the HHI value for committed UCAP MW by LDA by delivery year. The HHI values are calculated by the committed UCAP MW in each delivery year for demand resources.

Table 6-2 HHI value for committed UCAP MW by LDA by delivery year: 2019/2020 and 2020/2021 Delivery Years²³

Delivery Year	LDA	Committed UCAP			
		MW	HHI Value	HHI Concentration	
2019/2020	ATSI	713.1	2419	High	
	ATSI-CLEVELAND	333.9	2760	High	
	BGE	262.4	2181	High	
	COMED	1,759.9	2669	High	
	DPL-SOUTH	91.3	3037	High	
	EMAAC	1,186.7	1949	High	
	MAAC	661.3	2232	High	
	PEPCO	554.6	4517	High	
	PPL	741.4	2003	High	
	PS-NORTH	176.5	2198	High	
	PSEG	204.7	2163	High	
	RTO	4,017.3	2112	High	
	2020/2021	ATSI	719.8	2247	High
		ATSI-CLEVELAND	231.9	3848	High
BGE		249.5	2217	High	
COMED		1,657.3	2732	High	
DAY		241.5	3161	High	
DEOK		184.7	3664	High	
DPL-SOUTH		72.6	3010	High	
EMAAC		757.3	2291	High	
MAAC		557.8	2142	High	
PEPCO		236.3	2522	High	
PPL		616.6	2083	High	
PS-NORTH		152.7	2232	High	
PSEG		186.3	1747	Moderate	
RTO		3,581.4	2384	High	

²³ The RTO LDA refers to the rest of RTO.

Market Performance

Table 6-3 shows the cleared Demand Resource UCAP MW by delivery year. Total cleared demand response UCAP MW in PJM decreased by 1,257.4 MW, or 11.7 percent, from 10,703.1 MW in the 2019/2020 Delivery Year to 9,445.7 MW in the 2020/2021 Delivery Year. The DR percent of capacity decreased by 0.6 percentage points, from 6.0 percent in the 2019/2020 Delivery Year to 5.4 percent in the 2020/2021 Delivery Year.

Table 6-3 Cleared Demand Resource UCAP MW: 2007/2008 through 2020/2021 Delivery Year

	UCAP (MW)		
	DR RPM Cleared	Total RPM Cleared	DR Percent Cleared
2007/2008	127.6	129,409.2	0.1%
2008/2009	559.4	130,629.8	0.4%
2009/2010	892.9	134,030.2	0.7%
2010/2011	962.9	134,036.2	0.7%
2011/2012	1,826.6	134,139.6	1.4%
2012/2013	8,740.9	141,061.8	6.2%
2013/2014	10,779.6	159,830.5	6.7%
2014/2015	14,943.0	161,092.4	9.3%
2015/2016	15,453.7	173,487.4	8.9%
2016/2017	13,265.3	179,749.0	7.4%
2017/2018	11,870.5	180,590.3	6.6%
2018/2019	11,435.4	175,957.4	6.5%
2019/2020	10,703.1	177,040.6	6.0%
2020/2021	9,445.7	173,688.5	5.4%

Table 6-4 shows zonal monthly capacity market revenue to demand resources for the first three months of 2021. Capacity market revenue decreased in the first three months of 2021 by \$10.9 million, 11.7 percent, from \$93.3 million in the first three months of 2020 to \$83.4 million in the first three months of 2021. Lower demand resource revenues were a result of lower capacity market prices in the 2019/2020 and 2020/2021 RPM auctions. The capacity revenue in 2019 is from the 2018/2019 and 2019/2020 RPM auction clearing prices and the capacity revenue in 2021 is from the 2020/2021 RPM auction clearing prices. The annual capacity market prices decreased \$23.47 per MW-day from \$100.00 in the 2019/2020 Delivery Year to \$76.53 in the 2020/2021 Delivery Year, a 23.5 percent decrease.

Table 6-4 Zonal monthly demand resource capacity revenue: 2021

Zone	January	February	March	Total
ACEC	\$364,810	\$329,506	\$364,810	\$1,059,126
AEP, EKPC	\$3,309,544	\$2,989,265	\$3,309,544	\$9,608,353
APS	\$1,790,204	\$1,616,959	\$1,790,204	\$5,197,367
ATSI	\$1,882,518	\$1,700,339	\$1,882,518	\$5,465,375
BGE	\$468,186	\$422,877	\$468,186	\$1,359,248
COMED	\$8,465,782	\$7,646,513	\$8,465,782	\$24,578,078
DAY	\$465,983	\$420,888	\$465,983	\$1,352,854
DUKE	\$972,021	\$877,954	\$972,021	\$2,821,996
DUQ	\$383,237	\$346,149	\$383,237	\$1,112,623
DOM	\$465,983	\$420,888	\$465,983	\$1,352,854
DPL	\$972,021	\$877,954	\$972,021	\$2,821,996
JCPLC	\$817,686	\$738,555	\$817,686	\$2,373,926
MEC	\$644,939	\$582,525	\$644,939	\$1,872,403
OVEC	\$644,939	\$582,525	\$644,939	\$1,872,403
PECO	\$2,133,013	\$1,926,593	\$2,133,013	\$6,192,619
PE	\$644,939	\$582,525	\$644,939	\$1,872,403
PEPCO	\$432,443	\$390,594	\$432,443	\$1,255,481
PPL	\$1,594,416	\$1,440,118	\$1,594,416	\$4,628,950
PSEG	\$1,901,994	\$1,717,930	\$1,901,994	\$5,521,918
REC	\$22,613	\$20,424	\$22,613	\$65,650
Total	\$28,377,271	\$25,631,083	\$28,377,271	\$82,385,625

Pre-Emergency and Emergency Load Response resources must register all resources to respond within 30, 60 or 120 minutes of a PJM dispatched event. The quick lead time, or 30 minute lead time, is the default lead time, unless a CSP submits an exception request for 60 or 120 minute notification time based on a physical constraint.²⁴ The exception requests must clearly state why the resource is unable to respond within 30 minutes based on the defined reasons for exception listed in Manual 18.²⁵ Once a location is granted a longer lead time, the resource does not need to resubmit for a longer lead time each delivery year. Resources that request longer lead times without a physical constraint are rejected.

Table 6-5 shows the amount of nominated MW and locations by product type and lead time for the 2019/2020 Delivery Year. Nominated MW are Pre-Emergency or Emergency Load Response registrations used to satisfy a CSP's committed MW position for a delivery year. PJM approved 3,114 locations,

²⁴ See "PJM Manual 18: PJM Capacity Market," § 4.3.1, Rev. 46 (Nov. 19, 2020).

²⁵ See "PJM Manual 18: PJM Capacity Market," § 4.3.1, Rev. 46 (Nov. 19, 2020).

or 20.9 percent of all locations, which have 3,908.0 nominated MW, or 40.6 percent of all nominated MW, for exceptions to the 30 minute lead time rule for the 2019/2020 Delivery Year.

Table 6-5 Nominated MW and locations by product type and lead time: 2019/2020 Delivery Year

Lead Type	Pre-Emergency MW			Emergency MW			Total
	Base	Capacity Performance	Pre-Emergency Total	Base	Capacity Performance	Emergency Total	
Quick Lead (30 Minutes)	5,292.4	159.1	5,451.5	238.4	17.7	256.1	5,707.6
Short Lead (60 Minutes)	326.7	36.3	363.0	27.2	0.0	27.2	390.3
Long Lead (120 Minutes)	2,939.8	428.2	3,368.0	148.3	1.4	149.8	3,517.8
Total	8,558.9	623.6	9,182.6	414.0	19.1	433.1	9,615.7

Lead Type	Pre-Emergency Locations			Emergency Locations			Total
	Base	Capacity Performance	Pre-Emergency Total	Base	Capacity Performance	Emergency Total	
Quick Lead (30 Minutes)	10,887	356	11,243	513	26	539	11,782
Short Lead (60 Minutes)	289	8	297	52	0	52	349
Long Lead (120 Minutes)	2,052	425	2,477	285	3	288	2,765
Total	13,228	789	14,017	850	29	879	14,896

Table 6-6 shows the amount of nominated MW and locations by product type and lead time for the 2020/2021 Delivery Year. PJM approved 3,105 locations, or 21.3 percent of all locations, which have 3,548.6 nominated MW, or 45.0 percent of all nominated MW, for exceptions to the 30 minute lead time rule for the 2020/2021 Delivery Year.

Table 6-6 Nominated MW and locations by product type and lead time: 2020/2021 Delivery Year

Lead Type	Pre-Emergency MW		Emergency MW		Total
	Capacity Performance	Pre-Emergency Total	Capacity Performance	Emergency Total	
Quick Lead (30 Minutes)	4,097.2	4,097.2	240.6	240.6	4,337.9
Short Lead (60 Minutes)	326.9	326.9	28.8	28.8	355.7
Long Lead (120 Minutes)	3,043.0	3,043.0	150.0	150.0	3,192.9
Total	7,467.1	7,467.1	419.4	419.4	7,886.5

Lead Type	Pre-Emergency Locations		Emergency Locations		Total
	Capacity Performance	Pre-Emergency Total	Capacity Performance	Emergency Total	
Quick Lead (30 Minutes)	10,995	10,995	472	472	11,467
Short Lead (60 Minutes)	315	315	39	39	354
Long Lead (120 Minutes)	2,476	2,476	275	275	2,751
Total	13,786	13,786	786	786	14,572

There are two ways to measure load reductions of demand resources. The Firm Service Level (FSL) method, applied to the summer, measures the difference between a customer's peak load contribution (PLC) and its real-time load, multiplied by the loss factor (LF).²⁶ The Guaranteed Load Drop (GLD) method measures the minimum of: the comparison load minus real-time load multiplied by the loss factor; or the PLC minus the real-time load multiplied by the loss factor. The comparison load estimates what the load would have been if PJM did not declare a Load Management Event, similar to a CBL, by using a comparable day, same day, customer baseline, regression analysis or backup generation method. Limiting the GLD method to the minimum of the two calculations ensures reductions occur below the PLC, thus avoiding double counting of load reductions.²⁷ With the introduction of the Winter Peak Load (WPL) concept, effective for the 2017/2018 Delivery Year, both the FSL and GLD methods are modified for the non-summer period. The FSL method measures compliance during the non-summer period as the difference between a customer's WPL multiplied by the Zonal Winter Weather Adjustment Factor (ZWWAF) and the LF, rather than the PLC, and real-time load, multiplied by the LF. PJM calculates and posts on the PJM website the ZWWAF as the zonal winter weather normalized peak divided by the zonal average of the five coincident peak loads in December through February.²⁸ The Winter Peak Load is adjusted up for transmission and distribution line loss factors because one MW of load would be served by more than one MW of generation to account for transmission losses. The Winter Peak Load is normalized based on the winter conditions during the five coincident peak loads in winter using the ZWWAF to account for an extreme temperatures or a mild winter. The GLD method measures compliance during the non-summer period as the minimum of: the comparison load minus real-time load multiplied by the loss factor; or the WPL multiplied by the ZWWAF and the LF, rather than the PLC, minus the real-time load multiplied by the LF.²⁹

The capacity market is an annual market. A Capacity Performance resource has an annual commitment. Load is allocated capacity obligations based on the annual peak load which is a summer load. The amount of MW allocated to load

²⁶ Real-time load is hourly metered load.

²⁷ 135 FERC ¶ 61,212.

²⁸ "PJM Manual 18: PJM Capacity Market," § 4.3.7, Rev. 47 (Jan. 27, 2021).

²⁹ "PJM Manual 18: PJM Capacity Market," § 8.7A, Rev.46 (Nov. 19, 2020).

does not vary based on winter demand. The principle is that a customer's actual use of capacity should be compared to the level of capacity that a customer is required to pay for. Capacity costs are allocated to LSEs by PJM based on the single coincident peak load method. In PJM, the single coincident peak occurs in the summer.³⁰ LSEs generally allocate capacity costs to customers based on the five coincident peak method.³¹ The allocation of capacity costs to customers uses each customer's PLC. Customers pay for capacity based on the PLC, not the WPL. If an end customer has 3 MW of load during the coincidental peak load hour, but only 1 MW during the coincidental winter peak load hour, the end use customer must pay for 3 MW of capacity for the entire delivery year, but can only participate as a 1 MW demand response resource. Using PLC to measure compliance the entire delivery year would allow the customer to fully participate as a 3 MW demand response resource. FERC allowed the use of the WPL for calculating compliance for non-summer months effective June 1, 2017.³² The MMU recommends setting the baseline for measuring capacity compliance under summer and winter compliance at the customer's PLC, similar to GLD, to avoid double counting, to avoid under counting and to ensure that a customer's purchase of capacity is calculated correctly. The FSL and GLD equations for calculating load reductions are:

$$FSL\ Compliance_{Summer} = PLC - (Load \cdot LF)$$

$$FSL\ Compliance_{Non-Summer} = (WPL \cdot ZWWAF \cdot LF) - (Load \cdot LF)$$

$$GLD\ Compliance_{Summer} = \text{Minimum}\{(comparison\ load - Load) \cdot LF; PLC - (Load \cdot LF)\}$$

$$GLD\ Compliance_{Non-Summer} = \text{Minimum}\{(comparison\ load - Load) \cdot LF; (WPL \cdot ZWWAF \cdot LF) - (Load \cdot LF)\}$$

Table 6-7 shows the MW registered by measurement and verification method and by technology type for the 2019/2020 Delivery Year. For the 2019/2020 Delivery Year, 99.7 percent use the FSL method and 0.3 percent use the GLD measurement and verification method.

³⁰ OATT Attachment DD.5.11.

³¹ OATT Attachment M-2.

³² 162 FERC ¶ 61,159 (2018).

Table 6-7 Reduction MW by each demand response method: 2019/2020 Delivery Year

Measurement and Verification Method	Technology Type							Total	Percent by type
	On-site Generation		Refrigeration MW	Lighting MW	Manufacturing MW	Water Heating MW	Batteries and Plug Load MW		
	MW	HVAC MW							
Firm Service Level	1,202.7	3,108.6	215.4	861.2	3,963.5	125.5	49.0	9,525.8	99.7%
Guaranteed Load Drop	0.4	12.3	0.0	1.4	15.1	0.1	0.3	29.5	0.3%
Total	1,203.1	3,120.8	215.4	862.6	3,978.5	125.6	49.3	9,555.3	100.0%
Percent by method	12.6%	32.7%	2.3%	9.0%	41.6%	1.3%	0.5%	100.0%	

Table 6-8 shows the MW registered by measurement and verification method and by technology type for the 2020/2021 Delivery Year. For the 2020/2021 Delivery Year, 99.9 percent use the FSL method and 0.1 percent use the GLD measurement and verification method.

Table 6-8 Reduction MW by each demand response method: 2020/2021 Delivery Year

Measurement and Verification Method	Technology Type							Total	Percent by type
	On-site Generation		Refrigeration MW	Lighting MW	Manufacturing MW	Water Heating MW	Other, Batteries or Plug Load MW		
	MW	HVAC MW							
Firm Service Level	1,225.3	1,842.9	196.0	694.5	3,729.2	61.3	46.0	7,795.1	99.9%
Guaranteed Load Drop	0.3	1.1	0.0	0.0	4.4	0.0	0.3	6.1	0.1%
Total	1,225.5	1,844.0	196.0	694.5	3,733.6	61.3	46.2	7,801.2	100.0%
Percent by method	15.7%	23.6%	2.5%	8.9%	47.9%	0.8%	0.6%	100.0%	

Table 6-9 shows the fuel type used in the onsite generators for the 2019/2020 Delivery Year in the emergency and pre-emergency programs. During the 2019/2020 Delivery Year, 1,203.1 MW of the 9,555.31 nominated MW, 12.6 percent, used onsite generation. Of the 1,203.1 MW, 85.2 percent used diesel and 14.8 percent used natural gas, gasoline, oil, propane or waste products.

Table 6-9 Onsite generation fuel type (MW): 2019/2020 Delivery Year

Fuel Type	2019/2020	
	MW	Percent
Diesel	1,024.5	85.2%
Natural Gas, Gasoline, Oil, Propane, Waste Products	178.7	14.8%
Total	1,203.1	100.0%

Table 6-10 shows the fuel type used in the onsite generators for the 2020/2021 Delivery Year in the emergency and pre-emergency programs. During the 2020/2021 Delivery Year, 1,225.5 MW of the 7,801.2 nominated MW, 15.7 percent, used onsite generation. Of the 1,225.5 MW, 87.1 percent used diesel and 12.9 percent used natural gas, gasoline, oil, propane or waste products.

Table 6-10 Onsite generation fuel type (MW): 2020/2021 Delivery Year

Fuel Type	2020/2021	
	MW	Percent
Diesel	1,066.9	87.1%
Natural Gas, Gasoline, Oil, Propane, Waste Products	158.7	12.9%
Total	1,225.5	100.0%

Emergency and Pre-Emergency Event Reported Compliance

Capacity Performance resources measure performance nodally, except for demand resources. PJM cannot dispatch demand resources by node with the current rules because demand resources are not registered to a node. Demand resources can be dispatched by subzone only if the subzone is defined before dispatch. Aggregation rules allow a demand resource that incorporates many small end use customers to span an entire zone, which is inconsistent with nodal dispatch.

Subzonal dispatch became mandatory for emergency demand resources in the 2014/2015 Delivery Year, if the subzone was defined by PJM no later than the day before the dispatch.³³ A subzone is defined by zip code, not by nodal location. If a registration has any location in the dispatched subzone, the entire registration must respond. PJM does not measure compliance when demand response is dispatched in a subzone created on the same day as the dispatch. Subzonal dispatch creates a PAI for the subzone, even if PJM does not measure compliance for demand resources.

There are 13 dispatchable subzones in PJM last updated September 21, 2018: AEP_CANTON, ATSI_CLE, DPL_SOUTH, PS_NORTH, ATSI_NEWCASOE, PPL_WESCO, ATSI_BLKRIVER, PENELEC_ERIC, APS_EAST, DOM_CHES, DOM_

³³ OATT Attachment DD, Section 11.

YORKTOWN, AECO_ENGLAND, and JCPL_REDBANK.³⁴ Effective with the 2020/2021 Delivery Year, PJM will procure a single capacity product, Capacity Performance, which does not require predefined subzones for mandatory dispatch.³⁵

PJM can remove a defined subzone, and make changes to the subzone, at their discretion. Subzones should not be removed once defined, as the subzone may need to be dispatched again in the future. The METED_EAST, PENELEC_EAST, PPL_EAST and DOM_NORFOLK subzones were removed by PJM. More subzones may have been removed by PJM but PJM does not keep a record of created and removed subzones. The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones.

The subzone design and closed loop interfaces are related. PJM implemented closed loop interfaces with the stated purpose of improving the incorporation of reactive constraints into energy prices and to allow emergency DR to set price.³⁶ PJM applies closed loop interfaces so that it can use units needed for reactive support to set the energy price when they would not otherwise set price under the LMP algorithm. PJM also applies closed loop interfaces so that it can use emergency DR resources to set the real-time LMP when DR would not otherwise set price under the fundamental LMP logic. Of the 20 closed loop interface definitions, 11 (55 percent) were created for the purpose of allowing emergency DR to set price.³⁷ The closed loop interfaces created for the purpose of allowing emergency DR to set price are located in the RTO, MAAC, EMAAC, SWMAAC, DPL-SOUTH, ATSI, ATSI-CLEVELAND and BGE LDAs.

Demand resources can be dispatched for voluntary compliance during any hour of any day, but dispatched resources are not measured for compliance outside of the mandatory compliance window for each demand product. A

³⁴ See "Load Management Subzones," <<http://www.pjm.com/~media/markets-ops/demand-response/subzone-definition-workbook.ashx>> (Accessed January 21, 2020).

³⁵ OATT Attachment DD, Section 10A.

³⁶ See PJM/Alstom, "Approaches to Reduce Energy Uplift and PJM Experiences," presented at the FERC Technical Conference: Increasing Real-Time and Day-Ahead Market Efficiency Through Improved Software, Docket No. AD10-12-006 (June 23, 2015) <<http://www.ferc.gov/june-tech-conf/2015/presentations/m2-3.pdf>>.

³⁷ See the 2018 State of the Market Report for PJM, Volume 2, Section 4, Energy Uplift, for additional information regarding all closed loop interfaces and the impacts to the PJM markets.

demand response event during a product's mandatory compliance window also may not result in a compliance score. When limited, extended summer and annual demand response events occur for partial hours under 30 minutes or for a subzone dispatch that was not defined one business day before dispatch, the events are not measured for compliance.

Capacity Performance demand resources currently estimate five minute compliance with an hourly interval meter during PAIs. To accurately measure compliance on a five minute basis, a five minute interval meter is required. All other Capacity Performance resources require five minute interval meters, and demand resources should be no different. Limited, extended summer and annual demand resources are paid based on the average performance by registration for the duration of a demand response event. Each capacity performance demand response product should measure compliance on a five minute basis to accurately report reductions during demand response events. The current rules for limited, extended summer and annual demand response use the average reduction for the duration of an event. The average duration across multiple hours does not provide an accurate metric for each five minute interval of the event and is inconsistent with the measurement of generation resources. Measuring compliance on a five minute basis would provide accurate information to the PJM system. The MMU recommends limited, extended summer and annual demand response event compliance be calculated on an hourly basis for noncapacity performance resources and on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance.³⁸

Under the capacity performance design of the PJM Capacity Market, compliance for potential penalties will be measured for DR only during performance assessment intervals (PAI).³⁹ When pre-emergency or emergency demand response is dispatched, a PAI is triggered for PJM. PJM cannot dispatch pre-emergency or emergency demand response without triggering a PAI and measuring compliance. Before PJM created PAI to measure compliance, pre-emergency demand response could be dispatched without

calling an emergency event. As a result, PJM now effectively classifies all demand response as an emergency resource.

The MMU recommends that demand response resources be treated as economic resources like all other capacity resources and therefore that the dispatch of demand response resources not automatically trigger a performance assessment interval (PAI) for CP compliance. Emergencies should be triggered only when PJM has exhausted all economic resources including demand response resources. Table 6-11 shows the amount of nominated demand response MW, the required reserve margin and actual reserve margin as of June 1, for 2017, 2018, 2019 and 2020. There are 7,801.2 nominated MW of demand response for the 2020/2021 Delivery Year, 36.9 percent of the required reserve margin and 20.0 percent of the actual reserve margin on June 1, 2020.⁴⁰

Table 6-11 Demand response nominated MW compared to reserve margin: June 1, 2017 through 2020

	Demand Response Nominated MW	Required Reserve Margin	Demand Response Percent of Required Reserve Margin	Actual Reserve Margin	Demand Response Percent of Actual Reserve Margin
01-Jun-17	9,154.7	23,305.2	39.3%	33,828.1	27.1%
01-Jun-18	8,998.1	22,487.7	40.0%	31,987.5	28.1%
01-Jun-19	9,547.1	22,297.5	42.8%	33,421.9	28.6%
01-Jun-20	7,801.2	21,127.9	36.9%	33,039.8	23.6%

PJM will dispatch demand resources by zone or subzone for limited, extended summer and annual demand resources, or within a PAI area for Capacity Performance resources. When PJM dispatches all demand resources in multiple connecting zones, PJM further degrades the nodal design of electricity markets. PJM allows compliance to be measured across zones within a compliance aggregation area (CAA) or Emergency Action Area (EAA).^{41 42} A CAA, or EAA, is an electrically connected area that has the same capacity market price. This changes the way CSPs dispatch resources when multiple electrically contiguous areas with the same RPM clearing prices are

⁴⁰ 2018 State of the Market Report for PJM, Volume 2, Section 5: Capacity, Table 5-7.

⁴¹ CAA is "a geographic area of Zones or sub-Zones that are electrically contiguous and experience for the relevant Delivery Year, based on Resource Clear Prices of, for Delivery Years through May 31, 2018, Annual Resources and for the 2018/2019 Delivery Year and subsequent Delivery Years, Capacity Performance Resources, the same locational price separation in the Base Residual Auction, the same locational price separation in the First Incremental Auction, the same locational price separation in the Second Incremental Auction, or the same locational price separation in the Third Incremental Auction." OATT § 1.

⁴² PJM. "Manual 18: Capacity Market," § 8.7.2, Rev. 47 (Jan. 27, 2021).

³⁸ "PJM Manual 18: PJM Capacity Market," § 8.7A, Rev. 47 (Jan. 27, 2021).

³⁹ OATT § 1 (Performance Assessment Hour).

dispatched. The compliance rules determine how CSPs are paid and thus create incentives that CSPs will incorporate in their decisions about how to respond to PJM dispatch. The multiple zone approach is even less locational than the zonal and subzonal approaches and creates larger mismatches between the locational need for the resources and the actual response. If multiple zones within a CAA are called by PJM, a CSP will dispatch the least cost resources across the zones to cover the CSP's obligation. This can result in more MW dispatched in one zone that are locationally distant from the relief needed and no MW dispatched in another zone, yet the CSP could be considered 100 percent compliant and pay no penalties. More locational deployment of load management resources would improve efficiency. With full implementation of capacity performance, demand response will be dispatched by registrations within an area for which an Emergency Action is declared by PJM. PJM does not have the nodal location of each registration, meaning PJM will need to guess as to the useful demand response registration by registered location. The MMU recommends that demand resources be required to provide their nodal location. Nodal dispatch of demand resources would be consistent with the nodal dispatch of generation.

Definition of Compliance

Currently, the calculation methods of event and test compliance do not provide reliable results. PJM's interpretation of load management event rules allows over compliance to be reported when there is no actual over compliance. Settlement locations with a negative load reduction value (load increase) are not netted by PJM within registrations or within demand response portfolios. A resource that has load above their baseline during a demand response event has a negative performance value. PJM limits compliance shortfall values to zero MW. This is not explicitly stated in the Tariff or supporting Manuals and the compliance formulas for FSL and GLD customers do allow negative values.⁴³

Limiting compliance to only positive values incorrectly calculates compliance. For example, if a registration had two locations, one with a 50 MWh load increase when called, and another with a 75 MWh load reduction when called,

⁴³ OA Schedule 1 § 8.9.

PJM calculates compliance for that registration as a 75 MWh load reduction for that event hour. Negative settlement MWh are not netted across hours or across registrations for compliance purposes. A location with a load increase is set to a zero MW reduction. For example, in a two hour event, if a registration showed a 15 MWh load increase in hour one, but a 30 MWh reduction in hour two, the registration would have a calculated 0 MWh reduction in hour one and a 30 MWh reduction in hour two. This has compliance calculated at an average hourly 15 MWh load reduction for that two hour event, compared to a 7.5 MWh observed reduction. Reported compliance is greater than observed compliance, as locations with load increases, i.e. negative reductions, are treated as zero for compliance purposes.

Changing a demand resource compliance calculation from a negative value to 0 MW inaccurately values event performance and capacity performance. Inflated compliance numbers for an event overstates the true value and capacity of demand resources. A demand response capacity resource that performs negatively is also displacing another capacity resource that could supply capacity during a delivery year. By setting the negative compliance value to 0 MW, PJM is inaccurately calculating the value of demand resources.

Load increases are not netted against load decreases for dispatched demand resources across hours or across registrations within hours for compliance purposes, but are treated as zero. This skews the compliance results towards higher compliance since poorly performing demand resources are not used in the compliance calculation. When load is above the peak load contribution during a demand response event, the load reduction is negative; it is a load increase rather than a decrease. PJM ignores such negative reduction values and instead replaces the negative values with a zero MW reduction value. The PJM Tariff and PJM Manuals do not limit the compliance calculation value to a zero MW reduction value.⁴⁴ The compliance values PJM reports for demand response events are different than the actual compliance values accounting for both increases and decreases in load from demand resources that are called on and paid under the program.

⁴⁴ OA Schedule 1 § 8.9.

The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations.

Demand resources that are also registered as economic resources have a calculated CBL for the emergency event days. Demand resources that are not registered as Economic Resources use the three day CBL type with the symmetrical additive adjustment for measuring energy reductions without the requirements of a Relative Root Mean Squared Error (RRMSE) Test required for all economic resources.⁴⁵ The CBL must use the RRMSE test to verify that it is a good approximation for real-time load usage. The MMU recommends the RRMSE test be required for all demand resources with a CBL.

The CBL for a customer is an estimate of what load would have been if the customer had not responded to LMP and reduced load. The difference between the CBL and real-time load is the energy reduction. When load responds to LMP by using a behind the meter generator, the energy reduction should be capped at the generation output. Any additional energy reduction is a result of inaccuracy in the CBL estimate rather than an actual reduction. The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output.

An extreme example makes clear the fundamental problems with the use of measurement and verification methods to define the level of power that would have been used but for the DR actions, and the payments to DR customers that result from these methods. The current rules for measurement and verification for demand resources make a bankrupt company, a customer that no longer exists due to closing of a facility or a permanently shut down company, or a company with a permanent reduction in peak load due to a partial closing of a facility, an acceptable demand response customer under some interpretations of the tariff, although it is the view of the MMU that such customers should not be permitted to be included as registered demand resources. Companies that remain in business, but with a substantially reduced load, can maintain their pre-bankruptcy FSL (firm service level to which the customer agrees to

⁴⁵ 157 FERC ¶ 61,067 (2016).

reduce in an event) commitment, which can be greater than or equal to the post-bankruptcy peak load. The customer agrees to reduce to a level which is greater than or equal to its new peak load after bankruptcy. When demand response events occur the customer would receive credit for 100 percent reduction, even though the customer took no action and could take no action to reduce load. This problem exists regardless of whether the customer is still paying for capacity. To qualify and participate as a demand resource, the customer must have the ability to reduce load. “A participant that has the ability to reduce a measurable and verifiable portion of its load, as metered on an EDC account basis.”⁴⁶ Such a customer no longer has the ability to reduce load in response to price or a PJM demand response event. CSPs in PJM have and continue to register bankrupt customers as emergency or pre-emergency load response customers. PJM finds acceptable the practice of CSPs maintaining the registration of customers with a bankruptcy related reduction in demand that are unable, as a result, to respond to emergency events. Three proposals that included language to remove bankrupt customers from a CSP’s portfolio failed at the June 7, 2017, Market Implementation Committee.⁴⁷ The registered customers that are bankrupt and the amount of registered MW cannot be released for reasons of confidentiality.

The metering requirement for demand resources is outdated, and has not kept up with the changes to PJM’s market design. PJM moved to five minute settlements, but the metering requirement for demand resources remained at an hourly interval meter. It is impossible to measure energy usage on a five minute basis using an hourly interval meter. PJM will estimate real-time usage by prorating the hourly interval meter and assume if load is less than the CBL, that the reduction occurred during the required dispatch window. The meter reading is not telemetered to PJM in real time. The resource is allowed up to 60 days to report the data to PJM. The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that

⁴⁶ OA Schedule 1 § 8.2.

⁴⁷ There was one proposal from PJM, one proposal from a market participant and one proposal from the MMU. See *Approved Minutes from the Market Implementation Committee*, <<http://www.pjm.com/-/media/committees-groups/committees/mic/20170607/20170607-minutes.ashx>>.

dispatchers have the necessary information for reliability and that market payments to demand resources be calculated based on interval meter data at the site of the demand reductions so that they can accurately measure compliance.⁴⁸

When demand resources are not dispatched during a mandatory response window, each CSP must test their portfolio to the levels of capacity commitment.⁴⁹ A CSP picks the testing day, for one hour, on any non-holiday weekday during the applicable mandatory window. A CSP is able to retest if a resource fails to provide the required reduction by less than 25 percent. The ability of CSPs to pick the test time does not simulate emergency conditions. As a result, test compliance is not an accurate representation of the capability of the resource to respond to an actual PJM dispatch of the resource. Given that demand resources are now an annual product, multiple tests are required to ensure reduction capability year round. The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event.

Table 6-12 shows the test penalties by delivery year by product type for the 2015/2016 Delivery Year through the 2019/2020 Delivery Year.⁵⁰ The shortfall MW are calculated for each CSP by zone. The weighted rate per MW is the average penalty rate paid per MW. The total penalty column is the sum of the daily test penalties by delivery year and type. The testing window for the limited product is open through September. The testing window for the extended summer, annual and Capacity Performance product is open through the end of the delivery year.

Table 6-12 Test penalties by delivery year by product type: 2015/2016 through 2019/2020

Product Type	2015/2016			2016/2017			2017/2018			2018/2019			2019/2020		
	Shortfall MW	Weighted Rate per MW	Total Penalty	Shortfall MW	Weighted Rate per MW	Total Penalty	Shortfall MW	Weighted Rate per MW	Total Penalty	Shortfall MW	Weighted Rate per MW	Total Penalty	Shortfall MW	Weighted Rate per MW	Total Penalty
Limited	96.4	\$165.35	\$5,836,255	48.9	\$166.41	\$2,967,158	13.9	\$124.08	\$631,665	0.0	\$179.80	\$2,100			
Extended Summer	1.9	\$163.70	\$113,835	7.3	\$138.14	\$370,290	10.5	\$142.86	\$547,928						
Annual	3.7	\$184.67	\$250,621	4.8	\$137.45	\$241,406	16.3	\$144.00	\$855,940						
Base DR and EE										16.3	\$186.80	\$1,110,134	30.2	\$154.69	\$1,712,177
Capacity Performance				2.1	\$160.80	\$124,310	0.6	\$181.80	\$40,146	2.6	\$188.55	\$178,795			
Total	102.0	\$166.02	\$6,200,711	63.1	\$160.72	\$3,703,163	41.3	\$137.54	\$2,075,678	18.9	\$187.03	\$1,291,030	30.2	\$154.69	\$1,712,177

Emergency and Pre-Emergency Load Response Energy Payments

Emergency and pre-emergency demand response dispatched during a load management event by PJM are eligible to receive emergency energy payments if registered under the full program option. The full program option includes an energy payment for load reductions during a pre-emergency or emergency event for demand response events and capacity payments.⁵¹ There were 98.2 percent of nominated MW for the 2019/2020 Delivery Year registered under the full program option. There were 1.8 percent of nominated MW for the 2019/2020 Delivery Year registered as capacity only option. Demand resources clear the capacity market like all other capacity resources and the dispatch of demand resources should not trigger a scarcity event. The strike price is set by the CSP

48 See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

49 The mandatory response time for Limited DR is June through September between 12:00PM to 8:00PM EPT, for Extended Summer is June through October and the following May between 10:00AM to 10:00PM EPT, for Annual DR is June through October and the following May between 10:00AM to 10:00PM and is November through April between 6:00AM to 9:00PM EPT, for Base Capacity DR is June through September between 10:00AM to 10:00PM EPT, Capacity Performance DR is June through October and the following May between 10:00AM to 10:00PM EPT and November through April between 6:00AM through 9:00PM EPT. See PJM. "Manual 18: PJM Capacity Market," Rev. 46 (Nov. 19 2020).

50 Not all products received penalties or existed in every delivery year. For example, the Base and Capacity Performance products were not an option for the 2015/2016 Delivery Year.

51 *Id.*

before the delivery year starts and cannot be changed during the delivery year. The demand resource energy payments are equal to the higher of hourly zonal LMP or a strike price energy offer made by the participant, including a dollar per MWh minimum dispatch price and an associated shutdown cost. Demand resources should not be permitted to offer above \$1,000 per MWh without cost justification or to include a shortage penalty in the offer. FERC has stated clearly that demand resources in the capacity market must verify costs above \$1,000 per MWh, unless they are capacity only: “We clarify, however, that reforms adopted in this Final Rule, which provide that resources are eligible to submit cost-based incremental energy offers in excess of \$1,000/MWh and require that those offers be verified, do not apply to capacity-only demand response resources that do not submit incremental energy offers in energy markets.”⁵² PJM interprets the scarcity pricing rules to allow a maximum DR energy price of \$1,849 per MWh for the 2019/2020 Delivery Year.^{53 54} Demand resources registered with the full option should be required to verify energy offers in excess of \$1,000 per MWh. PJM does not require such verification.⁵⁵ The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources.

Shutdown costs for demand response resources are not adequately defined in Manual 15. PJM’s Cost Development Subcommittee (CDS) approved changes to Manual 15 to eliminate shutdown costs for demand response resources participating in the synchronized reserve market, but not demand resources or economic resources.⁵⁶

Table 6-13 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2019/2020 Delivery Year. The majority of participants, 75.2 percent of locations and 56.6 percent of nominated MW, have a minimum dispatch price between \$1,550 and \$1,849 per MWh, the maximum price allowed for the 2019/2020 Delivery Year, 3.6 percent of locations and 3.6 percent of

nominated MW have a dispatch price between \$0 and \$1,000 per MWh, and 96.4 percent of locations and 96.4 percent of nominated MW have a dispatch price above \$1,000 per MWh. The shutdown cost of resources with \$1,000 to \$1,275 per MWh strike prices had the highest average at \$181.18 per location and \$142.07 per nominated MW.

Table 6-13 Distribution of registrations and associated MW in the full option across ranges of minimum dispatch: 2019/2020 Delivery Year

Ranges of Strike Prices (\$/MWh)	Locations	Percent of Total	Nominated MW (ICAP)	Percent of Total	Shutdown Cost Per Nominated MW (ICAP)	
					Cost per Location	Nominated MW (ICAP)
\$0-\$1,000	530	3.6%	339.5	3.6%	\$46.98	\$86.48
\$1,000-\$1,275	2,766	18.8%	3,385.2	36.0%	\$181.18	\$142.07
\$1,275-\$1,550	350	2.4%	364.9	3.9%	\$57.49	\$55.14
\$1,550-\$1,849	11,069	75.2%	5,323.3	56.6%	\$49.79	\$103.53
Total	14,715	100.0%	9,412.8	100.0%	\$74.57	\$116.57

Table 6-14 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2020/2021 Delivery Year. The majority of participants, 76.7 percent of locations and 52.9 percent of nominated MW, have a minimum dispatch price between \$1,550 and \$1,849 per MWh, the maximum price allowed for the 2020/2021 Delivery Year, 1.7 percent of locations and 2.9 percent of nominated MW have a dispatch price between \$0 and \$1,000 per MWh, and 98.3 percent of locations and 97.1 percent of nominated MW have a dispatch price above \$1,000 per MWh. The shutdown cost of resources with \$1,000 to \$1,275 per MWh strike prices had the highest average at \$154.45 per location and \$136.42 per nominated MW.

⁵² 161 FERC ¶ 61,153 at P 8 (2017).

⁵³ 139 FERC ¶ 61,057 (2012).

⁵⁴ FERC accepted proposed changes to have the maximum strike price for 30 minute demand response to be \$1,000/MWh + 1*Shortage penalty - \$1.00, for 60 minute demand response to be \$1,000/MWh + (Shortage Penalty/2) and for 120 minute demand response to be \$1,100/MWh from ER14-822-000.

⁵⁵ OATT Attachment K Appendix Section 1.10.1A Day-Ahead Energy Market Scheduling (d) (x).

⁵⁶ “PJM Manual 15: Cost Development Guidelines,” § 8.1, Rev. 37 (Dec. 9, 2020).

Table 6-14 Distribution of registrations and associated MW in the full option across ranges of minimum dispatch: 2020/2021 Delivery Year

Ranges of Strike Prices (\$/MWh)	Locations	Percent of Total	Nominated MW (ICAP)	Percent of Total	Shutdown Cost per Location	Shutdown Cost Per Nominated MW (ICAP)
\$0-\$1,000	243	1.7%	222.4	2.9%	\$68.14	\$30.96
\$1,000-\$1,275	2,771	19.2%	3,102.7	39.8%	\$154.45	\$136.42
\$1,275-\$1,550	355	2.5%	345.0	4.4%	\$53.93	\$55.49
\$1,550-\$1,849	11,077	76.7%	4,118.9	52.9%	\$54.39	\$146.27
Total	14,446	100.0%	7,788.9	100.0%	\$73.80	\$136.88

PRD

The PRD rules are more aligned with the Capacity Performance construct effective December 30, 2019, although the rules still fall short.⁵⁷ PJM's initial filing was rejected by the Commission based on the MMU's comments and PJM's modified filing was accepted.⁵⁸ PJM's final filing adopted the MMU's recommendation to exclude the use of Winter Peak Load (WPL) when calculating the nominated MW for PRD resources used to satisfy RPM commitments. Load is allocated capacity obligations based on the annual peak load within PJM. The amount of capacity allocated to load is a function solely of summer coincident peak demand and is unaffected by winter demand. Use of the WPL to calculate the nominated MW for PRD resources to satisfy RPM commitments, would incorrectly restrict PRD to less than the total capacity the customer is required to buy. PJM's adoption of the MMU recommendation will correctly value PRD nominated MW. FERC required and PJM's filing also adopted, the MMU's recommendation that PRD should be eligible for bonus performance payments during Performance Assessment Intervals (PAI) only when PRD resources respond above their nominated MW value. Allowing PRD resources to collect bonus payments at times when they are not even required to meet their basic obligation would be inconsistent with the basic CP construct as it applies to all other CP resources.⁵⁹

57 See "Compliance Filing Regarding Price Responsive Demand Rules," Docket No. ER20-271-001 (February 28, 2020).

58 See "Order Rejecting Tariff Revisions," Docket No. ER19-1012-000 (June 27, 2019).

59 October 31 Filing, Attachment B, Proposed Revised OATT § 10A (c).

PJM's filing still fell short of completely aligning PRD with the Capacity Performance product. PRD resources will not have to respond during a PAI if the PAI's trigger price is above LMP during the PAI. All other CP resources have the obligation to perform during a PAI, regardless of the real-time LMP, subject to instructions from PJM. PRD should be held to the same standard during a PAI event.

PRD does not receive direct capacity or energy payments. PRD reduces the amount of capacity that must be purchased by the LSE and therefore reduces the LSE's payments for capacity. When PRD load is not on the system, that load also avoids paying for the associated energy. PRD meets its obligation by responding when LMP is at or above price thresholds defined in the PRD plan.⁶⁰ PRD does not have to respond during performance assessment intervals (PAI) and therefore is inferior to other capacity resources and is not a substitute for other capacity resources in the capacity performance construct. The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. PRD first cleared the capacity market in the BRA for the 2020/2021 Delivery Year, and cleared for the 2021/2022 Delivery Year.⁶¹

Economic Load Response Program

The Economic Load Response Program is for demand response customers that offer into the day-ahead or real-time energy market. The estimated load reduction is paid the zonal LMP, as long as the zonal LMP is greater than the monthly Net Benefits Test threshold.

Market Structure

Table 6-15 shows the average hourly HHI for each month and the average hourly HHI for January 1, 2010, through March 31, 2021. The ownership of economic demand response resources was highly concentrated in 2020 and 2021.⁶² Table 6-15 lists the share of reported reductions provided by, and the share of credits claimed by the four largest CSPs in each year. In the first three months of 2021, 95.8 percent of all economic DR reported reductions

60 The Demand Response Subcommittee (DRS) is currently working to align PRD with the CP designed products.

61 There were a total of 558 MW of cleared PRD in the 2020/2021 Delivery Year. See PJM Auction Results, <<https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2020-2021-base-residual-auction-results.ashx?la=en>>.

62 All HHI calculations in this section are at the parent company level.

and 83.1 percent of economic DR revenue were attributable to the four largest CSPs. The HHI for economic demand response was highly concentrated for the first three months of 2021. The annual HHI for economic demand response decreased by 1048 from 9065 for 2020 to 8017 for the first three months of 2021.

Table 6-15 Average hourly MWh HHI and market concentration in the economic program: January 2020 through March 2021⁶³

Month	Average Hourly MWh HHI			Top Four CSPs Share of Reduction			Top Four CSPs Share of Credit		
	2020	2021	Percent Change	2020	2021	Change in Percent	2020	2021	Change in Percent
	Jan	8983	9305	3.6%	98.1%	99.3%	1.2%	98.3%	98.6%
Feb	9652	7632	(20.9%)	100.0%	96.1%	(3.9%)	100.0%	91.8%	(8.2%)
Mar	9857	10000	1.5%	100.0%			100.0%		
Apr	10000								
May	9926								
Jun	8976			100.0%			99.9%		
Jul	8442			88.8%			90.2%		
Aug	8344			93.5%			93.1%		
Sep	8893			100.0%			100.0%		
Oct	9400								
Nov	8121			100.0%			100.0%		
Dec	7745								
Total	9065	8017	(11.6%)	82.3%	95.8%	13.5%	82.8%	83.1%	0.4%

Market Performance

Table 6-16 shows the total MW reported reductions made by participants in the economic program and the total credits paid for these reported reductions in the first three months of 2010 through 2021. The average credits per MWh paid decreased by \$5.93 per MWh, 11.0 percent, from \$28.06 per MWh in the first three months of 2020 to \$22.13 per MWh in the first three months of 2021. The PJM real-time, load-weighted, average LMP was 36.3 percent higher in the first three months of 2021 than in the first three months of 2020, from \$20.12 per MWh to \$31.58 per MWh. Curtailed energy for the economic program increased by 1,818 MWh, 149.5 percent, from 1,216 MWh in the first three months of 2020 to 3,034 MWh in the first three months of 2021. Total

⁶³ April, May, June and December 2020 reduction and credit share percent are redacted based on confidentiality rules. Data for March 2021 not available at time of publication.

credits paid for the economic load response program in the first three months of 2021 increased by \$0.03 million, 96.8 percent, from \$0.03 million in the first three months of 2020 to \$0.07 million in the first three months of 2021.

Table 6-16 Credits paid to economic program participants: January 2010 through March 2021

(Jan-Mar)	Total MWh	Total Credits	\$/MWh
2010	8,139	\$321,648	\$39.52
2011	3,272	\$240,304	\$73.45
2012	1,030	\$30,406	\$29.52
2013	21,048	\$1,083,755	\$51.49
2014	58,195	\$12,727,388	\$218.70
2015	38,644	\$4,175,116	\$108.04
2016	16,038	\$672,506	\$41.93
2017	12,973	\$534,378	\$41.19
2018	14,623	\$951,955	\$65.10
2019	7,260	\$390,708	\$53.82
2020	1,216	\$34,124	\$28.06
2021	3,034	\$67,154	\$22.13

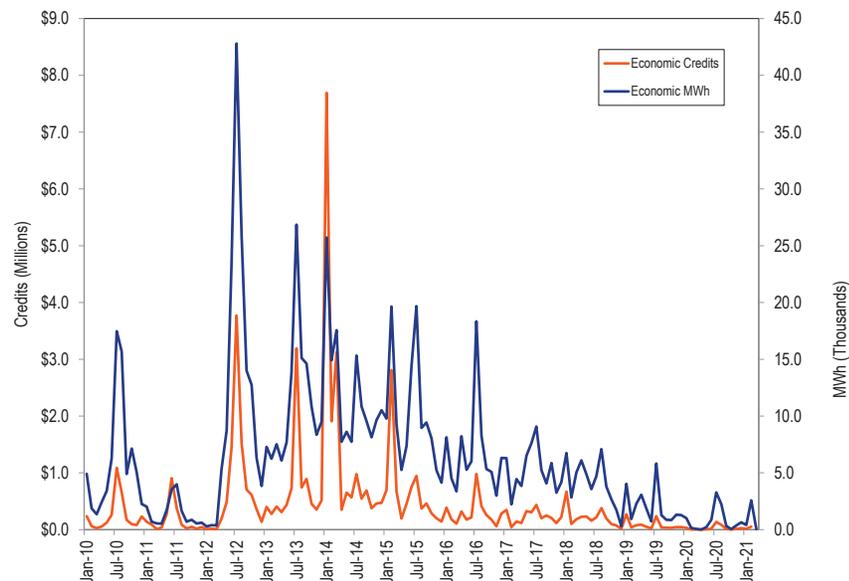
Economic demand response resources that are dispatched by PJM in both the economic and emergency programs are paid the higher price defined in the emergency rules.⁶⁴ For example, assume a demand resource has an economic offer price of \$100 per MWh and an emergency strike price of \$1,800 per MWh. If this resource were scheduled to reduce in the day-ahead energy market, the demand resource would receive \$100 per MWh, but if an emergency event were called during the economic dispatch, the demand resource would receive its emergency strike price of \$1,800 per MWh instead. The rationale for this rule is not clear.⁶⁵ All other resources that clear in the day-ahead market are financially firm at the clearing price. Payment at a guaranteed strike price and the ability to set energy market prices at the strike price effectively grant the seller the right to exercise market power.

⁶⁴ PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 10.4.5, Rev. 112 (Jan. 5, 2021).

⁶⁵ FERC Order No. 831.

Figure 6-2 shows monthly economic demand response credits and MWh, from January 1, 2010, through March 31, 2021.⁶⁶

Figure 6-2 Economic program credits and MWh by month: 2010 through December 2020



⁶⁶ Data for March 2021 not available at time of publication.

Table 6-17 shows performance for the first three months of 2020 and 2021 in the economic program by control zone. Total reported reductions under the economic program increased by 1,818 MWh, 149.5 percent, from 1,216 MWh in the first three months of 2020 to 3,034 MWh in the first three months of 2021. Total revenue under the economic program increased by \$0.03 million, 96.8 percent, from \$0.03 million in the first three months of 2020 to \$0.07 million in the first three months of 2021.⁶⁷

Emergency and economic demand response energy payments are uplift and not compensated by LMP revenues. Economic demand response energy costs are assigned to real-time exports from the PJM Region and real-time loads in each zone for which the load-weighted average real-time LMP for the hour during which the reduction occurred is greater than the price determined under the net benefits test for that month.⁶⁸ The zonal allocation is shown in Table 6-17.

⁶⁷ Economic demand response reductions that are submitted to PJM for payment but have not received payment are not included in Table 6-17. Payments for Economic demand response reductions are settled monthly.
⁶⁸ "PJM Manual 28: Operating Agreement Accounting," § 11.2.2, Rev. 84 (Dec. 17, 2020).

Table 6-17 Economic program participation by zone: January through March, 2020 and 2021

Zones	Credits			MWh Reductions			Credits per MWh Reduction		
	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change
ACEC	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
AEP	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
APS	\$0.00	\$0.00	NA	0	70	NA	NA	NA	NA
ATSI	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
BGE	\$0.00	\$0.00	NA	0	48	NA	NA	NA	NA
COMED	\$910.28	\$4,295.30	371.9%	49	52	6.0%	\$18.61	\$82.81	345.0%
DAY	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
DUKE	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
DUQ	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
DOM	\$0.00	\$573.38	NA	0	16	NA	NA	\$35.85	NA
DPL	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
JCPLC	\$1,876.10	\$0.00	NA	0	0	NA	NA	NA	NA
MEC	\$2,293.46	\$2,370.31	3.4%	74	31	(57.9%)	\$31.09	\$76.40	145.7%
OVEC	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
PECO	\$3,509.34	\$9,929.00	182.9%	86	1,220	1,318.4%	\$40.80	\$8.14	(80.1%)
PE	\$10,128.45	\$16,557.70	63.5%	372	479	28.6%	\$27.22	\$34.60	27.1%
PEPCO	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
PPL	\$0.00	\$0.00	NA	0	727	NA	NA	NA	NA
PSEG	\$15,406.59	\$33,428.60	117.0%	635	391	(38.4%)	\$24.25	\$85.43	252.3%
REC	\$0.00	\$0.00	NA	0	0	NA	NA	NA	NA
Total	\$34,124.22	\$67,154.29	96.8%	1,216	3,034	149.5%	\$28.06	\$22.13	(21.1%)

Table 6-18 shows average reported MWh reductions and credits by hour for the first three months of 2020 and 2021. The average LMP during Load Response is the reduction weighted average hourly DA or RT load weighted LMP during the economic load response hour. In the first three months of 2020, 50.1 percent of the reported reductions and 50.2 percent of credits occurred in hours ending 0900 to 2100, and in the first three months of 2021, 61.9 percent of the reported reductions and 61.2 percent of credits occurred in hours ending 0900 to 2100.

Table 6-18 Hourly frequency distribution of economic program reported MWh reductions and credits: 2020 and March 2021

Hour Ending (EPT)	MWh Reductions			Program Credits		
	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change
1 through 6	427	985	131%	\$13,366	\$17,218	29%
7	86	201	134%	\$2,052	\$3,809	86%
8	76	169	123%	\$1,290	\$3,805	195%
9	52	240	359%	\$1,132	\$3,394	200%
10	62	240	289%	\$1,098	\$3,028	176%
11	65	242	275%	\$1,190	\$3,185	168%
12	75	246	227%	\$1,844	\$3,312	80%
13	114	309	170%	\$4,084	\$5,665	39%
14	117	312	166%	\$3,842	\$5,994	56%
15	79	203	157%	\$2,286	\$5,202	128%
16	42	132	211%	\$1,355	\$3,221	138%
17	17	107	525%	\$534	\$2,874	439%
18	3	89	2,968%	\$39	\$2,064	5,204%
19	1	78	7,012%	\$14	\$1,303	9,410%
20	39	0	(100%)	\$659	\$0	(100%)
21	39	0	(100%)	\$589	\$0	(100%)
22	38	0	(100%)	\$569	\$0	(100%)
23 through 24	76	0	(100%)	\$1,264	\$0	(100%)
Total	1,407	3,552	152%	\$37,205	\$64,073	72%

Table 6-19 shows the distribution of economic program reported MWh reductions and credits by ranges of real-time zonal, load-weighted, average LMP in the first three months of 2020 and 2021. In the first three months of 2021, 1.5 percent of reported MWh reductions and 5.4 percent of program credits occurred during hours when the applicable zonal LMP was higher than \$175 per MWh.

Table 6-19 Frequency distribution of economic program zonal, load-weighted, average LMP (By hours): January 2020 through March 2021

LMP	MWh Reductions			Program Credits		
	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change	2020 (Jan-Mar)	2021 (Jan-Mar)	Percent Change
\$0 to \$25	786	246	(69%)	\$18,070	\$5,707	(68%)
\$25 to \$50	404	1,851	358%	\$14,998	\$20,183	35%
\$50 to \$75	16	381	2,260%	\$715	\$8,448	1,082%
\$75 to \$100	10	253	2,509%	\$341	\$15,263	4,378%
\$100 to \$125	0	175	100%	\$0	\$8,973	100%
\$125 to \$150	0	59	100%	\$0	\$3,814	100%
\$150 to \$175	0	22	100%	\$0	\$1,167	100%
> \$175	0	46	100%	\$0	\$3,599	100%
Total	1,216	3,034	149%	\$34,124	\$67,154	97%

Economic Load Response revenues are paid by real-time loads and real-time scheduled exports as an uplift charge. Table 6-20 shows the sum of real-time and day-ahead Economic Load Response charges paid in each zone and paid by exports. Real-time loads in AEP paid the highest Economic Load Response charges in the first three months of 2021.

Table 6-20 Zonal Economic Load Response charge: January through February, 2021⁶⁹

Zone	January	February	Total
ACEC	\$142	\$530	\$672
AEP	\$2,443	\$7,881	\$10,323
APS	\$980	\$3,168	\$4,147
ATSI	\$1,214	\$3,850	\$5,064
BGE	\$586	\$1,974	\$2,560
COMED	\$1,578	\$5,424	\$7,002
DAY	\$329	\$1,092	\$1,420
DUKE	\$499	\$1,662	\$2,161
DUQ	\$241	\$759	\$1,000
DOM	\$2,135	\$6,704	\$8,839
DPL	\$313	\$1,194	\$1,507
EKPC	\$273	\$988	\$1,261
JCPLC	\$298	\$1,253	\$1,551
MEC	\$243	\$970	\$1,213
OVEC	\$2	\$7	\$9
PECO	\$606	\$2,334	\$2,940
PE	\$333	\$1,043	\$1,376
PEPCO	\$488	\$1,815	\$2,303
PPL	\$658	\$2,598	\$3,257
PSEG	\$785	\$2,423	\$3,208
REC	\$25	\$76	\$101
Exports	\$681	\$4,559	\$5,239
Total	\$14,851	\$52,303	\$67,154

⁶⁹ Load response charges were calculated as of April 21, 2021 and may change as a result of continued PJM billing updates.

Table 6-21 shows the total zonal Economic Load Response charge per GWh of real-time load and exports in the first three months of 2021.

Table 6-21 Zonal economic load response charge per GWh of load and exports: January through March, 2021

Zone	January	February	March	Zonal Average
ACEC	\$0.000	\$0.001	\$0.000	\$0.000
AEP	\$0.000	\$0.001	\$0.000	\$0.000
APS	\$0.000	\$0.001	\$0.000	\$0.000
ATSI	\$0.000	\$0.001	\$0.000	\$0.000
BGE	\$0.000	\$0.001	\$0.000	\$0.000
COMED	\$0.000	\$0.001	\$0.000	\$0.000
DAY	\$0.000	\$0.001	\$0.000	\$0.000
DUKE	\$0.000	\$0.001	\$0.000	\$0.000
DUQ	\$0.000	\$0.001	\$0.000	\$0.000
DOM	\$0.000	\$0.001	\$0.000	\$0.000
DPL	\$0.000	\$0.001	\$0.000	\$0.000
EKPC	\$0.000	\$0.001	\$0.000	\$0.000
JCPLC	\$0.000	\$0.001	\$0.000	\$0.000
MEC	\$0.000	\$0.000	\$0.000	\$0.000
OVEC	\$0.000	\$0.001	\$0.000	\$0.000
PECO	\$0.000	\$0.001	\$0.000	\$0.000
PE	\$0.000	\$0.001	\$0.000	\$0.000
PEPCO	\$0.000	\$0.001	\$0.000	\$0.000
PPL	\$0.000	\$0.001	\$0.000	\$0.000
PSEG	\$0.000	\$0.001	\$0.000	\$0.000
REC	\$0.000	\$0.001	\$0.000	\$0.000
Exports	\$0.000	\$0.001	\$0.000	\$0.000
Monthly Average	\$0.000	\$0.001	\$0.000	\$0.000

Table 6-22 shows the monthly day-ahead and real-time Economic Load Response charges for 2020 through March 2021. The day-ahead Economic Load Response charges increased by \$0.03 million, 86.1 percent, from \$0.03 million in the first three months of 2020 to \$0.06 million in the first three months of 2021. The real-time Economic Load Response charges increased \$5.3 thousand, 272.1 percent, from \$1.9 thousand in the first three months of 2020 to \$7.3 thousand in the first three months of 2021.

Table 6-22 Monthly day-ahead and real-time economic load response charge: 2020 through March 2021⁷⁰

Month	Day-ahead Economic Load Response Charge			Real-time Economic Load Response Charge		
	2020	2021	Percent Change	2020	2021	Percent Change
Jan	\$28,908	\$14,204	(50.9%)	\$1,391	\$648	(53.5%)
Feb	\$2,317	\$45,645	1,870.3%	\$335	\$6,658	1,889.4%
Mar	\$936			\$237		
Apr	\$0		NA	\$197		
May	\$4,315			\$1,846		
Jun	\$11,138			\$5,458		
Jul	\$87,384			\$49,176		
Aug	\$70,100			\$14,727		
Sep	\$10,140			\$525		
Oct	\$1,694			\$331		
Nov	\$10,064			\$1,596		
Dec	\$25,410			\$894		
Total	\$252,407	\$59,849	(76.3%)	\$76,712	\$7,305	(90.5%)

Table 6-23 shows registered sites and MW for the last day of each month for the period January 1, 2015, through March 31, 2020. Registration is a prerequisite for CSPs to participate in the economic program. Average monthly registrations decreased by 87, 23.0 percent, from 380 in the first three months of 2020 to 292 in the first three months of 2021. Average monthly registered MW decreased by 1,396 MW, 47.8 percent, from 2,920 MW in the first three months of 2020 to 1,524 MW in the first three months of 2021.

Most economic demand response resources are registered in the emergency demand response program. Resources registered in both programs do not need to register for the same amount of MW. There are 98 economic registrations and 107 capacity registrations in the emergency program that share the same location ids in both programs. There are 804 nominated economic MW and 517 nominated capacity MW in the emergency program that share the same location ids in both programs

⁷⁰ Data for March 2021 not available at time of publication.

Table 6-23 Economic program registrations on the last day of the month: 2015 through March 2021⁷¹

Month	2015		2016		2017		2018		2019		2020		2021	
	Registrations	Registered MW												
Jan	1,078	2,960	838	2,557	871	2,603	537	2,570	374	2,651	377	2,909	282	1,502
Feb	1,076	2,956	835	2,557	842	2,578	537	2,628	370	2,640	382	2,912	281	1,514
Mar	1,075	2,949	834	2,556	850	2,576	519	2,641	378	2,648	380	2,941	314	1,557
Apr	1,076	2,938	832	2,556	897	2,574	501	2,624	366	2,594	350	2,917		
May	980	2,846	829	2,545	977	2,626	471	2,615	372	3,193	308	2,824		
Jun	871	2,614	518	2,500	577	1,305	397	2,576	370	2,768	285	1,418		
Jul	870	2,609	519	2,421	589	1,548	374	2,591	376	2,899	283	1,453		
Aug	869	2,609	805	2,569	590	1,541	382	2,609	360	2,885	292	1,482		
Sep	867	2,608	831	2,608	588	1,663	378	2,580	368	2,954	297	1,566		
Oct	858	2,568	822	2,564	574	1,660	382	2,584	375	2,909	275	1,361		
Nov	851	2,566	820	2,564	559	1,662	381	2,581	379	3,051	280	1,375		
Dec	850	2,566	807	2,561	556	1,659	392	2,671	383	3,070	282	1,327		
Avg	974	2,788	774	2,547	706	2,000	438	2,606	373	2,855	316	2,040	292	1,524

The registered MW in the economic load response program are not a good measure of the MW available for dispatch in the energy market. Economic resources can dispatch up to the amount of MW registered in the program, but are not required to offer any MW. Table 6-24 shows the sum of peak economic MW dispatched by registration each month from January 1, 2010, through March 31, 2021. The monthly peak is the sum of each registration's monthly noncoincident peak dispatched MW and annual peak is the sum of each registration's annual noncoincident peak dispatched MW. The peak dispatched MW for all economic demand response registered resources increased by 26.4 MW, 89.8 percent, from 29 MW in the first three months of 2020 to 56 MW in the first three months of 2021.⁷² The peak dispatched MW in 2020, 135 MW, were 2,140 MW less than the average MW registered in 2020, 2,275 MW.

Table 6-24 Sum of peak MW reported reductions for all registrations per month: 2010 through March 2021

Month	Sum of Peak MW Reductions for all Registrations per Month											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jan	183	132	110	193	446	169	139	123	142	88	28	21
Feb	121	89	101	119	307	336	128	83	70	58	11	55
Mar	115	81	72	127	369	198	120	111	71	38	12	6
Apr	111	80	108	133	146	143	118	54	71	41	3	
May	172	98	143	192	151	161	131	169	70	22	12	
Jun	209	561	954	433	483	833	121	240	105	26	38	
Jul	999	561	1,631	1,088	665	1,362	1,316	936	518	770	135	
Aug	794	161	952	497	358	272	249	141	581	33	99	
Sep	276	84	451	530	795	816	263	140	112	76	31	
Oct	118	81	242	168	214	136	150	88	69	29	9	
Nov	111	86	165	155	166	127	116	81	54	35	12	
Dec	114	88	98	168	155	122	147	83	11	31	5	
Annual	1,202	840	1,942	1,486	1,739	1,858	1,451	1,217	758	830	196	56

⁷¹ Data for years 2010 through 2014 are available in the 2018 State of the Market Report for PJM.

⁷² The total credits and MWh numbers for demand resources were calculated as of April 21, 2021 and may change as a result of continued PJM billing updates.

Table 6-25 shows total settlements submitted for the first three months of 2010 through 2021. A settlement is counted for every day on which a registration is dispatched in the economic program.

Table 6-25 Settlements submitted in the economic program: 2010 through March 2021

(Jan-Mar)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Number of Settlements	693	91	21	368	1,314	602	267	347	361	172	83	123

Table 6-26 shows the number of CSPs, and the number of participants in their portfolios, submitting settlements for the first three months of 2010 through 2021. The number of active participants increased by 9, 100 percent, from 9 in the first three months of 2020 to 18 in the first three months of 2021. All participants must be registered through a CSP.

Table 6-26 Participants and CSPs submitting settlements in the economic program by year: 2010 through March 2021

(Jan-Mar)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Active CSPs	5	5	4	9	12	11	6	6	11	9	7	7
Active Participants	90	25	9	49	115	47	17	19	26	18	9	18

Issues

FERC Order No. 831 requires that each RTO/ISO market monitoring unit verify all energy offers above \$1,000 per MWh.⁷³ Economic resources offer into the energy market and must provide supporting documentation to offer above \$1,000 per MWh. FERC stated, “[t]he offer cap reforms, however, do not apply to capacity-only demand response resources that do not submit incremental energy offers into energy markets.”⁷⁴ Demand resources participate in both the capacity and energy markets and are not capacity only resources. It is not clear whether FERC intended to exclude demand resources with high strike prices from the requirements of FERC Order No. 831. Demand resources should not be permitted to make offers above \$1,000 per MWh without the same verification requirements applied to economic resources or generation resources. The MMU recommends that the rules for maximum offer for the

⁷³ 157 FERC ¶ 61,115 at P 139 (2016).

⁷⁴ *Id.* at 8.

emergency and pre-emergency program match the maximum offer for generation resources.

On April 1, 2012, FERC Order No. 745 was implemented in the PJM economic program, requiring payment of full LMP for dispatched demand resources when a net benefits test (NBT) price threshold is exceeded. This approach replaced the payment of LMP minus the charges for wholesale power and transmission included in customers’ tariff rates. Following FERC Order No. 745, all ISO/RTOs are required to calculate an NBT threshold price each month above which the net benefits of DR are deemed to exceed the cost to load. PJM calculates the NBT price threshold by first taking the generation offers from the same month of the previous year. For example, the NBT price calculation for February 2017 was calculated using generation offers from February 2016. PJM then adjusts these offers to account for changes in fuel prices and uses these adjusted offers to create an average monthly supply curve. PJM estimates a function that best fits this supply curve and then finds the point on this curve where the elasticity is equal to one.⁷⁵ The price at this point is the NBT threshold price.

The NBT test is a crude tool that is not based in market logic. The NBT threshold price is a monthly estimate calculated from a monthly supply curve that does not incorporate real-time or day-ahead prices. In addition, it is a single threshold price used to trigger payments to economic demand response resources throughout the entire RTO, regardless of their location and regardless of locational prices.

The necessity for the NBT test is an illustration of the illogical approach to demand side compensation embodied in paying full LMP to demand resources. The benefit of demand side resources is not that they suppress market prices, but that customers can choose not to consume at the current price of power, that individual customers benefit from their choices and that the choices of all customers are reflected in market prices. If customers face the market price, customers should have the ability to not purchase power and the market impact of that choice does not require a test for appropriateness.

⁷⁵ “PJM Manual 11: Energy & Ancillary Services Market Operations,” §10.3.1, Rev. 112 (Jan. 5, 2021).

When the zonal LMP is above the NBT threshold price, economic demand response resources that reduce their power consumption are paid the full zonal LMP. When the zonal LMP is below the NBT threshold price, economic demand response resources are not paid for any load reported reductions.

Table 6-27 shows the NBT threshold price for the historical test from August 2010 through July 2011, and April 2012, when FERC Order No. 745 was implemented in PJM, through March 2021. The historical test was used as justification for the method of calculating the NBT for future months. The NBT threshold price has never exceeded the lowest historical test result of \$34.07 per MWh.

Table 6-27 Net benefits test threshold prices: August 2010 through March 2021

Month	Historical Test (\$/MWh)		Net Benefits Test Threshold Price (\$/MWh)									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jan		\$40.27		\$25.72	\$29.51	\$29.63	\$23.67	\$32.60	\$26.27	\$29.44	\$20.04	\$18.11
Feb		\$40.49		\$26.27	\$30.44	\$26.52	\$26.71	\$31.57	\$24.65	\$23.49	\$19.29	\$18.70
Mar		\$38.48		\$25.60	\$34.93	\$24.99	\$22.10	\$30.56	\$25.50	\$22.15	\$17.44	\$20.82
Apr		\$36.76	\$25.89	\$26.96	\$32.59	\$24.92	\$19.93	\$30.45	\$25.56	\$22.36	\$15.91	
May		\$34.68	\$23.46	\$27.73	\$32.08	\$23.79	\$20.69	\$29.77	\$25.52	\$21.01	\$14.69	
Jun		\$35.09	\$23.86	\$28.44	\$31.62	\$23.80	\$20.62	\$27.14	\$23.59	\$20.20	\$15.56	
Jul		\$36.78	\$22.99	\$29.42	\$31.62	\$23.03	\$20.73	\$24.42	\$23.57	\$19.76	\$14.66	
Aug	\$35.57		\$24.47	\$28.58	\$29.85	\$23.17	\$23.24	\$22.75	\$23.53	\$19.57	\$14.58	
Sep	\$34.07		\$24.93	\$28.80	\$29.83	\$21.69	\$24.70	\$21.51	\$22.23	\$18.19	\$15.16	
Oct	\$38.10		\$25.96	\$29.13	\$30.20	\$21.48	\$26.50	\$21.70	\$23.84	\$20.20	\$17.25	
Nov	\$36.83		\$25.63	\$31.63	\$29.17	\$22.28	\$29.27	\$26.41	\$23.89	\$21.11	\$18.35	
Dec	\$37.04		\$25.97	\$28.82	\$29.01	\$22.31	\$29.71	\$29.16	\$26.35	\$22.24	\$19.47	
Average	\$36.32	\$37.51	\$24.80	\$28.09	\$30.91	\$23.97	\$23.99	\$27.34	\$24.54	\$21.64	\$16.87	\$19.21

Table 6-28 shows the number of hours that at least one zone in PJM had day-ahead LMP or real-time LMP higher than the NBT threshold price. In the first three months of 2021, the highest zonal LMP in PJM was higher than the NBT threshold price 2,106 hours out of 2,159 hours, or 97.5 percent of all hours. Reductions occurred in 431 hours, 20.5 percent, of those 2,106 hours in the first three months of 2021. The last three columns illustrate how often economic demand response activity occurred when LMPs exceeded NBT threshold prices for January 1, 2020, through March 31, 2021. There are no economic payments when demand response occurs and zonal LMP is below the NBT threshold. Demand response reported reductions occurred in none of the hours in which LMP was below the NBT threshold price in the first three months of 2021, and 0.3 percent (1 hour) of the hours in which LMP was below the NBT threshold price in 2020.

Table 6-28 Hours with price higher than NBT and economic load response occurrences in those hours: 2020 through March 2021

Month	Number of Hours		Number of Hours with LMP Higher than NBT			Percent of NBT Hours with Economic Load Response		
	2020	2021	2020	2021	Percent Change	2020	2021	Percent Change
Jan	744	744	569	741	30.2%	38.1%	11.9%	(26.3%)
Feb	696	672	513	667	30.0%	15.0%	50.2%	35.2%
Mar	743	743	558	698	25.1%	9.0%	1.1%	(7.8%)
Apr	720		606			2.0%		
May	744		635			19.5%		
Jun	720		495			36.4%		
Jul	744		675			50.1%		
Aug	744		695			24.9%		
Sep	720		648			7.4%		
Oct	744		676			3.3%		
Nov	721		607			14.2%		
Dec	744		712			18.7%		
Total	8,784	2,159	7,389	2,106		19.8%	20.5%	

Energy Efficiency

Calculating the Nominated MW value for Energy Efficiency (EE) resources is different than calculating the Nominated MW value for other capacity resources. The maximum amount of Nominated MW a generator can offer into the capacity market is based on the maximum output of a generator. EE resources do not produce power, but reduce power consumption. The Nominated MW for EE resources are not measured, although they could be, but a calculated value based on a set of largely unverified and unverifiable assumptions.

Figure 6-3 shows the installed EE MW in PJM by technology for the 2019/2020 and 2020/2021 Delivery Years. An installed EE resource may participate as a capacity resource for up to four consecutive delivery years.⁷⁶

Prescriptive energy efficiency MW have an assumed savings calculated based on an assumed installation rate and the difference between the assumed electricity usage of what is being replaced and the assumed electricity usage of the new product. All lighting EE is prescriptive. Prescriptive energy efficiency MW were 86.5 percent of all energy efficiency MW and HVAC,

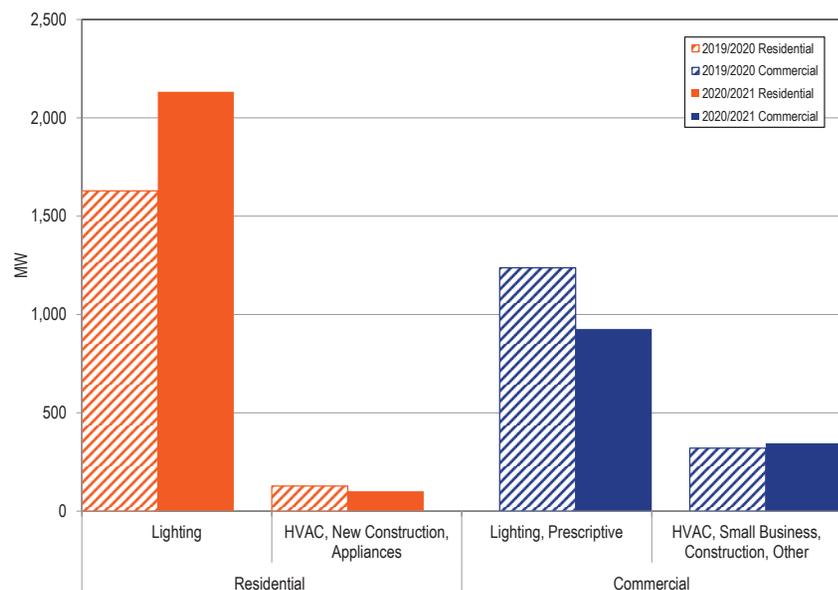
⁷⁶ PJM. "Manual 18: PJM Capacity Market," § 4.4, Rev. 46 (Nov. 19, 2020).

new construction and appliances were 13.5 percent in the 2019/2020 Delivery Year. Prescriptive energy efficiency MW were 85.1 percent and HVAC, new construction and appliances were 14.9 percent in the 2020/2021 Delivery Year. The measurement and verification method for prescriptive energy efficiency projects relies on neither measurement or verification but instead relies on unverified assumptions and is too imprecise to rely on as a source of capacity comparable to capacity from a power plant. The nonprescriptive measurement and verification methods are also inadequate and rely on samples and assumptions for limited periods.⁷⁷ There is no evidence that the programs result in changed behavior or increases in savings.

The MMU recommends that energy efficiency MW not be included in the PJM Capacity Market. The measurement and verification protocols for energy efficiency are too imprecise to rely on as a source of capacity. Effective energy efficiency measures reduce energy usage and capacity usage directly. The reduced market payments are the appropriate compensation.

⁷⁷ PJM. "Manual 18B: Energy Efficiency Measurement & Verification," § 2.2 Rev. 04 (August 22, 2019).

Figure 6-3 Installed energy efficiency MW by type: 2019/2020 and 2020/2021 Delivery Years



Energy efficiency resources are included in the PJM Capacity Market. Table 6-29 shows the amount of energy efficiency (EE) resources in PJM on June 1 for the 2012/2013 through 2019/2020 Delivery Years. EE resources may participate in PJM without restrictions imposed by a state unless the Commission authorizes a state to impose restrictions.⁷⁸ Only Kentucky has been authorized by the Commission.⁷⁹ The total MW of energy efficiency resources committed increased by 10.1 percent from 2,296.3 MW in the 2019/2020 Delivery Year to 2,528.5 MW in the 2020/2021 Delivery Year.⁸⁰

78 See 161 FERC ¶ 61,245 at P 57 (2017); 107 FERC ¶ 61,272 at P 8 (2008).

79 The Commission made an exception for Kentucky when it determined that RERRAs must obtain FERC approval prior to excluding EE, explaining that "the Commission accepted such condition at the time the Kentucky Commission approved the integration of Kentucky Power into PJM." 161 FERC ¶ 61,245 at P 67.

80 See the 2019 State of the Market Report for PJM, Vol. 2, Section 5: Capacity Market, Table 5-13.

Table 6-29 Energy efficiency resources (MW): June 1, 2012 to June 1, 2020

	UCAP (MW)		
	EE RPM Cleared	Total RPM Cleared	EE Percent Cleared
2012/2013	76.4	134,139.6	0.1%
2013/2014	666.1	141,061.8	0.5%
2014/2015	904.2	159,830.5	0.6%
2015/2016	1,077.7	161,092.4	0.7%
2016/2017	1,189.6	173,487.4	0.7%
2017/2018	1,723.2	179,749.0	1.0%
2018/2019	1,922.3	180,590.3	1.1%
2019/2020	2,296.3	175,957.4	1.3%
2020/2021	2,528.5	177,040.6	1.4%

Distributed Energy Resources

Distributed Energy Resources (DER) are not well defined, but generally include small scale generation directly connected to the grid, generation connected to distribution level facilities and behind the meter generation.⁸¹ For example, Table 6-9 shows the fuel mix of behind the meter generation participating as emergency demand response in the 2019/2020 Delivery Year. Clear rules for defining DERs and for defining the ways in which DERs will interact with the wholesale power markets do not yet exist, although the development of those rules is under active discussion.^{82 83} DERs should be treated like other resources. Creating preferential treatment for DERs could create an incentive to move resources behind the meter in a manner inconsistent with efficiency and competitive markets. FERC directed that DER aggregation be as geographically broad as technically feasible.⁸⁴

The current demand response rules appropriately restrict demand response from injecting power into the grid and receiving demand response revenue. At the January 30, 2019, Demand Response Subcommittee meeting, PJM, without a stakeholder process or FERC approval, decided to allow some economic load response payments when economic load response resources injects power into the grid. PJM's test compares the total benefits of running the generator

81 Some energy storage facilities may be DERs. FERC Order No. 841 requires that energy storage resources have access to capacity, energy and ancillary service markets. 162 FERC ¶ 61,127 at P 1 (2018).

82 In PJM, the Distributed Energy Resources Subcommittee (DERSC) is currently discussing these issues. *Distributed Energy Resources Subcommittee*, PJM, <<http://www.pjm.com/committees-and-groups/subcommittees/ders.aspx>>.

83 See "Notice of Technical Conference," Docket No. RM18-9-000 and AD18-10-000 (February 15, 2018); "Technical Conference Distributed Energy Resources," Docket No. RM18-9-000 and AD18-10-000 (April 10, 2018).

84 162 FERC ¶ 32,718 at P 139 (2016).

which includes generation payments and assumed retail rate savings against the total cost of the generator. If the total cost of the generator is greater than the benefits, then the resource would receive economic load response payments while injecting. The use of a retail rate in calculating wholesale power market benefits raises significant issues analogous to net metering that require discussion and tariff changes. PJM should not include retail rate benefits in the definition of demand response without approval of FERC.

Aggregation to a single node is technically feasible. Allowing DER aggregation across nodes is not necessary and is not consistent with the nodal market design. Getting the rules correct at the beginning of DER development is essential to the active and effective participation of DER in the wholesale power markets in a manner that enhances rather than undercuts the efficiency and competitiveness of the power markets.

Net Revenue

The Market Monitoring Unit (MMU) analyzed measures of PJM energy market structure, participant conduct and market performance. As part of the review of market performance, the MMU analyzed the net revenues earned by combustion turbine (CT), combined cycle (CC), coal plant (CP), diesel (DS), nuclear, solar, and wind generating units.

Overview

Net Revenue

- Energy market net revenues are significantly affected by energy prices and fuel prices. Energy prices and gas prices were higher in the first three months of 2021 than in the first three months of 2020.
- In the first three months of 2021, average energy market net revenues increased by 55 percent for a new combustion turbine (CT), 32 percent for a new combined cycle (CC), 9,549 percent for a new coal plant (CP), 53 percent for a new nuclear plant, 1,892 percent for a new diesel (DS), 38 percent for a new onshore wind installation, 67 percent for a new offshore wind installation and 27 percent for a new solar installation compared to the first three months of 2020.
- The price of natural gas increased by significantly more than the price of coal in the first three months of 2021, as a result of very high gas prices in mid February. As a result, the marginal costs of a new CC and a new CT were greater than the marginal cost of a new CP in February 2021 but lower in January and March.
- Based on Western Hub prices, the spark spread in the first three months of 2021 decreased by 7 percent while the spark spread standard deviation increased by 148 percent and the dark spread increased by 134 percent while the dark spread standard deviation decreased by 189 percent.

Recommendations

- The MMU recommends that the net revenue calculation used by PJM to calculate the net Cost of New Entry (CONE) and net ACR be based on a

forward looking estimate of expected energy and ancillary services net revenues using forward prices for energy and fuel. (Priority: Medium. First reported 2019. Status: Adopted 2020.)

Conclusion

Wholesale electric power markets are affected by externally imposed reliability requirements. A regulatory authority external to the market makes a determination as to the acceptable level of reliability which is enforced through a requirement to maintain a target level of installed or unforced capacity. The requirement to maintain a target level of installed capacity can be enforced via a variety of mechanisms, including government construction of generation, full-requirement contracts with developers to construct and operate generation, state utility commission mandates to construct capacity, or capacity markets of various types. Regardless of the enforcement mechanism, the exogenous requirement to construct capacity in excess of what is constructed in response to energy market signals has an impact on energy markets. The reliability requirement results in maintaining a level of capacity in excess of the level that would result from the operation of an energy market alone. The result of that additional capacity is to reduce the level and volatility of energy market prices and to reduce the duration of high energy market prices. This, in turn, reduces net revenue to generation owners which reduces the incentive to invest. The exact level of both aggregate and locational excess capacity is a function of the calculation methods used by RTOs and ISOs.

Net Revenue

When compared to annualized fixed costs and avoidable costs, net revenue is an indicator of generation investment profitability, and thus is a measure of overall market performance as well as a measure of the incentive to invest in new generation and to maintain existing generation in PJM markets. Net revenue equals total revenue received by generators from PJM energy, capacity and ancillary service markets and from the provision of black start and reactive services, less the short run marginal costs of energy production. In other words, net revenue is the amount that remains, after the short

run marginal costs of energy production have been subtracted from gross revenue. Net revenue is the contribution to fixed costs, which include a return on investment, depreciation and income taxes, and to avoidable costs, which include long term and intermediate term operation and maintenance expenses.¹ Net revenue is the contribution to total fixed and avoidable costs received by generators from all PJM markets.

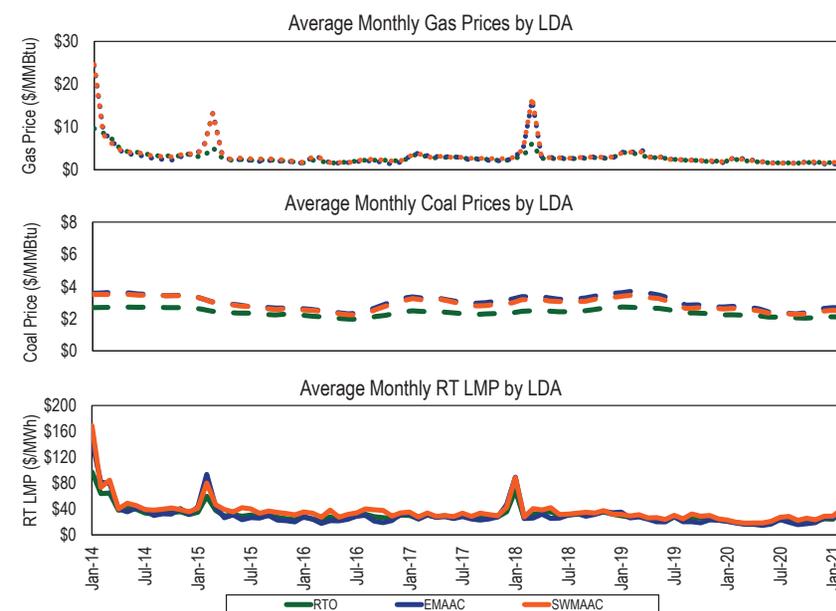
In a perfectly competitive, energy only market in long run equilibrium, net revenue from the energy market would be expected to equal the annualized fixed and avoidable costs for the marginal unit, including a competitive return on investment. The PJM market design includes other markets that contribute to the payment of fixed and avoidable costs. In PJM, the energy, capacity and ancillary service markets are all significant sources of revenue to cover the fixed and avoidable costs of generators, as are payments for the provision of black start and reactive services. Thus, in a perfectly competitive market in long run equilibrium, with energy, capacity and ancillary service revenues, net revenue from all sources would be expected to equal the annualized fixed and avoidable costs of generation for the marginal unit. Net revenue is a measure of whether generators are receiving competitive returns on invested capital and of whether market prices are high enough to encourage entry of new capacity and to encourage maintaining existing capacity. In actual wholesale power markets, where equilibrium seldom occurs, net revenue is expected to fluctuate above and below the equilibrium level based on actual conditions in all relevant markets.

Net revenues are significantly affected by energy prices, fuel prices and capacity prices. PJM real-time energy market prices increased significantly in the first three months of 2021. The load-weighted, average real-time LMP was 55.3 percent higher in the first three months of 2021 than in the first three months of 2020, \$30.84 per MWh versus \$19.85 per MWh. Gas prices increased in the first three months of 2021 compared to the first three months of 2020, as a result of very high gas prices in mid February. Gas price volatility increased and gas price differences among regions increased. Western PJM gas prices were much higher in mid February than eastern PJM

¹ Avoidable costs are sometimes referred to as going forward costs.

gas prices although both increased significantly. Coal prices were relatively unchanged for the entire time period and across PJM. The price of eastern natural gas was 84.9 percent higher and the price of western natural gas was 259.2 percent higher; the price of Northern Appalachian coal was 4.5 percent higher; the price of Central Appalachian coal was 15.7 percent higher; the price of Powder River Basin coal was 1.9 percent lower (Figure 7-1).²

Figure 7-1 Energy market net revenue factor trends: 2014 through March 2021



² Average daily gas prices in COMED were above \$129/MMBTU from February 13 through February 16, 2021.

Spark Spreads and Dark Spreads

The spark or dark spread is defined as the difference between the LMP received for selling power and the cost of fuel used to generate power, converted to a cost per MWh. The spark spread compares power prices to the cost of gas and the dark spread compares power prices to the cost of coal. The spread is a measure of the approximate difference between revenues and marginal costs and is an indicator of net revenue and profitability.

$$Spread \left(\frac{\$}{MWh} \right) = LMP \left(\frac{\$}{MWh} \right) - Fuel Price \left(\frac{\$}{MMBtu} \right) * Heat Rate \left(\frac{MMBtu}{MWh} \right)$$

Spread volatility is a result of fluctuations in LMP and the price of fuel. Spreads can be positive or negative.

Spark spreads increased in the first three months of 2021 compared to the first three months of 2020 with the exception of COMED, and the volatility of spark spreads increased. Dark spreads increased significantly in the first three months of 2021 compared to the very low levels in the first three months of 2020.

Table 7-1 shows average peak hour spreads for the January through March, by year and Table 7-2 shows the associated standard deviations.

Table 7-1 Peak hour spreads (\$/MWh): January through March, 2014 through 2021

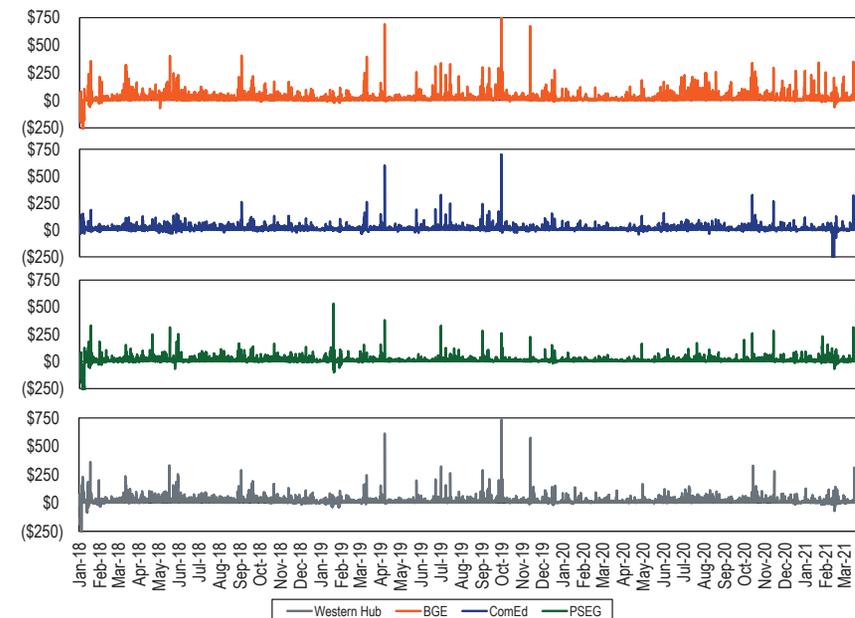
Jan-Mar	BGE		COMED		PSEG		Western Hub	
	Spark	Dark	Spark	Dark	Spark	Dark	Spark	Dark
2014	\$36.35	\$118.47	\$8.36	\$67.19	\$14.16	\$110.22	\$23.48	\$91.81
2015	\$8.67	\$44.83	\$16.92	\$33.83	\$8.48	\$54.31	\$13.50	\$38.40
2016	\$21.69	\$23.85	\$12.51	\$21.25	\$7.42	\$10.43	\$17.31	\$15.93
2017	\$13.95	\$15.47	\$8.50	\$22.64	\$8.86	\$9.48	\$11.26	\$11.81
2018	\$1.16	\$35.31	\$11.14	\$24.98	(\$10.32)	\$22.18	\$5.45	\$28.10
2019	\$11.15	\$13.15	\$7.84	\$22.17	\$7.50	\$6.13	\$8.44	\$10.77
2020	\$10.08	\$8.62	\$9.00	\$14.40	\$7.52	\$2.90	\$9.77	\$7.85
2021	\$15.92	\$23.95	(\$18.67)	\$26.31	\$9.18	\$12.41	\$10.48	\$18.34

Table 7-2 Peak hour spread standard deviation (\$/MWh): January through March, 2014 through 2021

Jan-Mar	BGE		COMED		PSEG		Western Hub	
	Spark	Dark	Spark	Dark	Spark	Dark	Spark	Dark
2014	\$166.8	\$218.4	\$132.1	\$129.2	\$152.3	\$167.6	\$162.2	\$158.9
2015	\$49.5	\$59.7	\$28.8	\$33.0	\$54.0	\$64.2	\$46.8	\$50.5
2016	\$22.5	\$23.6	\$10.0	\$10.1	\$12.5	\$16.8	\$14.4	\$15.3
2017	\$18.8	\$20.3	\$9.5	\$9.6	\$13.1	\$15.7	\$13.5	\$13.9
2018	\$88.5	\$57.5	\$18.3	\$21.9	\$95.7	\$55.9	\$74.8	\$47.7
2019	\$20.2	\$21.8	\$14.2	\$14.6	\$26.8	\$33.0	\$17.1	\$16.7
2020	\$10.5	\$10.5	\$8.3	\$8.5	\$6.3	\$6.4	\$11.4	\$11.2
2021	\$38.0	\$40.4	\$144.4	\$34.1	\$27.3	\$31.8	\$28.2	\$32.3

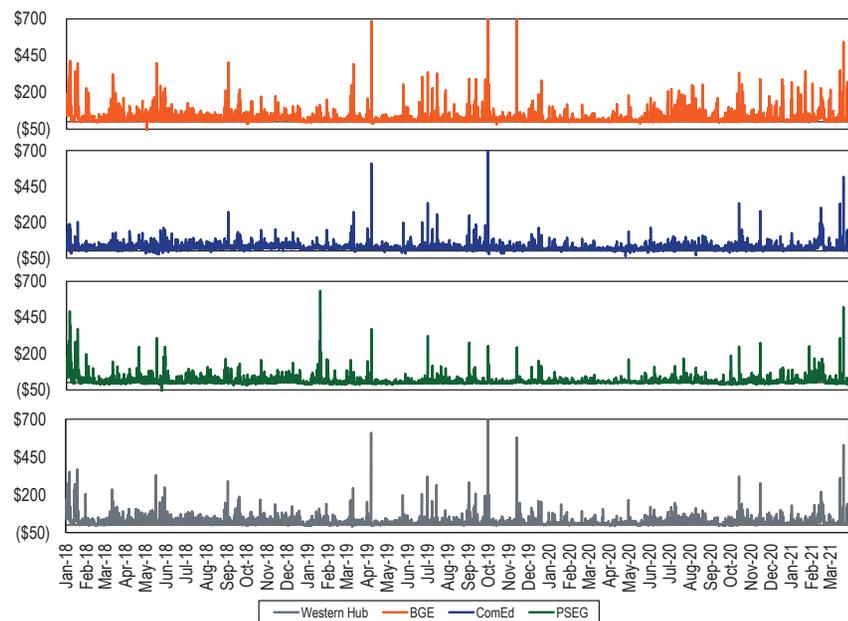
Figure 7-2 shows the hourly spark spread for peak hours for BGE, ComEd, PSEG, and Western Hub.

Figure 7-2 Hourly spark spread (gas) for peak hours (\$/MWh): 2018 through March 2021³



³ Spark spreads use a combined cycle heat rate of 7,000 Btu/kWh, zonal hourly LMPs and daily gas prices; Chicago City Gate for ComEd, Zone 6 non-NY for BGE, Zone 6 NY for PSEG, and Texas Eastern M3 for Western Hub.

Figure 7-3 Hourly dark spread (coal) for peak hours (\$/MWh): 2018 through March 2021⁴



⁴ Dark spreads use a heat rate of 10,000 Btu/kWh, zonal hourly LMPs and daily coal prices; Powder River Basin coal for ComEd, Northern Appalachian coal for BGE and Western Hub, and Central Appalachian coal for PSEG.

Theoretical Energy Market Net Revenue

The net revenues presented in this section are theoretical as they are based on explicitly stated assumptions about how a new unit with specific characteristics would operate under economic dispatch. The economic dispatch uses technology specific operating constraints in the calculation of a new entrant’s operations and potential net revenue in PJM markets.

Analysis of energy market net revenues for a new entrant includes eight power plant configurations:

- The CT plant is a single GE Frame 7HA.02 CT with an installed capacity of 360.1 MW, equipped with evaporative coolers, and selective catalytic reduction (SCR) for NO_x reduction.
- The CC plant includes two GE Frame 7HA.02 CTs and a single steam turbine generator with an installed capacity of 1,137.2 MW, equipped with evaporative cooling, duct burners, a heat recovery steam generator (HRSG) for each CT, with steam reheat, and SCR for NO_x reduction.
- The CP is a subcritical steam unit with an installed capacity of 600.0 MW, equipped with selective catalytic reduction system (SCR) for NO_x control, a flue gas desulphurization (FGD) system with chemical injection for SO_x and mercury control, and a bag-house for particulate control.
- The DS plant is a single oil fired CAT 2 MW unit with an installed capacity of 2.0 MW using New York Harbor ultra low sulfur diesel.
- The nuclear plant includes two units and related facilities using the Westinghouse AP1000 technology with an installed capacity of 2,200 MW.
- The onshore wind installation includes 37 Siemens 2.7 MW wind turbines with an installed capacity of 99.9 MW.
- The offshore wind installation includes of 43 Siemens 7.0 MW wind turbines with an installed capacity of 301.0 MW.
- The solar installation is a 35.5 acre ground mounted fixed tilt solar farm with an installed AC capacity of 10 MW.

Net revenue calculations for the CT, CC and CP include the hourly effect of actual local ambient air temperature on plant heat rates and generator output for each of the three plant configurations.⁵ ⁶ Plant heat rates account for the efficiency changes and corresponding cost changes resulting from ambient air temperatures.

CO₂, NO_x and SO₂ emission allowance costs are included in the hourly plant dispatch cost, the short run marginal cost.⁷ CO₂, NO_x and SO₂ emission allowance costs were obtained from daily spot cash prices.⁸

The class average equivalent availability factor for each type of plant was calculated from PJM data and incorporated into all revenue calculations.⁹ In addition, each CT, CC, CP, and DS plant was assumed to take a continuous 14 day annual planned outage in the fall season.

Zonal net revenues reflect average zonal LMP and fuel costs based on locational fuel indices and zone specific delivery charges.¹⁰ The delivered fuel cost for natural gas reflects the zonal, daily delivered price of natural gas from a specific pipeline and is from published commodity daily cash prices, with a basis adjustment for transportation costs.¹¹ The delivered cost of coal reflects the zone specific, delivered price of coal and was developed from the published prompt month prices, adjusted for rail transportation costs.¹² Net revenues are calculated for all zones except OVEC.¹³

Short run marginal cost includes fuel costs, emissions costs, and the short run marginal component of VOM costs.¹⁴ ¹⁵ Average short run marginal costs are

shown, including all components, in Table 7-3 and the short run marginal component of VOM is also shown separately.

Table 7-3 Average short run marginal costs: January through March, 2021

Unit Type	Short Run Marginal Costs (\$/MWh)	Heat Rate (Btu/kWh)	VOM (\$/MWh)
CT	\$36.04	9,241	\$0.36
CC	\$24.90	6,296	\$1.41
CP	\$29.76	9,250	\$4.21
DS	\$147.20	9,660	\$0.25
Nuclear	\$0.00	NA	\$0.00
Wind	\$0.00	NA	\$0.00
Wind (off shore)	\$0.00	NA	\$0.00
Solar	\$0.00	NA	\$0.00

A comparison of the monthly average short run marginal cost of the theoretical CT, CC and CP plants since 2014 shows that, on average, the short run marginal costs of the CC plant have been less than those of the CP plant but the costs of the CC plant have been more volatile than the costs of the CP plant as a result of the higher volatility of gas prices compared to coal prices (Figure 7-4). The marginal costs of a new CC and a new CT were greater than the marginal cost of a new CP in February 2021 as a result of higher gas prices.

⁵ Hourly ambient conditions supplied by DTN.

⁶ Heat rates provided by Pasteris Energy, Inc. No load costs are included in the dispatch price since each unit type is dispatched at full load for every economic hour resulting in a single offer point.

⁷ CO₂ emission allowance costs only included for states participating in RGGI, including New Jersey.

⁸ CO₂, NO_x and SO₂ emission daily prompt prices obtained from Evolution Markets, Inc.

⁹ Outage figures obtained from the PJM eGADS database.

¹⁰ Startup fuel burns and emission rates provided by Pasteris Energy, Inc. Startup station power consumption costs were obtained from the station service rates published quarterly by PJM and netted against the MW produced during startup at the preceding applicable hourly LMP. All starts associated with combined cycle units are assumed to be hot starts.

¹¹ Gas daily cash prices obtained from Platts.

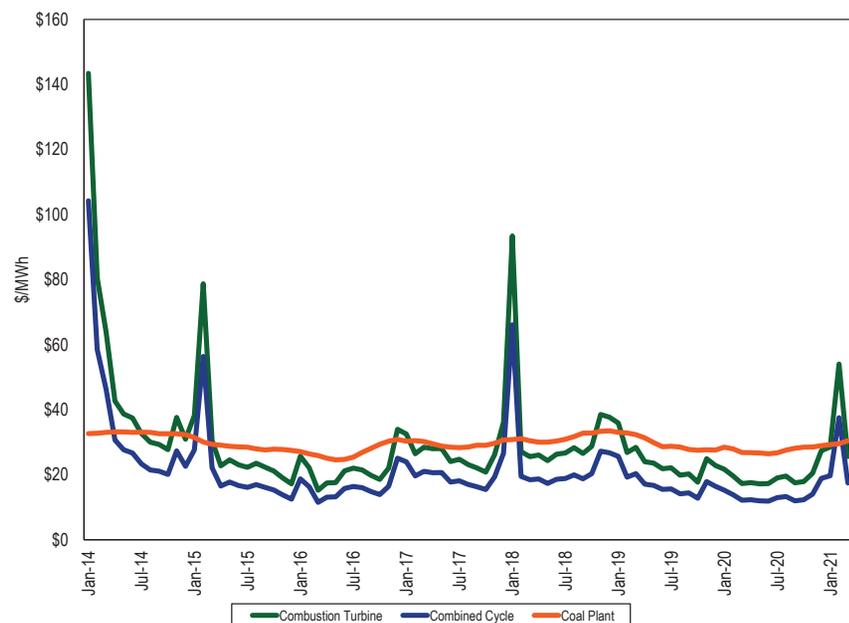
¹² Coal prompt month prices obtained from Platts.

¹³ The Ohio Valley Electric Corporation (OVEC) includes a generating plant in Ohio and a generating plant in Indiana, and high voltage transmission lines, but does not occupy a single geographic footprint like the other control zones.

¹⁴ Fuel costs are calculated using the daily spot price and may not equal what individual participants actually paid.

¹⁵ VOM rates provided by Pasteris Energy, Inc.

Figure 7-4 Average short run marginal costs: 2014 through March 2021



The net revenue measure does not include the potentially significant contribution from the explicit or implicit sale of the option value of physical units or from bilateral agreements to sell output at a price other than the PJM day-ahead or real-time energy market prices, e.g., a forward price.

Gas prices, coal prices, and energy prices are reflected in new entrant run hours. The new entrant coal plant ran for significantly more hours in the first three months of 2021 than in the first three months of 2020, returning to levels consistent with years prior to 2020. Table 7-4 shows the average run hours by a new entrant unit.

Table 7-4 Average run hours: January through March, 2014 through 2021¹⁶

	CT	CC	CP	DS	Nuclear
2014	1,041	1,827	2,092	145	2,160
2015	1,427	1,996	1,818	101	2,160
2016	1,794	2,120	1,197	17	2,184
2017	1,149	2,117	1,181	6	2,160
2018	1,307	2,023	1,199	90	2,160
2019	1,060	2,056	793	8	2,160
2020	1,252	2,098	173	5	2,184
2021	867	2,031	1,071	20	2,160

New Entrant Combustion Turbine

Energy market net revenue was calculated for a new CT plant economically dispatched by PJM. It was assumed that the CT plant had a minimum run time of two hours. The unit was first committed day ahead in profitable blocks of at least two hours, including start costs. If the unit was not already committed day-ahead, it was run in real time in standalone profitable blocks of at least two hours, or any profitable hours bordering the profitable day-ahead or real-time block.

The new entrant CT is larger and more efficient than most CTs currently operating in PJM. The economically dispatched new entrant CT ran for more than twice as many hours as large CTs currently operating in PJM. The new entrant CT energy market net revenue results must therefore be interpreted carefully when comparing to existing CTs which are generally smaller and less efficient than the newest CT technology used by the new entrant CT.

New entrant CT plant energy market net revenues were higher in 14 of 20 zones in the first three months of 2021 as a result of significantly higher and more variable energy prices offset in part by high gas prices in mid February (Table 7-5).

¹⁶ Previous year run hours changed slightly since 2020 Quarterly State of the Market report for PJM: January through March. Run hours and net revenues are fully recalculated for the previous year when calculating for the annual 2020 State of the Market Report for PJM and may change slightly due to parameter updates or changes in market settlements data.

Table 7-5 Energy net revenue for a new entrant gas fired CT under economic dispatch: January through March, 2014 through 2021 (Dollars per installed MW-year)¹⁷

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$37,754	\$12,776	\$9,793	\$5,094	\$6,806	\$7,471	\$971	\$2,335	141%
AEP	\$54,108	\$28,204	\$17,445	\$8,061	\$29,985	\$9,977	\$8,681	\$6,920	(20%)
APS	\$67,470	\$45,378	\$13,746	\$6,445	\$36,990	\$5,997	\$2,111	\$6,771	221%
ATSI	\$35,579	\$23,015	\$15,204	\$8,790	\$37,051	\$10,895	\$8,913	\$9,099	2%
BGE	\$43,148	\$12,147	\$19,132	\$8,307	\$12,933	\$5,766	\$2,798	\$7,914	183%
COMED	\$22,324	\$11,462	\$8,184	\$3,957	\$10,373	\$4,047	\$4,209	\$2,543	(40%)
DAY	\$32,065	\$20,233	\$15,044	\$7,517	\$31,940	\$11,113	\$10,418	\$13,110	26%
DOM	\$39,669	\$16,211	\$18,598	\$7,708	\$15,105	\$7,316	\$5,139	\$6,468	26%
DPL	\$38,694	\$12,217	\$6,240	\$3,796	\$6,485	\$3,500	\$502	\$11,400	2,170%
DUKE	\$29,200	\$17,892	\$14,061	\$6,192	\$38,188	\$9,490	\$8,904	\$11,911	34%
DUQ	\$14,592	\$9,130	\$14,864	\$4,724	\$8,098	\$3,872	\$4,217	\$3,931	(7%)
EKPC	\$49,038	\$21,659	\$15,107	\$6,595	\$20,778	\$8,411	\$7,595	\$7,417	(2%)
JCPLC	\$41,229	\$14,179	\$7,559	\$6,342	\$7,018	\$6,376	\$990	\$2,183	120%
MEC	\$41,388	\$20,993	\$13,828	\$7,711	\$11,234	\$5,616	\$5,731	\$5,162	(10%)
PE	\$81,671	\$58,960	\$24,023	\$9,259	\$38,540	\$10,088	\$8,218	\$11,635	42%
PECO	\$41,809	\$20,891	\$12,766	\$6,174	\$9,570	\$5,030	\$4,413	\$2,836	(36%)
PEPCO	\$46,885	\$13,007	\$10,982	\$6,099	\$11,383	\$4,754	\$1,679	\$4,707	180%
PPL	\$148,553	\$84,974	\$20,750	\$10,291	\$45,447	\$7,185	\$4,138	\$8,473	105%
PSEG	\$52,790	\$28,103	\$15,489	\$8,117	\$10,758	\$6,631	\$1,107	\$5,889	432%
REC	\$31,162	\$16,289	\$7,900	\$5,640	\$5,466	\$5,443	\$1,063	\$11,580	989%
PJM	\$58,381	\$24,386	\$14,036	\$6,841	\$19,707	\$6,949	\$4,590	\$7,114	55%

¹⁷ The energy net revenues presented for the PJM area in this section are calculated using the zonal average LMP.

New Entrant Combined Cycle

Energy market net revenue was calculated for a new CC plant economically dispatched by PJM. It was assumed that the CC plant had a minimum run time of four hours. The unit was first committed day ahead in profitable blocks of at least four hours, including start costs.¹⁸ If the unit was not already committed day ahead, it was run in real time in standalone profitable blocks of at least four hours, or any profitable hours bordering the profitable day-ahead or real-time block.

New entrant CC plant energy market net revenues were higher in 16 of 20 zones in the first three months of 2021 as a result of significantly higher energy prices offset in part by high gas prices in mid February (Table 7-6).

Table 7-6 Energy net revenue for a new entrant CC under economic dispatch: January through March, 2014 through 2021 (Dollars per installed MW-year)¹⁹

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$51,917	\$21,960	\$14,306	\$11,375	\$14,242	\$15,555	\$6,938	\$6,030	(13%)
AEP	\$63,214	\$35,476	\$22,439	\$14,388	\$37,756	\$19,117	\$14,404	\$15,274	6%
APS	\$79,776	\$54,676	\$25,811	\$14,554	\$46,949	\$16,517	\$11,267	\$16,637	48%
ATSI	\$40,769	\$31,458	\$20,863	\$14,986	\$43,292	\$19,944	\$14,633	\$18,416	26%
BGE	\$57,866	\$21,830	\$30,782	\$16,487	\$23,231	\$15,814	\$12,218	\$17,808	46%
COMED	\$24,402	\$18,254	\$13,878	\$8,627	\$14,200	\$9,801	\$9,551	\$7,761	(19%)
DAY	\$35,604	\$28,773	\$20,747	\$14,010	\$39,039	\$20,249	\$16,064	\$22,487	40%
DOM	\$50,643	\$25,250	\$24,676	\$14,431	\$20,823	\$16,553	\$11,694	\$15,138	29%
DPL	\$50,053	\$18,656	\$12,529	\$5,832	\$9,759	\$4,941	\$1,069	\$12,699	1,088%
DUKE	\$31,977	\$26,108	\$19,795	\$12,381	\$44,259	\$18,431	\$14,670	\$20,904	42%
DUQ	\$18,875	\$12,222	\$19,372	\$10,714	\$16,465	\$11,025	\$10,595	\$10,833	2%
EKPC	\$57,036	\$29,698	\$20,355	\$12,851	\$29,400	\$17,123	\$13,661	\$16,578	21%
JCPLC	\$57,326	\$23,293	\$12,163	\$12,537	\$14,412	\$14,564	\$7,105	\$5,967	(16%)
MEC	\$52,805	\$30,724	\$17,860	\$13,766	\$19,939	\$14,113	\$11,694	\$13,201	13%
PE	\$91,359	\$59,225	\$26,285	\$15,380	\$44,819	\$19,297	\$13,778	\$20,931	52%
PECO	\$55,336	\$32,397	\$16,873	\$12,277	\$19,415	\$13,054	\$10,350	\$10,151	(2%)
PEPCO	\$61,605	\$23,012	\$23,146	\$13,829	\$19,546	\$14,300	\$9,497	\$11,589	22%
PPL	\$145,463	\$78,794	\$23,078	\$15,942	\$49,592	\$15,145	\$10,102	\$16,946	68%
PSEG	\$72,991	\$40,604	\$19,821	\$14,442	\$21,129	\$15,740	\$7,909	\$9,768	24%
REC	\$47,382	\$23,878	\$12,337	\$11,761	\$11,689	\$14,013	\$7,483	\$13,447	80%
PJM	\$100,026	\$31,814	\$19,856	\$13,029	\$26,998	\$15,265	\$10,734	\$14,128	32%

¹⁸ All starts associated with combined cycle units are assumed to be warm starts.

¹⁹ The energy net revenues presented for the PJM area in this section represent the zonal average energy net revenues.

New Entrant Coal Plant

Energy market net revenue was calculated for a new CP plant economically dispatched by PJM. It was assumed that the CP plant had a minimum run time of eight hours. The unit was first committed day ahead in profitable blocks of at least eight hours, including start costs. If the unit was not already committed day ahead, it was run in real time in standalone profitable blocks of at least eight hours, or any profitable hours bordering the profitable day-ahead or real-time block.

New entrant CP plant energy market net revenues were higher in all zones as a result of significantly higher energy prices and flat coal prices (Table 7-7).

Table 7-7 Energy net revenue for a new entrant CP: January through March, 2014 through 2021 (Dollars per installed MW-year)²⁰

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$107,792	\$40,142	\$3,745	\$1,178	\$27,616	\$3,213	\$0	\$3,622	NA
AEP	\$70,724	\$23,049	\$7,207	\$7,989	\$25,147	\$5,842	\$351	\$14,139	3,927%
APS	\$82,000	\$30,858	\$1,920	\$4,367	\$26,577	\$2,782	\$0	\$6,767	NA
ATSI	\$78,044	\$24,868	\$5,250	\$9,070	\$26,103	\$5,642	\$53	\$11,050	20,656%
BGE	\$128,660	\$45,329	\$11,045	\$4,976	\$32,587	\$3,458	\$73	\$10,806	14,697%
COMED	\$64,187	\$19,365	\$3,321	\$6,818	\$9,309	\$5,332	\$66	\$11,789	17,659%
DAY	\$70,902	\$23,132	\$4,989	\$7,351	\$22,582	\$5,662	\$325	\$16,056	4,848%
DOM	\$109,653	\$50,560	\$13,348	\$5,025	\$35,570	\$5,116	\$384	\$12,984	3,282%
DPL	\$131,152	\$53,979	\$6,464	\$3,809	\$33,156	\$4,046	\$6	\$12,867	204,490%
DUKE	\$65,351	\$20,314	\$4,263	\$5,715	\$27,293	\$4,441	\$101	\$14,616	14,313%
DUQ	\$61,547	\$16,396	\$4,752	\$7,852	\$25,393	\$4,699	\$27	\$10,240	37,519%
EKPC	\$65,318	\$19,449	\$3,685	\$5,339	\$16,816	\$3,322	\$55	\$13,586	24,414%
JCPLC	\$112,807	\$41,387	\$2,170	\$1,327	\$27,748	\$2,940	\$0	\$3,626	NA
MEC	\$124,027	\$49,857	\$4,409	\$4,229	\$32,741	\$4,316	\$525	\$9,779	1,761%
PE	\$92,537	\$38,559	\$4,808	\$3,194	\$24,633	\$3,599	\$35	\$10,838	30,900%
PECO	\$105,865	\$39,385	\$1,975	\$1,169	\$27,486	\$2,761	\$0	\$5,072	NA
PEPCO	\$106,471	\$32,196	\$2,494	\$1,062	\$25,469	\$1,733	\$0	\$5,828	NA
PPL	\$105,142	\$38,500	\$2,031	\$1,309	\$26,658	\$1,634	\$0	\$5,369	NA
PSEG	\$141,330	\$60,005	\$5,254	\$3,272	\$30,535	\$4,276	\$0	\$4,985	NA
REC	\$138,906	\$61,121	\$4,860	\$3,287	\$28,539	\$4,966	\$0	\$9,236	NA
PJM	\$98,121	\$36,423	\$4,900	\$4,417	\$26,598	\$3,989	\$100	\$9,663	9,549%

²⁰ The energy net revenues presented for the PJM area in this section represent the zonal average energy net revenues.

New Entrant Nuclear Plant

Energy market net revenue was calculated assuming that the nuclear plant was dispatched day ahead by PJM for all available plant hours. The unit runs for all hours and output reflects the class average equivalent availability factor.²¹

New entrant nuclear plant energy market net revenues were higher in all zones as a result of significantly higher energy prices (Table 7-8).

Table 7-8 Energy net revenue for a new entrant nuclear plant: January through March, 2014 through 2021 (Dollars per installed MW-year)^{22 23}

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$211,846	\$115,640	\$48,725	\$58,221	\$94,760	\$60,423	\$37,593	\$55,024	46%
AEP	\$138,944	\$79,965	\$52,917	\$58,719	\$81,608	\$58,767	\$40,931	\$60,943	49%
APS	\$160,110	\$97,683	\$55,589	\$60,569	\$92,244	\$60,182	\$40,555	\$60,408	49%
ATSI	\$147,452	\$81,034	\$52,730	\$60,761	\$85,634	\$60,612	\$41,365	\$60,343	46%
BGE	\$221,336	\$117,188	\$72,903	\$67,346	\$105,209	\$64,215	\$43,501	\$68,689	58%
COMED	\$121,565	\$67,311	\$47,298	\$54,992	\$57,591	\$52,559	\$38,015	\$57,276	51%
DAY	\$138,517	\$77,939	\$52,634	\$59,527	\$80,788	\$60,909	\$42,956	\$64,884	51%
DOM	\$190,797	\$112,959	\$62,378	\$63,021	\$102,639	\$62,157	\$40,958	\$63,690	56%
DPL	\$224,316	\$126,346	\$61,073	\$63,399	\$100,951	\$60,325	\$38,079	\$69,135	82%
DUKE	\$131,887	\$74,773	\$51,588	\$57,464	\$86,563	\$58,821	\$41,383	\$63,091	52%
DUQ	\$127,759	\$70,888	\$52,008	\$59,245	\$84,336	\$58,959	\$41,119	\$58,792	43%
EKPC	\$131,844	\$73,721	\$50,862	\$56,994	\$72,894	\$57,057	\$40,988	\$61,415	50%
JCPLC	\$218,343	\$116,586	\$46,100	\$59,689	\$94,793	\$59,323	\$37,785	\$54,736	45%
MEC	\$207,794	\$111,544	\$46,218	\$59,539	\$95,281	\$59,162	\$38,361	\$57,473	50%
PE	\$170,103	\$98,672	\$50,863	\$58,911	\$87,072	\$59,494	\$39,506	\$59,682	51%
PECO	\$209,402	\$114,373	\$45,162	\$57,657	\$94,548	\$57,937	\$36,838	\$54,283	47%
PEPCO	\$217,980	\$114,824	\$65,798	\$65,002	\$102,966	\$63,377	\$42,283	\$65,001	54%
PPL	\$208,338	\$113,104	\$46,485	\$59,062	\$91,735	\$55,819	\$36,183	\$55,079	52%
PSEG	\$234,034	\$124,111	\$48,419	\$60,394	\$97,373	\$61,330	\$37,947	\$59,862	58%
REC	\$231,133	\$125,393	\$47,495	\$60,714	\$94,786	\$61,717	\$38,526	\$66,528	73%
PJM	\$182,175	\$100,703	\$52,862	\$60,061	\$90,189	\$59,657	\$39,744	\$60,817	53%

²¹ The annual class average equivalent availability factor was used in the calculation of energy market net revenues.

²² The energy net revenues presented for the PJM area in this section represent the zonal average energy net revenues because fuel costs for nuclear units are included in the NEI nuclear costs.

²³ The net revenues have changed since the 2018 State of the Market Report for PJM. The marginal cost of the nuclear plant has been reduced from \$8.50/MWh to \$0/MWh. Unit fuel costs have been moved to ACR.

New Entrant Diesel

Energy market net revenue was calculated for a DS plant economically dispatched by PJM in real time.

New entrant DS plant energy market net revenues were higher in all zones in the first three months of 2021 as a result of significantly higher and more variable energy prices (Table 7-9).

Table 7-9 Energy market net revenue for a new entrant DS: January through March, 2014 through 2021 (Dollars per installed MW-year)

Zone	Jan-Mar									Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021		
ACEC	\$32,171	\$11,172	\$1,895	\$131	\$9,687	\$1,171	\$19	\$804		4,236%
AEP	\$14,072	\$2,816	\$316	\$18	\$3,182	\$228	\$121	\$1,193		887%
APS	\$17,632	\$6,050	\$391	\$64	\$5,853	\$225	\$79	\$761		868%
ATSI	\$13,724	\$2,448	\$256	\$70	\$2,327	\$203	\$127	\$730		476%
BGE	\$48,591	\$9,773	\$2,207	\$843	\$11,091	\$588	\$226	\$2,486		1,001%
COMED	\$11,036	\$1,626	\$152	\$0	\$603	\$164	\$96	\$1,369		1,329%
DAY	\$13,842	\$2,296	\$269	\$17	\$1,401	\$246	\$143	\$1,442		908%
DOM	\$42,074	\$9,235	\$1,282	\$390	\$13,183	\$385	\$145	\$1,270		778%
DPL	\$35,919	\$12,810	\$1,670	\$732	\$11,197	\$1,176	\$19	\$11,509		61,612%
DUKE	\$13,051	\$1,892	\$399	\$11	\$2,689	\$207	\$121	\$1,679		1,291%
DUQ	\$12,607	\$2,016	\$255	\$72	\$2,615	\$181	\$152	\$757		400%
EKPC	\$14,101	\$2,087	\$493	\$10	\$1,485	\$205	\$122	\$1,946		1,496%
JCPLC	\$32,414	\$11,631	\$456	\$209	\$10,693	\$1,131	\$17	\$750		4,218%
MEC	\$31,497	\$10,905	\$425	\$167	\$10,574	\$357	\$109	\$950		770%
PE	\$15,656	\$5,284	\$266	\$95	\$4,610	\$94	\$145	\$738		411%
PECO	\$31,741	\$11,085	\$421	\$173	\$9,516	\$1,071	\$21	\$777		3,601%
PEPCO	\$50,549	\$8,848	\$1,182	\$394	\$11,047	\$466	\$168	\$1,212		623%
PPL	\$32,438	\$11,661	\$397	\$199	\$8,376	\$82	\$23	\$799		3,332%
PSEG	\$31,987	\$11,287	\$520	\$205	\$9,756	\$1,481	\$19	\$1,189		6,147%
REC	\$29,526	\$12,515	\$507	\$200	\$8,823	\$1,325	\$21	\$5,283		24,951%
PJM	\$29,787	\$7,372	\$688	\$200	\$6,935	\$549	\$94	\$1,882		1,892%

New Entrant Onshore Wind Installation

Energy market net revenues for an onshore wind installation were calculated hourly assuming the unit generated at the average capacity factor of all operating wind units in the zone with an installed capacity greater than 3 MW.²⁴ The unit is credited with wind RECs for its generation and is assumed to have taken a 1603 payment instead of either the Investment Tax Credit (ITC) or Production Tax Credit (PTC).²⁵

Onshore wind energy market net revenues were higher as a result of significantly higher energy prices.

Table 7-10 Energy market net revenue for an onshore wind installation (Dollars per installed MW-year): January through March, 2014 through 2021

Zone	Jan-Mar									Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021		
AEP	\$45,406	\$26,566	\$21,777	\$22,697	\$38,566	\$23,727	\$13,525	\$18,024		33%
APS	\$53,819	\$33,489	\$19,391	\$24,579	\$39,477	\$19,314	\$13,487	\$17,251		28%
COMED	\$39,397	\$23,379	\$16,746	\$21,821	\$24,103	\$20,127	\$11,754	\$18,216		55%
PE	\$66,094	\$43,528	\$21,076	\$25,331	\$41,510	\$20,090	\$12,783	\$17,270		35%

²⁴ Net revenues are calculated for zones in which there are sufficient operating units to determine capacity factor for a new entrant unit.

²⁵ The 1603 payment is a direct payment of 30 percent of the project cost. The use of the 1603 option is based on observed behavior in the PJM markets.

New Entrant Offshore Wind Installation

Energy market net revenues for an offshore wind installation were calculated hourly assuming the unit generated at a 45 percent capacity factor. The unit is credited with wind RECs for its generation and is assumed to have taken a 1603 payment instead of either the Investment Tax Credit (ITC) or Production Tax Credit (PTC).

Offshore wind energy market net revenues were higher as a result of higher energy prices.

Table 7-11 Energy market net revenue for an offshore wind installation (Dollars per installed MW-year): January through March, 2014 through 2021

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$96,357	\$54,104	\$23,705	\$27,675	\$45,810	\$29,481	\$18,414	\$25,497	38%
DPL	\$102,937	\$58,882	\$27,522	\$30,270	\$48,750	\$29,041	\$18,625	\$37,677	102%
DOM	\$99,725	\$51,146	\$28,579	\$30,001	\$50,997	\$29,115	\$19,397	\$30,847	59%

New Entrant Solar Installation

Energy market net revenues for a solar installation were calculated hourly assuming the unit was generating at the average hourly capacity factor of operating solar units in the zone with an installed capacity greater than 3 MW.²⁶ The unit is credited with SRECs for its generation and is assumed to have taken a 1603 payment instead of either the Investment Tax Credit (ITC) or Production Tax Credit (PTC).²⁷

Solar energy market net revenues were higher as a result of significantly higher energy prices.

Table 7-12 Energy market net revenue for a solar installation (Dollars per installed MW-year): January through March, 2014 through 2021

Zone	Jan-Mar								Change in 2021 from 2020
	2014	2015	2016	2017	2018	2019	2020	2021	
ACEC	\$21,536	\$13,316	\$5,993	\$6,914	\$10,062	\$7,282	\$4,438	\$5,187	17%
DOM	-	-	\$11,030	\$12,432	\$16,098	\$10,274	\$6,915	\$9,150	32%
DPL	-	-	\$8,621	\$9,593	\$12,531	\$8,845	\$5,452	\$7,086	30%
JCPLC	\$20,041	\$10,930	\$4,953	\$6,140	\$8,959	\$6,448	\$3,984	\$4,594	15%
PSEG	\$19,380	\$14,236	\$6,048	\$6,760	\$10,192	\$7,759	\$4,895	\$6,894	41%

²⁶ Net revenues are calculated for zones in which there are sufficient operating units to determine capacity factor for a new entrant unit.

²⁷ The 1603 payment is a direct payment of 30 percent of the project cost.

Historical New Entrant CC Revenue Adequacy

Total unit net revenues include energy and capacity revenues. Analysis of the total unit revenues of theoretical new entrant CCs for three representative locations shows that CC units that entered the PJM markets in 2007 have covered 87 percent of their total costs in the BGE and PSEG Zones and 45 percent of total costs in the ComEd Zone, including the return on and of capital, on a cumulative basis. The analysis also shows that theoretical new entrant CCs that entered the PJM markets in 2012 have covered their total costs on a cumulative basis in the PSEG Zone and 98 percent of total costs in the BGE Zone and 56 percent of total costs in the ComEd Zone. Energy market revenues alone were not sufficient to cover total costs in any scenario, which demonstrates the critical role of the capacity market revenue in covering total costs.

Under cost of service regulation, units are guaranteed that they will cover their total costs, assuming that the costs were determined to be reasonable. To the extent that units built in the PJM markets did not cover their total costs, investors were worse off and customers were better off than under cost of service regulation.

Figure 7-5 compares cumulative energy market net revenues and energy market net revenues plus capacity market revenues to cumulative leveled costs for a new entrant CC that began operation on January 1, 2007, and a new entrant CC that began operation on January 1, 2012. The solid black line shows the total net revenue required to cover total costs. The solid colored lines show net energy revenue by zone. The dashed colored lines show the sum of net energy and capacity revenue by zone.

Figure 7-5 Historical new entrant CC revenue adequacy: 2007 through March 2021 and 2012 through March 2021²⁸

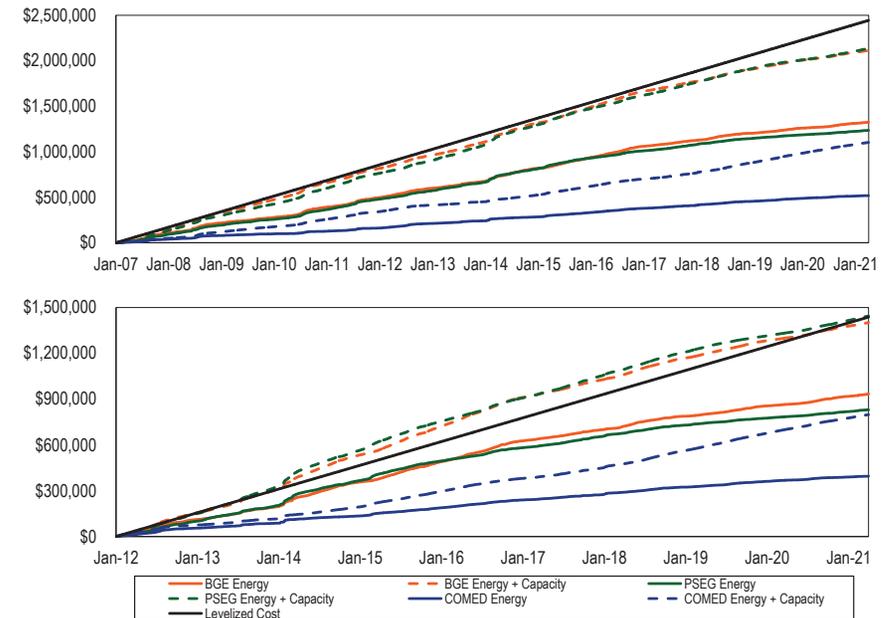


Table 7-13 shows the percent of leveled total costs recovered.

Table 7-13 Percent of leveled total costs recovered

	2007 CC	2012 CC
BGE	87%	98%
ComEd	45%	56%
PSEG	87%	100%

²⁸ The gas pipeline pricing points used in this analysis are Zone 6 non-NY for BGE, Chicago City Gate for ComEd, and Texas Eastern M3 for PSEG.

Assumptions used for this analysis are shown in Table 7-14.

Table 7-14 Assumptions for analysis of new entry in 2007 and 2012

	2007 CC	2012 CC
Project Cost	\$658,598,000	\$665,995,000
Fixed O&M (\$/MW-Year)	\$20,016	\$20,126
End of Life Value	\$0	\$0
Loan Term	20 years	20 years
Percent Equity (%)	50%	50%
Percent Debt (%)	50%	50%
Loan Interest Rate (%)	7%	7%
Cost of Equity (%)	12.0%	12.0%
Federal Income Tax Rate (%)	35%	35%
State Income Tax Rate (%)	9%	9%
General Escalation (%)	2.5%	2.5%
Technology	GE Frame 7FA.04	GE Frame 7FA.05
ICAP (MW)	601	655
Depreciation MACRS 150% declining balance	20 years	20 years
IRR (%)	12.0%	12.0%

Nuclear Net Revenue Analysis

The analysis of nuclear plants includes annual avoidable costs and incremental capital expenditures from the Nuclear Energy Institute (NEI) based on NEI's calculations of average costs for all U.S. nuclear plants.^{29 30} The analysis includes the most recent operating cost data and incremental capital expenditure data for single unit plants and multi unit plants published by NEI, for 2019.³¹ This is likely to result in conservatively high costs for the forward looking analysis. NEI average operating costs have decreased since their peak in 2012 (11.5 percent decrease from 2012 through 2019 for all plants including single and multiple unit plants).³² NEI average incremental capital

29 Operating costs from: Nuclear Energy Institute (October, 2020). "Nuclear Costs in Context," <<https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/Nuclear-Costs-in-Context.pdf>>. Individual plants may vary from the average due to factors such as geographic location, local labor costs, the timing of refueling outages and other unit specific factors. This is the most current NEI data available.

30 The NEI costs for Hope Creek were treated as that of a two unit configuration because the unit is located in the same area as Salem 1 & 2. The net surplus of Hope Creek is sensitive to the accuracy of this assumption.

31 NEI also provides average costs by plant run by operators with one plant or multiple plants, by market, and by type of nuclear reactor. Plants run by operators with multiple plants have lower average costs than plants run by operators with a single plant. Plants participating in wholesale markets have lower average costs than plants in regulated markets. PWR reactors have lower average costs than BWR reactors.

32 Operating costs in this paragraph are operating costs as specified by NEI and do not include fuel costs or capital expenditures. Operating costs for single unit plants decreased by \$3.22/MWh, or 11.6 percent, from 2018 to 2019, a likely result of both cost reductions and the exclusion of recently retired single unit plants. Operating costs for single unit plants decreased by \$2.01/MWh or 7.6 percent from 2012 to 2019. Operating costs for multiple unit plants decreased by \$0.44/MWh, or 2.5 percent, from 2018 to 2019, and decreased by \$2.21/MWh, or 11.5 percent, from 2012 to 2019.

expenditures have decreased since their peak in 2012 (45.6 percent decrease from 2012 through 2019 for all plants including single and multiple unit plants).³³ NEI's incremental capital expenditures peaked in 2012 as a result of regulatory requirements following the 2011 accident at the Fukushima nuclear plant in Japan.

The results for nuclear plants are sensitive to small changes in PJM energy and capacity prices, both actual and forward prices.³⁴ When gas prices are high and LMPs are high as a result, net revenues to nuclear plants increase. In 2014, the polar vortex resulted in a significant increase in net revenues to nuclear plants. When gas prices are low and LMPs are low as a result, net revenues to nuclear plants decrease. In 2016, PJM energy prices were then at the lowest level since the introduction of competitive markets on April 1, 1999, and remained low in 2017. As a result, in 2016 and 2017, a significant proportion of nuclear plants did not cover annual avoidable costs based on current year prices.³⁵ In 2018, high gas prices and high LMPs resulted in a significant increase in net revenues for nuclear plants in PJM. Energy prices in 2018 were significantly higher than in 2017. Although energy prices in 2019 were lower than in 2016, higher capacity market revenues more than offset the difference. Energy prices in 2020 were lower than 2019 prices, but forward energy prices for 2021 through 2023 are above 2019 energy prices. The result is that nuclear plant energy revenues based on forward period prices are expected to be higher than 2019 energy revenues. The results for nuclear plants are also sensitive to changes in costs and whether actual unit costs are less than or greater than the benchmark NEI data.

Table 7-15 includes the publicly available data on energy market prices, Table 7-16 and Table 7-17 show capacity market prices and Table 7-18 shows nuclear cost data for the 16 nuclear plants in PJM in addition to Oyster Creek, which retired September 17, 2018, and Three Mile Island, which retired September 20, 2019.³⁶ The analysis excludes the Cook nuclear units and the

33 Capital expenditures have decreased 46.0 percent since 2012 for single unit plants and 44.5 percent for multiple unit plants.

34 A change in the capacity market price of \$24 per MW-day translates into a change in capacity revenue of \$1.00 per MWh for a nuclear power plant operating at a capacity factor of 100 percent. A change in the capacity market price of \$24 per MW-day translates into a change in capacity revenue of \$1.07 per MWh for a nuclear power plant operating at a capacity factor of 0.933 percent.

35 The MMU submitted testimony in New Jersey on the same issues of nuclear economics. *Establishing Nuclear Diversity Certificate Program*. Bill No. S-877 New Jersey Senate Environment and Energy Committee. (2018). *Revised Statement of Joseph Bowling*.

36 Installed capacity is from NEI, "Map of U.S. Nuclear Plants," <<https://www.nei.org/resources/map-of-us-nuclear-plants>>.

Catawba 1 nuclear unit. The Cook nuclear units are designated FRR and receive cost of service revenues and are not subject to PJM market revenues.³⁷ Catawba 1 is not in PJM but is pseudo tied to PJM.

For nuclear plants, all calculations are based on publicly available data in order to avoid revealing confidential information. Nuclear unit revenue is based on day-ahead LMP at the relevant node. Nuclear unit capacity revenue assumes that the unit cleared its full unforced capacity at the BRA locational clearing price. Unforced capacity is determined using the annual class average EFORD rate.

Table 7-15 Nuclear unit day-ahead LMP: 2008 through 2020

	ICAP	Average DA LMP (\$/MWh)												
	(MW)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beaver Valley	1,808	\$49.46	\$31.51	\$35.59	\$37.43	\$30.34	\$34.24	\$41.86	\$30.35	\$27.07	\$29.11	\$36.35	\$26.22	\$20.33
Braidwood	2,337	\$48.10	\$27.76	\$31.48	\$32.02	\$27.51	\$30.26	\$37.34	\$25.97	\$24.30	\$24.99	\$27.11	\$22.88	\$18.23
Byron	2,300	\$47.61	\$23.98	\$28.49	\$28.09	\$24.25	\$29.22	\$35.05	\$21.00	\$17.94	\$23.79	\$26.96	\$22.19	\$17.66
Calvert Cliffs	1,708	\$78.63	\$41.05	\$51.27	\$46.53	\$35.19	\$40.27	\$57.88	\$40.30	\$32.64	\$31.57	\$38.79	\$28.00	\$21.88
Davis Besse	894	-	-	-	\$39.68	\$31.68	\$36.10	\$47.21	\$31.94	\$27.80	\$28.85	\$34.44	\$26.33	\$20.54
Dresden	1,797	\$48.76	\$28.27	\$32.73	\$33.07	\$28.42	\$31.82	\$39.22	\$27.45	\$25.89	\$26.35	\$28.25	\$23.41	\$18.73
Hope Creek	1,172	\$73.34	\$39.43	\$48.03	\$45.52	\$33.07	\$37.43	\$51.99	\$32.41	\$23.20	\$26.78	\$32.93	\$22.45	\$17.32
LaSalle	2,271	\$47.96	\$27.71	\$31.53	\$31.93	\$27.56	\$30.94	\$37.88	\$26.28	\$23.95	\$24.71	\$27.19	\$22.75	\$18.14
Limerick	2,242	\$73.49	\$39.49	\$48.23	\$45.27	\$33.09	\$37.28	\$51.71	\$32.65	\$23.37	\$26.99	\$33.08	\$22.68	\$17.31
North Anna	1,892	\$75.14	\$39.89	\$50.59	\$45.47	\$33.87	\$38.55	\$53.37	\$38.05	\$30.50	\$31.27	\$38.44	\$27.39	\$21.06
Oyster Creek	608	\$75.49	\$40.43	\$49.29	\$46.74	\$33.69	\$38.62	\$52.85	\$33.10	\$23.79	\$27.52	\$34.03	\$23.68	\$18.07
Peach Bottom	2,347	\$73.09	\$39.32	\$47.70	\$44.73	\$32.81	\$37.37	\$51.52	\$31.98	\$23.07	\$26.76	\$32.63	\$21.58	\$16.93
Perry	1,240	-	-	\$36.99	\$38.76	\$31.68	\$36.69	\$46.14	\$32.77	\$27.84	\$29.91	\$37.24	\$26.76	\$20.49
Quad Cities	1,819	\$47.28	\$24.81	\$27.53	\$26.79	\$20.43	\$25.94	\$30.71	\$19.47	\$18.04	\$23.09	\$25.54	\$21.13	\$15.95
Salem	2,328	\$73.41	\$39.51	\$48.02	\$45.50	\$33.06	\$37.40	\$51.96	\$32.37	\$23.18	\$26.76	\$32.90	\$22.43	\$17.32
Surry	1,676	\$71.96	\$39.02	\$49.30	\$45.01	\$33.62	\$37.98	\$51.75	\$37.91	\$30.08	\$31.08	\$38.50	\$26.65	\$20.41
Susquehanna	2,520	\$69.96	\$38.24	\$45.95	\$44.78	\$32.10	\$36.76	\$50.93	\$32.47	\$23.66	\$27.14	\$32.42	\$21.08	\$16.03
Three Mile Island	803	\$72.46	\$39.11	\$46.72	\$44.15	\$32.43	\$36.83	\$50.47	\$30.94	\$22.96	\$27.12	\$31.76	\$23.47	\$19.07

³⁷ See "Resources Designated in 2021/2022 FRR Capacity Plans as of May 1, 2018," <<https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-resources-designated-in-frr-plans.ashx?a=en>>.

Table 7-16 BRA capacity market clearing prices (\$/MW-Day): 2008 through 2021³⁸

	ICAP	BRA Capacity Price (\$/MW-Day)														
	(MW)	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22
Beaver Valley	1,808	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$165	\$100	\$77	\$140
Braidwood	2,337	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$215	\$203	\$188	\$196
Byron	2,300	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$215	\$203	\$188	\$196
Calvert Cliffs	1,708	\$189	\$210	\$237	\$174	\$110	\$133	\$226	\$137	\$167	\$119	\$120	\$165	\$100	\$86	\$140
Davis Besse	894	-	-	-	-	\$109	\$20	\$28	\$126	\$357	\$114	\$120	\$165	\$100	\$77	\$171
Dresden	1,797	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$215	\$203	\$188	\$196
Hope Creek	1,172	\$198	\$149	\$191	\$174	\$110	\$140	\$245	\$137	\$167	\$119	\$120	\$225	\$120	\$188	\$166
LaSalle	2,271	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$215	\$203	\$188	\$196
Limerick	2,242	\$198	\$149	\$191	\$174	\$110	\$140	\$245	\$137	\$167	\$119	\$120	\$225	\$120	\$188	\$166
North Anna	1,892	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$165	\$100	\$77	\$140
Oyster Creek	608	\$198	\$149	\$191	\$174	\$110	\$140	\$245	\$137	\$167	\$119	\$120	\$225	\$120	\$188	-
Peach Bottom	2,347	\$198	\$149	\$191	\$174	\$110	\$140	\$245	\$137	\$167	\$119	\$120	\$225	\$120	\$188	\$166
Perry	1,240	-	-	-	-	\$109	\$20	\$28	\$126	\$357	\$114	\$120	\$165	\$100	\$77	\$171
Quad Cities	1,819	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$215	\$203	\$188	\$196
Salem	2,328	\$198	\$149	\$191	\$174	\$110	\$140	\$245	\$137	\$167	\$119	\$120	\$225	\$120	\$188	\$166
Surry	1,676	\$41	\$112	\$102	\$174	\$110	\$16	\$28	\$126	\$136	\$59	\$120	\$165	\$100	\$77	\$140
Susquehanna	2,520	\$41	\$112	\$191	\$174	\$110	\$133	\$226	\$137	\$167	\$119	\$120	\$165	\$100	\$86	\$140
Three Mile Island	803	\$41	\$112	\$191	\$174	\$110	\$133	\$226	\$137	\$167	\$119	\$120	\$165	\$100	\$86	\$140

³⁸ Oyster Creek retired September 17, 2018. Exelon. "Oyster Creek Generating Station Retires from Service," (September 17, 2018) <<http://www.exeloncorp.com/newsroom/oyster-creek-retires>>. Three Mile Island retired September 20, 2019. Exelon. "Three Mile Island Generating Station Unit 1 Retires from Service After 45 Years," (September 20, 2019) <<https://www.exeloncorp.com/newsroom/three-mile-island-generating-station-unit-1-retires>>.

Capacity revenues are not presented for calendar year 2022 because the 2022/2023 BRA has not been run.

Table 7-17 Nuclear unit capacity market revenue (\$/MWh): 2008 through 2021^{39 40}

	ICAP (MW)	Capacity Revenue (\$/MWh)													
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Beaver Valley	1,808	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$6.42	\$5.61	\$3.82	\$5.03
Braidwood	2,337	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$7.71	\$9.20	\$8.60	\$8.52
Byron	2,300	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$7.71	\$9.20	\$8.60	\$8.52
Calvert Cliffs	1,708	\$8.73	\$9.59	\$8.64	\$5.87	\$5.38	\$8.21	\$7.53	\$6.74	\$6.04	\$5.26	\$6.42	\$5.62	\$4.07	\$5.21
Davis Besse	894	NA	NA	NA	NA	\$2.49	\$1.08	\$3.70	\$11.40	\$9.33	\$5.17	\$6.42	\$5.61	\$3.82	\$5.85
Dresden	1,797	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$7.71	\$9.20	\$8.60	\$8.52
Hope Creek	1,172	\$7.33	\$7.37	\$7.82	\$5.87	\$5.54	\$8.81	\$7.87	\$6.74	\$6.04	\$5.26	\$7.98	\$7.24	\$7.06	\$7.74
LaSalle	2,271	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$7.71	\$9.20	\$8.60	\$8.52
Limerick	2,242	\$7.33	\$7.37	\$7.82	\$5.87	\$5.54	\$8.81	\$7.87	\$6.74	\$6.04	\$5.26	\$7.98	\$7.24	\$7.06	\$7.74
North Anna	1,892	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$6.42	\$5.61	\$3.82	\$5.03
Oyster Creek	608	\$7.33	\$7.37	\$7.82	\$5.87	\$5.54	\$8.81	\$7.87	\$6.74	\$6.04	\$5.26	NA	NA	NA	NA
Peach Bottom	2,347	\$7.33	\$7.37	\$7.82	\$5.87	\$5.54	\$8.81	\$7.87	\$6.74	\$6.04	\$5.26	\$7.98	\$7.24	\$7.06	\$7.74
Perry	1,240	NA	NA	NA	NA	\$2.49	\$1.08	\$3.70	\$11.40	\$9.33	\$5.17	\$6.42	\$5.61	\$3.82	\$5.85
Quad Cities	1,819	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$7.71	\$9.20	\$8.60	\$8.52
Salem	2,328	\$7.33	\$7.37	\$7.82	\$5.87	\$5.54	\$8.81	\$7.87	\$6.74	\$6.04	\$5.26	\$7.98	\$7.24	\$7.06	\$7.74
Surry	1,676	\$3.57	\$4.50	\$6.23	\$5.87	\$2.41	\$1.01	\$3.70	\$5.75	\$3.96	\$4.17	\$6.42	\$5.61	\$3.82	\$5.03
Susquehanna	2,520	\$3.57	\$6.72	\$7.82	\$5.87	\$5.38	\$8.21	\$7.53	\$6.74	\$6.04	\$5.26	\$6.42	\$5.61	\$4.07	\$5.21
Three Mile Island	803	\$3.57	\$6.72	\$7.82	\$5.87	\$5.38	\$8.21	\$7.53	\$6.74	\$6.04	\$5.26	\$6.42	\$5.61	\$4.07	\$5.21

³⁹ Capacity revenue calculated by adjusting the BRA Capacity Price for calendar year, by the class average EFORD, and by the 2019 class average capacity factor of 0.933 percent. Class average capacity factor is from 2019 State of the Market Report for PJM, Volume 2, Section 5: Capacity Market.

⁴⁰ Oyster Creek retired September 17, 2018. Exelon. "Oyster Creek Generating Station Retires from Service," (September 17, 2018) <<http://www.exeloncorp.com/newsroom/oyster-creek-retires>>. Three Mile Island retired September 20, 2019. Exelon. "Three Mile Island Generating Station Unit 1 Retires from Service After 45 Years," (September 20, 2019) <<https://www.exeloncorp.com/newsroom/three-mile-island-generating-station-unit-1-retires>>.

Table 7-18 Nuclear unit costs: 2008 through 2020^{41 42}

	ICAP (MW)	NEI Costs (\$/MWh)												
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beaver Valley	1,808	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Braidwood	2,337	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Byron	2,300	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Calvert Cliffs	1,708	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Davis Besse	894	\$35.31	\$39.36	\$41.23	\$45.45	\$47.41	\$44.16	\$44.32	\$44.51	\$41.39	\$42.66	\$42.00	\$38.40	\$38.40
Dresden	1,797	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Hope Creek	1,172	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
LaSalle	2,271	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Limerick	2,242	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
North Anna	1,892	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Oyster Creek	608	\$35.31	\$39.36	\$41.23	\$45.45	\$47.41	\$44.16	\$44.32	\$44.51	\$41.39	\$42.66	NA	NA	NA
Peach Bottom	2,347	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Perry	1,240	\$35.31	\$39.36	\$41.23	\$45.45	\$47.41	\$44.16	\$44.32	\$44.51	\$41.39	\$42.66	\$42.00	\$38.40	\$38.40
Quad Cities	1,819	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Salem	2,328	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Surry	1,676	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Susquehanna	2,520	\$26.73	\$29.76	\$31.34	\$34.51	\$36.06	\$33.84	\$33.84	\$32.90	\$31.63	\$30.89	\$29.07	\$28.38	\$28.38
Three Mile Island	803	\$35.31	\$39.36	\$41.23	\$45.45	\$47.41	\$44.16	\$44.32	\$44.51	\$41.39	\$42.66	\$42.00	NA	NA

Table 7-19 shows the surplus or shortfall in \$/MWh for the 16 nuclear plants in PJM and Oyster Creek and Three Mile Island calculated using historic LMP and cost data. In 2016, 13 nuclear plants, with a total capacity of 25,075 MW, in addition to Oyster Creek and Three Mile Island, did not recover all their fuel costs, operating costs, and capital expenditures. In 2017, seven nuclear plants with a total capacity of 12,658 MW, in addition to Oyster Creek and Three Mile Island, did not recover all their fuel costs, operating costs, and capital expenditures. In 2018, one nuclear plant, with a total capacity of 894 MW, in addition to Oyster Creek and Three Mile Island, did not recover all their fuel costs, operating costs, and capital expenditures. In 2019, two nuclear plants, with a total capacity of 4,654 MW, in addition to Three Mile Island, did not recover all their fuel costs, operating costs, and capital expenditures. Although Susquehanna shows a shortfall in 2019, cost reductions mean that Susquehanna did cover their fuel costs, operating costs, and capital

expenditures.⁴³ The surplus or shortfall assumes that the unit cleared its full unforced capacity at the BRA locational clearing price.⁴⁴ Unforced capacity is determined using the annual class average EFORD rate.

The market revenues are based in part on the sale of capacity. Some nuclear plants did not clear the capacity market as a result of decisions by plant owners about how to offer the plants. When nuclear plants do not clear in the capacity market, it is a result of the offer behavior of the plants and does not reflect the economic viability of the plants unless the plants offer accurate net avoidable costs and fail to clear. This analysis is intended to define whether the plants are receiving a retirement signal from the PJM markets. If the plants are viable

including both energy and capacity market revenues based on actual clearing prices, then the PJM markets indicate that the plant is economically viable. If plant owners decide to offer so as to not clear in the capacity market, that does not change the market signals to the plants. Such decisions may reflect a variety of considerations. Three Mile Island did not clear in the 2018/2019 Auction⁴⁵ and Three Mile Island, Quad Cities, and a portion of Byron's capacity did not clear in the 2019/2020 Auction.⁴⁶ Three Mile Island and Quad Cities did not clear in the 2020/2021 Auction.⁴⁷ Three Mile Island, Dresden, and most of Byron did not clear in the 2021/2022 Auction.⁴⁸ Beaver Valley, Davis Besse, and Perry did not clear in the 2021/2022 Auction.⁴⁹

43 Talen Energy Investor Day, February 12, 2019.

44 Installed capacity is from NEI. "Maps of U.S. Nuclear Plants," <<https://www.nei.org/resources/map-of-us-nuclear-plants>>.

45 Exelon. "Exelon Announces Outcome of 2019-2020 PJM Capacity Auction," (May 25, 2016) <<http://www.exeloncorp.com/newsroom/pjm-auction-results-2016>>.

46 Exelon. "Exelon Announces Outcome of 2019-2020 PJM Capacity Auction," (May 25, 2016) <<http://www.exeloncorp.com/newsroom/pjm-auction-results-2016>>.

47 Exelon. "Exelon Announces Outcome of 2020-2021 PJM Capacity Auction," (May 24, 2017) <<http://www.exeloncorp.com/newsroom/pjm-auction-results-release-2017>>.

48 Exelon. "Exelon Announces Outcome of 2021-2022 PJM Capacity Auction," (May 24, 2018) <<http://www.exeloncorp.com/newsroom/exelon-announces-outcome-of-2021-2022-pjm-capacity-auction>>.

49 PRNewswire. "FirstEnergy Solutions Comments on Results of PJM Capacity Auction," (May 24, 2018) <<https://www.prnewswire.com/news-releases/firstenergy-solutions-comments-on-results-of-pjm-capacity-auction-300654549.html>>.

41 Operating costs from: Nuclear Energy Institute (October, 2020). "Nuclear Costs in Context," <<https://www.nei.org/resources/reports-briefs/nuclear-costs-in-context>>.

42 Oyster Creek retired on September 17, 2018. Exelon. "Oyster Creek Generating Station Retires from Service," (September 17, 2018) <<http://www.exeloncorp.com/newsroom/oyster-creek-retires>>. Three Mile Island retired September 20, 2019. Exelon. "Three Mile Island Generating Station Unit 1 Retires from Service After 45 Years," (September 20, 2019) <<https://www.exeloncorp.com/newsroom/three-mile-island-generating-station-unit-1-retires>>.

Nuclear unit revenue is a combination of energy market revenue, ancillary market revenue and capacity market revenue. Negative energy market prices do not have a significant impact on nuclear unit revenue. Since 2014, negative energy market prices have affected nuclear plants' annual total revenues by an average of 0.1 percent. Negative LMPs reduced nuclear plant total revenues by an average of 0.0 percent and a maximum of 0.6 percent in 2014, an average of 0.2 percent and a maximum of 1.2 percent in 2015, an average of 0.1 percent and a maximum of 0.7 percent in 2016, an average of 0.0 percent and a maximum of 0.6 percent in 2017, an average of 0.0 percent and a maximum of 0.0 percent in 2018, an average of 0.0 percent and a maximum of 0.2 percent in 2019, and an average of 0.1 percent and a maximum of 1.7 percent in 2020.⁵⁰

In 2020, no nuclear plants covered their fuel costs, operating costs, and capital expenditures as a result of lower energy prices, based on current year (2020) prices.

Table 7-19 Nuclear unit surplus (shortfall) based on public data: 2008 through 2020⁵¹

	ICAP (MW)	Surplus (Shortfall) (\$/MWh)												
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beaver Valley	1,808	\$26.3	\$6.3	\$10.5	\$8.8	(\$3.3)	\$1.4	\$11.7	\$3.2	(\$0.4)	\$2.6	\$13.9	\$3.7	(\$4.0)
Braidwood	2,337	\$24.9	\$2.5	\$6.4	\$3.4	(\$6.1)	(\$2.6)	\$7.2	(\$1.2)	(\$3.1)	(\$1.5)	\$6.0	\$3.9	(\$1.3)
Byron	2,300	\$24.5	(\$1.3)	\$3.4	(\$0.6)	(\$9.4)	(\$3.6)	\$4.9	(\$6.1)	(\$9.5)	(\$2.7)	\$5.8	\$3.2	(\$1.9)
Calvert Cliffs	1,708	\$60.6	\$20.9	\$28.6	\$17.9	\$4.5	\$14.6	\$31.6	\$14.1	\$7.2	\$6.1	\$16.3	\$5.4	(\$2.2)
Davis Besse	894	NA	NA	NA	NA	(\$13.2)	(\$7.0)	\$6.6	(\$1.2)	(\$4.0)	(\$8.4)	(\$0.9)	(\$6.2)	(\$13.8)
Dresden	1,797	\$25.6	\$3.0	\$7.6	\$4.4	(\$5.2)	(\$1.0)	\$9.1	\$0.3	(\$1.5)	(\$0.0)	\$7.2	\$4.6	(\$0.7)
Hope Creek	1,172	\$54.0	\$17.0	\$24.5	\$16.9	\$2.6	\$12.4	\$26.0	\$6.3	(\$2.0)	\$1.6	\$12.3	\$1.7	(\$3.6)
LaSalle	2,271	\$24.8	\$2.5	\$6.4	\$3.3	(\$6.1)	(\$1.9)	\$7.7	(\$0.9)	(\$3.5)	(\$1.8)	\$6.0	\$3.8	(\$1.5)
Limerick	2,242	\$54.1	\$17.1	\$24.7	\$16.6	\$2.6	\$12.2	\$25.7	\$6.5	(\$2.1)	\$1.5	\$12.1	\$1.7	(\$3.9)
North Anna	1,892	\$52.0	\$14.6	\$25.5	\$16.8	\$0.2	\$5.7	\$23.2	\$10.9	\$3.0	\$4.7	\$16.0	\$4.8	(\$3.3)
Oyster Creek	608	\$47.5	\$8.4	\$15.9	\$7.2	(\$8.2)	\$3.3	\$16.4	(\$4.7)	(\$11.6)	(\$9.9)	NA	NA	NA
Peach Bottom	2,347	\$53.7	\$16.9	\$24.2	\$16.1	\$2.3	\$12.3	\$25.5	\$5.8	(\$2.2)	\$1.4	\$11.8	\$0.7	(\$4.1)
Perry	1,240	NA	NA	NA	NA	(\$13.2)	(\$6.4)	\$5.5	(\$0.3)	(\$4.0)	(\$7.3)	\$1.9	(\$5.8)	(\$13.9)
Quad Cities	1,819	\$24.1	(\$0.4)	\$2.4	(\$1.8)	(\$13.2)	(\$6.9)	\$0.6	(\$7.7)	(\$9.5)	(\$3.5)	\$4.4	\$2.1	(\$3.7)
Salem	2,328	\$54.0	\$17.1	\$24.5	\$16.9	\$2.6	\$12.4	\$26.0	\$6.2	(\$2.3)	\$1.3	\$11.9	\$1.4	(\$3.9)
Surry	1,676	\$48.8	\$13.8	\$24.2	\$16.4	(\$0.0)	\$5.1	\$21.6	\$10.8	\$2.6	\$4.5	\$16.0	\$4.1	(\$4.0)
Susquehanna	2,520	\$46.8	\$15.2	\$22.4	\$16.1	\$1.4	\$11.1	\$24.6	\$6.3	(\$1.6)	\$1.8	\$10.0	(\$1.4)	(\$8.0)
Three Mile Island	803	\$40.7	\$6.5	\$13.3	\$4.6	(\$9.6)	\$0.9	\$13.7	(\$6.8)	(\$12.4)	(\$10.3)	(\$3.8)	NA	NA

In order to evaluate the expected viability of nuclear plants, analysis was performed based on forward energy market prices for 2021, 2022 and 2023 and known capacity market prices for 2021. The purpose of the forward analysis is to evaluate whether current forward prices are consistent with nuclear plants covering their annual avoidable costs over the next three years. While the forward capacity market prices are known, actual energy prices will vary from forward values. Nuclear plants may sell their output at a range of forward prices and for a range of future years.

⁵⁰ Analysis is based on actual unit generation and received energy market and capacity market revenues. Negative prices in the DA and RT market were set to zero for comparison. Results round to 0.0 percent.

⁵¹ The values for 2016 through 2019 have changed slightly from previous values to account for reactive supply and voltage control revenues.

Table 7-20 shows PJM energy prices (LMP), annual fuel, and operating and capital expenditures used for the analysis of the period 2021 through 2023. Capacity revenues are not presented for calendar year 2022 and 2023 because the 2022/2023 BRA has not been run. The LMPs are based on forward prices with a basis adjustment for the specific plant locations.⁵² Forward prices are as of April 1, 2021. The 2021 energy prices include actual day-ahead market prices through March 31, 2021, and forward prices for April through December 2021. The capacity prices are known based on PJM capacity auction results.

Table 7-20 Forward prices in PJM energy markets, capacity revenue, and annual costs⁵³

	ICAP (MW)	Average Forward LMP (\$/MWh)			Capacity Revenue (\$/MWh)	2019 NEI Costs (\$/MWh)		
		2021	2022	2023		Fuel	Operating	Capital
Beaver Valley	1,808	\$26.82	\$28.09	\$27.22	\$5.03	\$6.06	\$17.00	\$5.32
Braidwood	2,337	\$24.43	\$25.42	\$24.63	\$8.52	\$6.06	\$17.00	\$5.32
Byron	2,300	\$23.69	\$24.58	\$23.81	\$8.52	\$6.06	\$17.00	\$5.32
Calvert Cliffs	1,708	\$28.77	\$29.41	\$28.50	\$5.21	\$6.06	\$17.00	\$5.32
Davis Besse	894	\$27.12	\$28.35	\$27.47	\$5.85	\$6.50	\$24.60	\$7.30
Dresden	1,797	\$25.15	\$26.12	\$25.31	\$8.52	\$6.06	\$17.00	\$5.32
Hope Creek	1,172	\$23.67	\$25.14	\$24.35	\$7.74	\$6.06	\$17.00	\$5.32
LaSalle	2,271	\$24.35	\$25.33	\$24.54	\$8.52	\$6.06	\$17.00	\$5.32
Limerick	2,242	\$23.61	\$25.09	\$24.30	\$7.74	\$6.06	\$17.00	\$5.32
North Anna	1,892	\$27.98	\$28.66	\$27.76	\$5.03	\$6.06	\$17.00	\$5.32
Peach Bottom	2,347	\$23.31	\$24.82	\$24.04	\$7.74	\$6.06	\$17.00	\$5.32
Perry	1,240	\$27.15	\$28.29	\$27.41	\$5.85	\$6.50	\$24.60	\$7.30
Quad Cities	1,819	\$21.96	\$22.54	\$21.84	\$8.52	\$6.06	\$17.00	\$5.32
Salem	2,328	\$23.66	\$25.14	\$24.35	\$7.74	\$6.06	\$17.00	\$5.32
Surry	1,676	\$27.43	\$27.63	\$26.77	\$5.03	\$6.06	\$17.00	\$5.32
Susquehanna	2,520	\$22.33	\$23.00	\$22.28	\$5.21	\$6.06	\$17.00	\$5.32

The MMU also calculates the capacity price that would be required to cover the net avoidable costs for each nuclear plant. Under the Commission's December 19, 2019, MOPR Order, a competitive offer in the capacity market for a subsidized nuclear plant is defined to be net avoidable costs.⁵⁴ As a

⁵² Forward prices on April 1, 2021. Forward prices are reported for PJM trading hubs which are adjusted to reflect the historical differences between prices at the trading hub and prices at the relevant plant locations. The basis adjustment is based on 2020 data.

⁵³ Oyster Creek retired on September 17, 2018. Exelon. "Oyster Creek Generating Station Retires from Service," (September 17, 2018) <<http://www.exeloncorp.com/newsroom/oyster-creek-retires>>. Three Mile Island retired September 20, 2019. Exelon. "Three Mile Island Generating Station Unit 1 Retires from Service After 45 Years," (September 20, 2019) <<https://www.exeloncorp.com/newsroom/three-mile-island-generating-station-unit-1-retires>>.

⁵⁴ See 169 FERC ¶ 61,239 at P 148.

result, subsidized nuclear plants could make offers in the capacity market as low as but no lower than net avoidable costs. The capacity price required to cover net avoidable costs, when compared to recent capacity market prices, is an indicator of whether nuclear plants subject to the MOPR rules would clear in a capacity auction.

Based on the FERC order about inclusion of maintenance expense in energy offers, major maintenance costs can no longer be included in gross ACR values.⁵⁵ The MMU calculates the capacity price that would be required to cover the net avoidable costs for each nuclear plant with major maintenance included in avoidable costs and with major maintenance excluded from avoidable costs. For the case including major maintenance, gross ACR is NEI total cost including fuel, operating cost, and capital expenditures. For the case excluding major maintenance, gross ACR is NEI total cost including fuel and operating cost, excluding capital expenditures as a proxy for fixed VOM, given that NEI does not provide a breakout of major maintenance. NEI capital expenditures are likely to be a conservatively low estimate of major maintenance expense.

While the FERC order on major maintenance defines a competitive offer under the MOPR order, all generating plants including nuclear plants must cover their gross avoidable costs, including major maintenance, to remain economically viable. All of the MMU analysis of nuclear plant economics includes gross avoidable costs as reported by NEI unless explicitly stated otherwise.

In Table 7-21, the capacity price required to cover avoidable costs in \$ per MWh is calculated by taking the total NEI costs in \$ per MWh and subtracting the total expected energy and ancillary services revenues in \$ per MWh. Total expected energy revenue is the unit's ICAP multiplied by the average forward LMP multiplied by the class average equivalent availability factor. Total expected ancillary services revenue is reactive capability revenue.⁵⁶ The capacity price required to cover avoidable costs in \$ per MW-day is calculated

⁵⁵ See 167 FERC ¶ 61,030 at P 41.

⁵⁶ Reactive Supply & Voltage Control Revenue Requirements available from PJM <<https://www.pjm.com/markets-and-operations/billing-settlements-and-credit.aspx>>.

by multiplying the required price in \$ per MWh by 24. Plants may have actual operating costs higher or lower than the NEI average.

In Table 7-21, for 2022, using forward prices as of April 1, 2021, the capacity price required to cover avoidable costs ranges from \$0/MW-day for a multiple unit plant to \$220.01/MW-day for a single unit plant for NEI data as reported including capex as a proxy for major maintenance, and from \$0/MW-day for multiple unit plants to \$57.25/MW-day for a single unit plant, excluding capital expenditures as a proxy for major maintenance.

Table 7-21 Net ACR

	ICAP (MW)	Net ACR (\$/MWh)			Net ACR (\$/MW-Day)			Net ACR Excluding Capital (\$/MW-Day)		
		2021	2022	2023	2021	2022	2023	2021	2022	2023
Beaver Valley	1,808	\$1.32	\$0.05	\$0.92	\$29.44	\$1.02	\$20.53	\$0.00	\$0.00	\$0.00
Braidwood	2,337	\$3.70	\$2.71	\$3.51	\$82.59	\$60.47	\$78.17	\$0.00	\$0.00	\$0.00
Byron	2,300	\$4.48	\$3.59	\$4.36	\$99.89	\$80.09	\$97.11	\$0.00	\$0.00	\$0.00
Calvert Cliffs	1,708	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Davis Besse	894	\$11.04	\$9.80	\$10.68	\$246.14	\$218.56	\$238.19	\$83.38	\$55.80	\$75.42
Dresden	1,797	\$2.90	\$1.93	\$2.75	\$64.73	\$43.13	\$61.22	\$0.00	\$0.00	\$0.00
Hope Creek	1,172	\$4.28	\$2.81	\$3.60	\$95.48	\$62.63	\$80.31	\$0.00	\$0.00	\$0.00
LaSalle	2,271	\$3.84	\$2.87	\$3.65	\$85.73	\$63.88	\$81.49	\$0.00	\$0.00	\$0.00
Limerick	2,242	\$4.63	\$3.15	\$3.94	\$103.28	\$70.27	\$87.87	\$0.00	\$0.00	\$0.00
North Anna	1,892	\$0.23	\$0.00	\$0.45	\$5.12	\$0.00	\$10.01	\$0.00	\$0.00	\$0.00
Peach Bottom	2,347	\$4.79	\$3.27	\$4.06	\$106.70	\$72.99	\$90.42	\$0.00	\$0.00	\$0.00
Perry	1,240	\$11.01	\$9.87	\$10.75	\$245.42	\$220.01	\$239.67	\$82.66	\$57.25	\$76.91
Quad Cities	1,819	\$6.24	\$5.66	\$6.36	\$139.21	\$126.23	\$141.89	\$20.60	\$7.62	\$23.27
Salem	2,328	\$4.59	\$3.11	\$3.91	\$102.40	\$69.43	\$87.10	\$0.00	\$0.00	\$0.00
Surry	1,676	\$0.78	\$0.59	\$1.44	\$17.46	\$13.07	\$32.19	\$0.00	\$0.00	\$0.00
Susquehanna	2,520	\$5.77	\$5.10	\$5.82	\$128.67	\$113.70	\$129.70	\$10.05	\$0.00	\$11.08

Table 7-22 shows the surplus or shortfall that would be received net of avoidable costs and incremental capital expenditures by year, based on forward prices, on a per MWh basis. The fuel and operating costs are the 2019 NEI fuel, operating, and capital costs. Plants may have operating costs higher or lower than the NEI average. Table 7-22 shows the total dollar surplus or shortfall and adjusts energy revenues and operating costs using the annual class average capacity factor.

Changes in forward energy market prices can significantly affect expected profitability of nuclear plants in PJM. The current analysis, based on forward prices for energy and known forward prices for capacity, shows that only three plants, Davis Besse, Perry, and Susquehanna would not cover their annual avoidable costs in 2021. Two of these plants, Davis Besse and Perry, are single unit sites which have higher operating costs per MWh than multiple unit plants and show an annual shortfall of \$5.19 and \$5.16 per MWh in 2021. In March 2018, Davis Besse and Perry requested deactivation in 2021 but reversed the decision based on new subsidies in Ohio. On March 31, 2021, Ohio repealed the subsidies for nuclear units.⁵⁷ Susquehanna has reduced its operating costs below the NEI average costs and is not operating at a loss when the unit specific information is accounted for.⁵⁸

Hope Creek, Quad Cities, and Salem all currently receive subsidies. Based on forward prices as of April 1, 2021 and NEI average costs, none of these units need a subsidy.

⁵⁷ See Ohio S.B. 44/H.B. 128; see also Ohio Governor Mike DeWine's Website, News Release: "Governor DeWine Signs Ohio Transportation Budget," which can be accessed at: <<https://governor.ohio.gov/wps/portal/gov/governor/media/news-and-media/transportation-budget-signed-03312021>>.

⁵⁸ Bank of America Global Research, October 26, 2020.

Table 7-22 Nuclear unit forward annual surplus (shortfall)^{59 60}

	ICAP (MW)	Surplus (Shortfall)	Subsidy	Surplus (Shortfall)	Surplus (Shortfall)
		(\$/MWh)	(\$/MWh)	Excluding Subsidy	Including Subsidy
		2021	2021	(\$ in millions)	(\$ in millions)
Beaver Valley	1,808	\$3.71		\$56.1	\$56.1
Braidwood	2,337	\$4.82		\$93.6	\$93.6
Byron	2,300	\$4.04		\$77.5	\$77.5
Calvert Cliffs	1,708	\$5.79		\$81.9	\$81.9
Davis Besse	894	(\$5.19)		(\$37.0)	(\$37.0)
Dresden	1,797	\$5.62		\$83.7	\$83.7
Hope Creek	1,172	\$3.46	\$10.00	\$33.9	\$129.3
LaSalle	2,271	\$4.68		\$88.3	\$88.3
Limerick	2,242	\$3.11		\$58.5	\$58.5
North Anna	1,892	\$4.81		\$75.5	\$75.5
Peach Bottom	2,347	\$2.96		\$58.3	\$58.3
Perry	1,240	(\$5.16)		(\$51.1)	(\$51.1)
Quad Cities	1,819	\$2.28	\$16.50	\$35.1	\$279.4
Salem	2,328	\$3.15	\$10.00	\$61.5	\$251.0
Surry	1,676	\$4.25		\$59.3	\$59.3
Susquehanna	2,520	(\$0.56)		(\$9.8)	(\$9.8)

⁵⁹ Report to the General Assembly in Compliance with Section 1-75(d-5) of the Illinois Power Agency Act 20 ILCS 3855/1-75(d-5)(F)(2). Illinois Commerce Commission. August 2019. The report finds that while total ZECs payments are limited by rate impact caps and volume caps, the law's limitation does not unduly constrain the procurement of ZECs.

⁶⁰ Application of PSEG Nuclear, LLC for the Zero Emission Certificate Program – Hope Creek, Order Determining the Eligibility of Hope Creek Nuclear Generator to Receive ZECs, BPU Docket No. ER20080559 (April 27, 2021). Application of PSEG Nuclear, LLC for the Zero Emission Certificate Program – Salem 1, Order Determining the Eligibility of Salem Unit 1 Nuclear Generator to Receive ZECs, BPU Docket No. ER20080557 (April 27, 2021). Application of PSEG Nuclear, LLC for the Zero Emission Certificate Program – Salem 2, Order Determining the Eligibility of Salem Unit 2 Nuclear Generator to Receive ZECs, BPU Docket No. ER20080557 (April 27, 2021).

Environmental and Renewable Energy Regulations

Environmental requirements and renewable energy mandates have a significant impact on PJM markets.

The investments required for environmental compliance have affected offer behavior in the capacity market. Expectations about the cost and life of such investments and about future capacity and energy prices have affected retirement decisions. The markets have also provided incentives for new, lower emissions units to enter.

Environmental requirements and initiatives at both the federal and state levels, and state renewable energy mandates and associated incentives have resulted in the construction of substantial amounts of renewable capacity in the PJM footprint, especially wind and solar resources. Renewable energy credit (REC) markets created by state programs, and federal tax credits have significant impacts on PJM wholesale markets. But state renewables programs in PJM are not coordinated with one another, are generally not consistent with the PJM market design or PJM prices, have widely differing objectives, have widely differing implied prices of carbon and are not transparent on pricing and quantities. The effectiveness of state renewables programs would be enhanced if they were coordinated with one another and with PJM markets, and if they increased transparency. States could evaluate the impacts of a range of carbon prices if PJM would provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to the PJM states in order to permit the states to consider a potential agreement on the development of a multistate framework for carbon pricing and the distribution of carbon revenues. A single carbon price across PJM, established by the states, would be the most efficient way to reduce carbon output, if that is the goal.

Overview

Federal Environmental Regulation

- **MATS.** The U.S. Environmental Protection Agency's (EPA) Mercury and Air Toxics Standards rule (MATS) applies the Clean Air Act (CAA) maximum achievable control technology (MACT) requirement to new or modified sources of emissions of mercury and arsenic, acid gas, nickel, selenium and cyanide.¹ On May 22, 2020, the EPA published its determination that MATS is not appropriate and necessary based on a cost-benefit analysis.² The list of coal steam units subject to MATS, however, remains in place.³ All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS. The EPA's May 22, 2020, finding is under review pursuant to Executive Order 13990.
- **Air Quality Standards (NO_x and SO₂ Emissions).** The CAA requires each state to attain and maintain compliance with fine particulate matter (PM) and ozone national ambient air quality standards (NAAQS). The CAA also requires that each state prohibit emissions that significantly interfere with the ability of another state to meet NAAQS.⁴ On March 15, 2021, the EPA finalized decreases to allowable emissions under the Cross-State Air Pollution Rule (CSAPR) and the 2008 ozone NAAQS for 10 PJM states.⁵
- **NSR.** On August 1, 2019, the EPA proposed to reform the New Source Review (NSR) permitting program.⁶ NSR requires new projects and existing projects receiving major overhauls that significantly increase emissions to obtain permits. Recent EPA proposals would reduce the number of projects that require permits.
- **RICE.** Stationary reciprocating internal combustion engines (RICE) are electrical generation facilities like diesel engines typically used for backup,

¹ *National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil Fuel Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, EPA Docket No. EPA-HQ-OAR-2009-0234, 77 Fed. Reg. 9304 (Feb. 16, 2012).

² *See National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Reconsideration of Supplemental Finding and Residual Risk and Technology Review*, Docket No. EPA-HQ-OAR-2018-0794, 85 Fed. Reg. 31286.

³ *Id.* at 31291.

⁴ CAA § 110(a)(2)(D)(i)(I).

⁵ *Revised Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*, Docket No. EPA-HQ-OAR-2020-0272; FRL-10013-42- OAR, 85 Fed. Reg. 23054 (Apr. 30, 2021).

⁶ *Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NNSR): Project Emissions Accounting*, EPA Docket No. EPA-HQ-OAR-2018-0048; FRL-9997-95-OAR, 84 Fed. Reg. 39244 (Aug. 9, 2019).

emergency or supplemental power. RICE must be tested annually.⁷ RICE do not have to meet the same emissions standards if they are emergency stationary RICE. Environmental regulations allow emergency stationary RICE participating in demand response programs to operate for up to 100 hours per calendar year when providing emergency demand response when there is a PJM declared NERC Energy Emergency Alert Level 2 or there are five percent voltage/frequency deviations.

PJM does not prevent emergency stationary RICE that cannot meet its capacity market obligations as a result of EPA emissions standards from participating in PJM markets as DR. Some emergency stationary RICE that cannot meet its capacity market obligations as a result of emissions standards are now included in DR portfolios. Emergency stationary RICE should be prohibited from participation as DR either when registered individually or as part of a portfolio if it cannot meet its capacity market obligations as a result of emissions standards.

- **Greenhouse Gas Emissions.** On January 19, 2021, the U.S. Court of Appeals for the District of Columbia Circuit vacated the EPA's Affordable Clean Energy (ACE) rule which would have permitted more CO₂ emissions than under the Clean Power Plan (CPP), which ACE had replaced.⁸ Neither the ACE nor CPP is currently effective.
- **Cooling Water Intakes.** An EPA rule implementing Section 316(b) of the Clean Water Act (CWA) requires that cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts.⁹
- **Waters of the United States.** The EPA finalized a rule that significantly narrows the definition of the Waters of the United States. In contrast, the Supreme Court expanded the scope of the CWA when it held that discharge of pollutants from a point source into non jurisdictional groundwater "is the functional equivalent of a direct discharge" when pollutants are conveyed by groundwater into jurisdictional waters.¹⁰ The

⁷ See 40 CFR § 63.6640(f).

⁸ American Lung Association et al. v. EPA, No. 19-1140.

⁹ See EPA, *National Pollutant Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities*, EPA-HQ-OW-2008-0667, 79 Fed. Reg. 48300 (Aug. 15, 2014).

¹⁰ *County of Maui v. Hawaii Wildlife Fund*, Slip. Op. No. 18–260 (April 23, 2020).

EPA's definition of the Waters of the United States is among the actions under review pursuant to Executive Order 13990.

- **Coal Ash.** The EPA administers the Resource Conservation and Recovery Act (RCRA), which governs the disposal of solid and hazardous waste.¹¹ The EPA has proposed significant changes to the implementing regulations.

State Environmental Regulation

- **Regional Greenhouse Gas Initiative (RGGI).** The Regional Greenhouse Gas Initiative (RGGI) is a CO₂ emissions cap and trade agreement among Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia that applies to power generation facilities. New Jersey rejoined on January 1, 2020.¹² Virginia joined RGGI on January 1, 2021, and Pennsylvania is preparing to join.¹³ ¹⁴ The auction price in the March 3, 2021 was \$7.60 per ton, or \$8.38 per metric tonne.
- **Carbon Price.** If the price of carbon were \$50.00 per metric tonne, short run marginal costs would increase by \$24.52 per MWh or 68.0 percent for a new combustion turbine (CT) unit, \$16.71 per MWh or 67.1 percent for a new combined cycle (CC) unit and \$43.15 per MWh or 145.0 percent for a new coal plant (CP) for January through March, 2021.

State Renewable Portfolio Standards

- **RPS.** In PJM, 10 of 14 jurisdictions have enacted legislation requiring that a defined percentage of retail suppliers' load be served by renewable resources, for which definitions vary. These are typically known as renewable portfolio standards, or RPS. As of March 31, 2021, Delaware, Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia and Washington, DC have renewable portfolio standards. Virginia had a voluntary RPS in 2020, but a new mandatory RPS became effective on January 1, 2021. Indiana has voluntary renewable

¹¹ 42 U.S.C. §§ 6901 et seq.

¹² "Statement on New Jersey Greenhouse Gas Rule," RGGI Inc., (June 17, 2019) <https://www.rggi.org/sites/default/files/Uploads/Press-Releases/2019_06_17_NJ_Announcement_Release.pdf>.

¹³ "Statement on Virginia Greenhouse Gas Rule," RGGI, (July 8, 2020) <<https://www.rggi.org/news-releases/rggi-releases>>.

¹⁴ Executive Order–2019-07. Commonwealth Leadership in Addressing Climate Change through Electric Sector Emissions Reductions, Tom Wolf, Governor, October 3, 2019, <<https://www.governor.pa.gov/newsroom/executive-order-2019-07-commonwealth-leadership-in-addressing-climate-change-through-electric-sector-emissions-reductions/>>.

portfolio standards. Kentucky, Tennessee and West Virginia do not have renewable portfolio standards.

- **RPS Cost.** The cost of complying with RPS, as reported by the states, is \$5.6 billion over the six year period from 2014 through 2019, an average annual RPS compliance cost of \$936.7 million. The compliance cost for 2019, the most recent year with almost complete data, was \$1.2 billion.¹⁵

Emissions Controls in PJM Markets

- **Regulations.** Environmental regulations affect decisions about emission control investments in existing units, investment in new units and decisions to retire units. As a result of environmental regulations and agreements to limit emissions, many PJM units burning fossil fuels have installed emission control technology.
- **Emissions Controls.** In PJM, as of March 31, 2021, 93.6 percent of coal steam MW had some type of flue-gas desulfurization (FGD) technology to reduce SO₂ emissions, while 99.8 percent of coal steam MW had some type of particulate control, and 94.7 percent of fossil fuel fired capacity had NO_x emission control technology. All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS.

Renewable Generation

- **Renewable Generation.** Wind and solar generation was 4.6 percent of total generation in PJM in the first three months of 2021. RPS Tier I generation was 6.3 percent of total generation in PJM and RPS Tier II generation was 2.1 percent of total generation in PJM in the first three months of 2021. Only Tier I generation is defined to be renewable but Tier 1 includes some carbon emitting generation.

Recommendations

- The MMU recommends that renewable energy credit markets based on state renewable portfolio standards be brought into PJM markets as they are an increasingly important component of the wholesale energy market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the Commission reconsider its disclaimer of jurisdiction over RECs markets because, given market changes since that decision, it is clear that RECs materially affect jurisdictional rates. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to the PJM states in order to permit the states to consider a potential agreement on the development of a multistate framework for carbon pricing and the distribution of carbon revenues. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that jurisdictions with a renewable portfolio standard make the price and quantity data on supply and demand more transparent. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that load and generation located at separate nodes be treated as separate resources in order to ensure that load and generation face consistent incentives throughout the markets. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that emergency stationary RICE be prohibited from participation as DR either when registered individually or as part of a portfolio if it cannot meet the capacity market requirements to be DR as a result of emissions standards that impose environmental run hour limitations. (Priority: Medium. First reported 2019. Status: Not adopted.)

Conclusion

Environmental requirements and renewable energy mandates at both the federal and state levels have a significant impact on the cost of energy and capacity in PJM markets. Renewable energy credit (REC) markets are markets related to the production and purchase of wholesale power, but FERC has

¹⁵ The 2019 compliance cost value for PJM states does not include Illinois, Michigan or North Carolina. Based on past data these states generally account for 3.0 percent of the total RPS compliance cost of PJM states.

determined that RECs are not regulated under the Federal Power Act unless the REC is sold as part of a transaction that also includes a wholesale sale of electric energy in a bundled transaction.¹⁶ The MMU recommends that the Commission reconsider its disclaimer of jurisdiction over RECs markets because, given market changes since that decision, it is clear that RECs materially affect jurisdictional rates.

RECs clearly affect prices in the PJM wholesale power market. Some resources are not economic except for the ability to purchase or sell RECs. RECs provide out of market payments to qualifying renewable resources, primarily wind and solar. The credits provide an incentive to make negative energy offers and more generally provide an incentive to enter the market, to remain in the market and to operate whenever possible. These subsidies affect the offer behavior and the operational behavior of these resources in PJM markets and in some cases the existence of these resources and thus the market prices and the mix of clearing resources. FERC's recent MOPR order addressed these impacts.

RECs markets are, as an economic fact, integrated with PJM markets including energy and capacity markets, but are not formally recognized as part of PJM markets. It would be preferable to have a single, transparent market for RECs operated by the PJM RTO on behalf of the states that would meet the standards and requirements of all states in the PJM footprint including those with no RPS. This would provide better information for market participants about supply and demand and prices and contribute to a more efficient and competitive market and to better price formation. This could also facilitate entry by qualifying renewable resources by reducing the risks associated with lack of transparent market data. The MMU recommends that PJM provide a full analysis of the impact of carbon pricing on PJM generating units and carbon pricing revenues to states in order to permit states to consider the development of a multistate framework: for RECs markets; for potential

¹⁶ See 139 FERC ¶ 61,061 at PP 18, 22 (2012) (“[W]e conclude that unbundled REC transactions fall outside of the Commission’s jurisdiction under sections 201, 205 and 206 of the FPA. We further conclude that bundled REC transactions fall within the Commission’s jurisdiction under sections 201, 205 and 206 of the FPA... [A]lthough a transaction may not directly involve the transmission or sale of electric energy, the transaction could still fall under the Commission’s jurisdiction because it is ‘in connection with’ or ‘affects’ jurisdictional rates or charges.”).

agreement on carbon pricing including the distribution of carbon revenues; and for coordination with PJM wholesale markets.

REC markets are not consistently or adequately transparent. Data on REC prices, clearing quantities and markets are not publicly available for all PJM states. The provision of more complete data would facilitate competition to provide energy from renewable sources.

The economic logic of RPS programs and the associated REC and SREC prices is not always clear. The price of carbon implied by REC prices ranges from \$7.67 per tonne in Washington, DC to \$17.88 per tonne in Ohio. The price of carbon implied by SREC prices ranges from \$66.50 per tonne in Pennsylvania to \$882.33 per tonne in Washington, DC. The effective prices for carbon compare to the RGGI clearing price in March 2021 of \$8.38 per tonne and to the social cost of carbon which is estimated in the range of \$50 per tonne.¹⁷ The impact on the cost of generation from a new combined cycle unit of a \$50 per tonne carbon price would be \$16.71 per MWh.¹⁸ The impact of an \$800 per tonne carbon price would be \$267.30 per MWh. This wide range of implied carbon prices is not consistent with an efficient, competitive, least cost approach to the reduction of carbon emissions.

In addition, even the explicit environmental goals of RPS programs are not clear. While RPS is frequently considered to target carbon emissions, Tier 1 resources include some carbon emitting generation and Tier 2 resources include additional carbon emitting generation.

PJM markets provide a flexible mechanism for incorporating the costs of environmental controls and meeting environmental requirements in a cost effective manner. Costs for environmental controls are part of offers for capacity resources in the PJM Capacity Market. The costs of emissions credits are included in energy offers. PJM markets also provide a flexible mechanism that incorporates renewable resources and the impacts of renewable energy

¹⁷ “Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12899,” Interagency Working Group on the Social Cost of Greenhouse Gases, United States Government, (Aug. 2016), <https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf>.

¹⁸ The cost impact calculation assumes a heat rate of 6,296 MMBtu per MWh and a carbon emissions rate of 0.053070 tonne per MMBtu. The \$800 per tonne carbon price represents the approximate upper end of the carbon prices implied by the 2019 REC and SREC prices in the PJM jurisdictions with RPS. Additional cost impacts are provided in Table 8-18.

credit markets, and ensures that renewable resources have access to a broad market. PJM markets provide efficient price signals that permit valuation of resources with very different characteristics when they provide the same product.

PJM markets could also provide a flexible mechanism to limit carbon output, for example by incorporating a consistent carbon price in unit offers which would be reflected in PJM's economic dispatch. If there is a social decision to limit carbon output, a consistent carbon price would be the most efficient way to implement that decision. The states in PJM could agree, if they decided it was in their interests, with the appropriate information, on a carbon price and on how to allocate the revenues from a carbon price that would make all states better off. A mechanism like RGGI leaves all decision making with the states. The carbon price would not be FERC jurisdictional or subject to PJM decisions. The MMU continues to recommend that PJM provide modeling information to the states adequate to inform such a decision making process. Such modeling information would include the impact on the dispatch of every unit, the impact on energy prices and the carbon pricing revenues that would flow to each state. This would permit states to make critical decisions about carbon pricing. For example, states receiving high levels of revenue could shift revenue to states disproportionately hurt by a carbon price if they believed that all states would be better off as a result. A carbon price would also be an alternative to specific subsidies to individual nuclear power plants and to the current wide range of implied carbon prices embedded in RPS programs and instead provide a market signal to which any resource could respond. The imposition of specific and prescriptive environmental dispatch rules would, in contrast, pose a threat to economic dispatch and efficient markets and create very difficult market power monitoring and mitigation issues. The provision of subsidies to individual units creates a discriminatory regime that is not consistent with competition. The use of inconsistent implied carbon prices by state is also inconsistent with an efficient market and inconsistent with the least cost approach to meeting state environmental goals.

The annual average cost of complying with RPS over the six year period from 2014 through 2019 for the nine jurisdictions that had RPS was \$936.7 million,

or a total of \$5.2 billion over six years. The RPS compliance cost for 2019, the most recent year for which there is almost complete data, was \$1.2 billion.¹⁹ RPS costs are payments by customers to the sellers of qualifying resources. The revenues from carbon pricing flow to the states.

If all the PJM states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances would be approximately \$2.5 billion per year if the carbon price were \$7.60 per short ton and emissions levels were five percent below 2020 emission levels. If all the PJM states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances would be approximately \$16.6 billion if the carbon price were \$50 per short ton and emission levels were five percent below 2020 levels. If only the current RPS states participated in a regional carbon market, the estimated revenue returned to the states/customers from selling carbon allowances at \$7.60 per short ton would be about \$1.7 billion. The costs of a carbon price are the impact on energy market prices, net of the revenue returned to states/customers.

Federal Environmental Regulation

The U.S. Environmental Protection Agency (EPA) administers the Clean Air Act (CAA), the Clean Water Act (CWA) and the Resource Conservation and Recovery Act (RCRA), all of which address pollution created by electric power production. The administration of these statutes is relevant to the operation of PJM markets.²⁰

The CAA regulates air emissions by providing for the establishment of acceptable levels of emissions of hazardous air pollutants. The EPA issues technology based standards for major sources and area sources of emissions.^{21 22}

¹⁹ The 2019 compliance cost value for PJM states does not include Illinois, Michigan or North Carolina. Based on past data these states generally account for 3.0 percent of the total RPS compliance cost of PJM states.

²⁰ For more details, see the *2019 State of the Market Report for PJM*, Vol. II, Appendix H: "Environmental and Renewable Energy Regulations."

²¹ 42 U.S.C. § 7401 et seq. (2000).

²² The EPA defines a "major source" as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants. An "area source" is any stationary source that is not a major source.

The CWA regulates discharges from point sources that affect water quality and temperature.

The Resource Conservation and Recovery Act (RCRA) regulates the disposal of solid and hazardous waste.²³ Regulation of coal ash or coal combustion residuals affects coal fired power plants.

The EPA's actions have affected and will continue to affect the cost to build and operate generating units in PJM, which in turn affects wholesale energy prices and capacity prices.

CAA: NESHAP/MATS

Section 112 of the CAA requires the EPA to promulgate emissions control standards, known as the National Emission Standards for Hazardous Air Pollutants (NESHAP), from both new and existing area and major sources. On December 21, 2011, the EPA issued its Mercury and Air Toxics Standards rule (MATS), which applies the CAA maximum achievable control technology (MACT) requirement to new or modified sources of emissions of mercury and arsenic, acid gas, nickel, selenium and cyanide.

On May 22, 2020, the EPA published a rule finalizing its Supplemental Cost Finding for the MATS, and the risk and technology review required by the CAA.²⁴ The EPA determined that the estimated cost to coal and oil fired power plants of complying with the MATS rule in 2015 outweighed the estimated quantifiable benefits attributable to regulating hazardous air pollutant (HAP) emissions in 2015.²⁵ The EPA determined that based on analysis of costs versus benefits it is not "appropriate and necessary" to regulate HAP emissions from power plants under Section 112 of the Clean Air Act.²⁶ ²⁷ The immediate practical effect is limited because the emission standards and other requirements of the 2012 MATS rule remain in place and the list of coal and oil

fired power plants regulated under Section 112 of the Act remains in place.²⁸ Removal of the appropriate and necessary finding creates the possibility of a challenge to the MATS rule if applied to the proposed construction or upgrade of a power plant.

On January 20, 2021, an executive order was issued stating national objectives "to listen to the science; to improve public health and protect our environment; to ensure access to clean air and water; to limit exposure to dangerous chemicals and pesticides; to hold polluters accountable, including those who disproportionately harm communities of color and low-income communities; to reduce greenhouse gas emissions; to bolster resilience to the impacts of climate change; to restore and expand our national treasures and monuments; and to prioritize both environmental justice and the creation of the well-paying union jobs necessary to deliver on these goals" ("Executive Order 13990").²⁹ The order directs government agencies to immediately review, and as appropriate and consistent with applicable law, "take action to address the promulgation of Federal regulations and other actions during the last 4 years that conflict with these important national objectives, and to immediately commence work to confront the climate crisis."³⁰ The May 22, 2021, supplemental finding on MATS is an action specified for review.³¹

On April 9, 2020, the EPA finalized a rule establishing a new sub category in the MATS with less stringent requirements for units fueled by eastern bituminous refuse coal, waste coal.³² The rule allows four refuse coal plants, Grant Town Power Plant (Unit 1A and 1 B (40 MW each)) in West Virginia; and Colver Power Project (110 MW), Ebensburg Power Plant (50 MW), and Scrubgrass Generating Co. (Units 1 and 2 (42 MW each)) in Pennsylvania; to emit higher levels of acid gases and SO₂.³³ The EPA stated that it was

²³ 42 U.S.C. §§ 6901 et seq.

²⁴ See *National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Reconsideration of Supplemental Finding and Residual Risk and Technology Review*, Docket No. EPA-HQ-OAR-2018-0794, 85 Fed. Reg. 31286.

²⁵ *Id.* at 31299.

²⁶ *Michigan v. EPA*, 135 S.Ct. 2699 (2015) (reversed EPA determination that cost does not have to be read into the definition of "appropriate").

²⁷ 85 Fed. Reg. at 31288.

²⁸ *Id.* at 31291. The EPA explains (*id.*): "The Court's holding in *New Jersey* [517 F.3d 574 (D.C. Cir. 2008)] plainly states that CAA section 112(c)(9) 'unambiguously limit[s] EPA's discretion to remove sources, including EGUs, from the section 112(c)(1) list once they have been added to it' 517 F.3d 574, 583 (D.C. Cir. 2008)."

²⁹ See President Joseph R. Biden Jr., Executive Order 13990 re "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" ("Executive Order 13990").

³⁰ *Id.* (Sec. 1).

³¹ *Id.* at Sec. 2(iv).

³² See *National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units—Subcategory of Certain Existing Electric Utility Steam Generating Units Firing Eastern Bituminous Coal Refuse for Emissions of Acid Gas Hazardous Air Pollutants*, Docket No. EPA-HQ-OAR-2018-0794, 85 Fed. Reg. 20838 (April 15, 2020).

³³ *Id.* at 20841.

concerned that units would close and leave coal refuse piles, which are prone to smoldering and emit uncontrolled acid gases and other HAP.³⁴

CAA: NAAQS/CSAPR

The CAA requires each state to attain and maintain compliance with fine particulate matter and ozone national ambient air quality standards (NAAQS). Under NAAQS, the EPA establishes emission standards for six air pollutants, including NO_x, SO₂, O₃ at ground level, PM, CO, and Pb, and approves state plans to implement these standards, known as State Implementation Plans (SIPs).

In January 2015, the EPA began implementation of the Cross-State Air Pollution Rule (CSAPR) to address the CAA's requirement that each state prohibit emissions that significantly interfere with the ability of another state to meet NAAQS. CSAPR requires specific states in the eastern and central United States to reduce power plant emissions of SO₂ and NO_x that cross state lines and contribute to ozone and fine particle pollution in other states. CSAPR requires reductions to levels consistent with the 1997 ozone and fine particle and 2006 fine particle NAAQS. CSAPR covers 28 states, including all of the PJM states except Delaware, and also excluding the District of Columbia.³⁵

On March 15, 2021, in response to a court holding in *Wisconsin v. EPA*,³⁶ the EPA finalized increases to the good neighbor obligations (i.e. reduced allowable emissions) under the 2008 ozone NAAQS for 12 states.³⁷ Eleven of the affected states are PJM states: Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The EPA determined that Tennessee's emissions budget "fully eliminated the state's

³⁴ *Id.* at 20847.

³⁵ Section 126 of the CAA permits a downwind state to file a petition with the EPA to regulate the emissions from particular resources in another state. On October 5, 2018, EPA denied petitions filed under this provision filed by Delaware and Maryland. See *Response to Clean Air Act Section 126(b) Petitions From Delaware and Maryland*, EPA Docket No. EPA-HQ-OAR-2018-0295, 83 Fed. Reg. 50444 (Oct. 5, 2018). Delaware filed a petition requesting that the EPA regulate emissions from the Brunner Island coal plant in Pennsylvania, the Harrison coal plant in West Virginia, the Homer City coal plant in Pennsylvania and the Conemaugh coal plant in Pennsylvania. Maryland filed a petition requesting that the EPA regulate 36 generating units at coal plants located in Indiana, Kentucky, Ohio, Pennsylvania and West Virginia. U.S. Court of Appeals for the D.C. Circuit Case No. 18-1285. On May 15, 2020, the Court denied an appeal of the EPA decision filed by Maryland, except that the Court agreed that EPA did not sufficiently support its rejection based on the cost effectiveness of Maryland's request that two waste coal plants, Cambria Cogeneration (Pa.) and Grant Town Cogen (W.Va.), be required to operate selective noncatalytic reduction (SNCR) controls, and remanded the decision. *Maryland v. Wheeler*, Case No. 18-1285 (D.C. Cir. May 19, 2020).

³⁶ *Wisconsin v. EPA*, 938 F.3d 303, 318–20 (D.C. Cir. 2019).

³⁷ *Revised Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*, Docket No. EPA-HQ-OAR-2020-0272; FRL-10013-42- OAR, 85 Fed. Reg. 23054 (Apr. 30, 2021).

significant contribution to downwind nonattainment and interference with maintenance of the 2008 ozone NAAQS."³⁸ For the remaining PJM states, projected 2021 emissions were found to contribute at or above a threshold of 1 percent of the NAAQS (0.75 ppb) to the identified nonattainment and/or maintenance problems in downwind states.³⁹ Starting with the 2021 ozone season for emissions trading under CSAPR, the new FIPs require power plants in the affected states (also including Louisiana and New York) to participate in a new CSAPR NO_x Ozone Season Group 3 Trading Program.⁴⁰ Participation in the more stringent new program would replace the obligation to participate in the existing CSAPR NO_x Ozone Season Group 2 Trading Program.^{41 42}

The EPA's new emissions budgets for each PJM state for each ozone season for 2021 through 2024, and beyond are shown in Table 8-1. Table 8-1 also includes the states budgets that would have been in effect had the rules not been revised.

Table 8-1 CSAPR NO_x ozone season group 3 state budgets: 2021 through 2024^{43 44}

	Emissions Budget (Tons)							
	Budget without revised rule				Revised budget			
PJM State	2021	2022	2023	2024+	2021	2022	2023	2024+
Illinois	9,368	9,368	8,413	8,292	9,102	9,102	8,179	8,059
Indiana	15,856	15,383	15,357	12,232	13,051	12,582	12,553	9,564
Kentucky	15,588	15,588	15,588	15,588	15,300	14,051	14,051	14,051
Maryland	1,501	1,267	1,267	1,350	1,499	1,266	1,266	1,348
Michigan	13,898	13,459	11,182	10,968	12,727	12,290	9,975	9,786
New Jersey	1,346	1,346	1,346	1,346	1,253	1,253	1,253	1,253
Ohio	15,829	15,927	15,927	15,927	9,690	9,773	9,773	9,773
Pennsylvania	11,896	11,896	11,896	11,896	8,379	8,373	8,373	8,373
Virginia	4,664	4,274	4,361	4,025	4,516	3,897	3,980	3,663
West Virginia	15,165	15,165	15,165	15,165	13,334	12,884	12,884	12,884

³⁸ *Id.* at 23066.

³⁹ *Id.* at 23085–23086.

⁴⁰ *Id.* at 23121.

⁴¹ *Id.*

⁴² On April 30, 2021, the MMU sent a market message to PJM market participants explaining how to account for the changes in cost-based offers. See "CSAPR Ozone Season Changes," <https://www.monitoringanalytics.com/reports/Market_Messages/Messages/IMM_CSAPR_Ozone_Season_Changes_20210430.pdf>

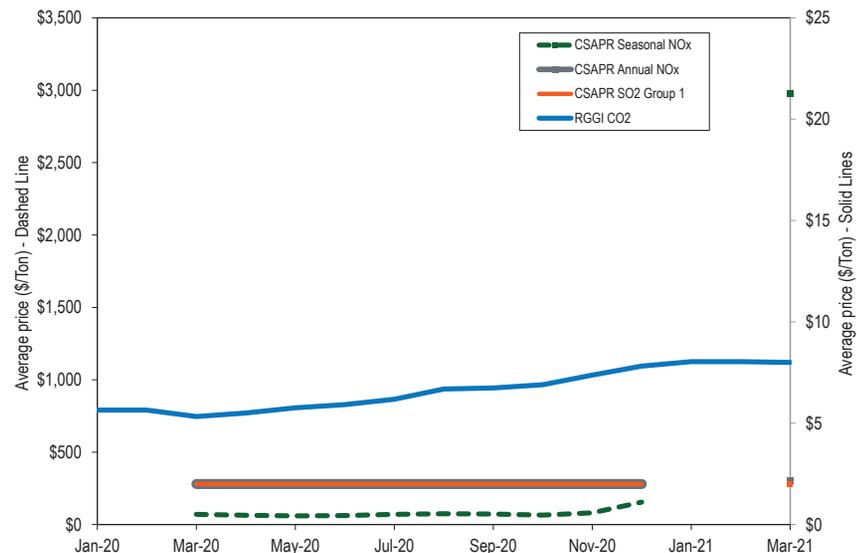
⁴³ *Id.* at 23123–23124 (Table VII.C.2–1–4).

⁴⁴ See "State Budgets under the Revised Cross-State Air Pollution Rule Update", EPA, <<https://www.epa.gov/csapr/state-budgets-under-revised-cross-state-air-pollution-rule-update>>.

Figure 8-1 shows average, monthly settled prices for NO_x, CO₂ and SO₂ emissions allowances including CSAPR related allowances for 2020. Figure 8-1 also shows the average, monthly settled price for the Regional Greenhouse Gas Initiative (RGGI) CO₂ allowances.

In the first three months of 2021, CSAPR annual NO_x prices were 8 percent higher than in the first three months of 2020. In 2020, CSAPR Seasonal NO_x prices were on average \$78.04 per credit, with prices exceeding \$200.00 in late December. In March 2021 the average price was \$2,977.27 per credit, a 4,139.5 percent increase over the March 2020 average price of \$70.23 per credit.

Figure 8-1 Spot monthly average emission price comparison: January 2020 through March 2021



CAA: NSR

Parts C and D of Title I of the CAA provide for New Source Review (NSR) in order to prevent new projects and projects receiving major modifications from increasing emissions in areas currently meeting NAAQS or from inhibiting progress in areas that do not.⁴⁵ NSR requires permits before construction commences. In PJM, permits are issued by state environmental regulators, or in a process involving state and regional EPA regulators.⁴⁶

NSR review applies a two part analysis to projects at facilities such as power plants, some of which involve multiple units and combinations of new and existing units. The first part considers whether a modification would cause a “significant emission increase” of a regulated NSR pollutant. The second part considers whether any identified increase is also a “significant net emission increase.”

On August 1, 2019, the EPA proposed revisions to the NSR permitting program under which, both emissions increases and decreases from a major modification would be considered in the first part of the NSR applicability test.⁴⁷ Under the revised rule the need for a permit and associated investments in pollution controls would be more frequently avoided than under the current rule.

On March 25, 2020, the EPA released a memorandum changing the EPA’s longstanding interpretation of “begin actual construction” under the NSR preconstruction permitting regulations.⁴⁸ EPA policy has been to preclude almost every physical onsite construction activity that is of a permanent nature prior to issuance of a permit. Under the new interpretation, which focuses on the statutory meaning of “emissions unit,”⁵⁰ the policy precludes **only** the construction of the emissions unit. The EPA clarified that the costs and

⁴⁵ 42 U.S.C § 7470 et seq.

⁴⁶ CAA permitting in EPA Region 2 (New Jersey) is the responsibility of the state’s environmental regulatory authority; CAA permitting in Region 3 (Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia) is the shared responsibility of each state’s environmental regulatory authority and EPA Region 3; CAA permitting in Region 4 (Kentucky and North Carolina) is the shared responsibility of each state’s environmental regulatory authority and EPA Region 4; CAA permitting in EPA Region 5 (Illinois, Indiana, Michigan and Ohio) is the responsibility of each state’s environmental regulatory authority.

⁴⁷ *Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NNSR): Project Emissions Accounting*, EPA Docket No. EPA-HQ-OAR-2018-0048; FRL-9997-95-OAR, 84 Fed. Reg. 39244 (Aug. 9, 2019).

⁴⁸ See Anne L. Idsal, Principal Deputy Assistant Administrator, Memorandum re Interpretation of “Begin Actual Construction” Under the New Source Review Preconstruction Permitting Regulations” (“March 25th Memo”).

⁴⁹ See 40 CFR § 52.21(b)(11); 40 CFR § 52.21(a)(2)(iii).

⁵⁰ 40 CFR § 52.21(b)(7) (“any part of a stationary source that emits or would have the potential to emit any regulated NSR pollutant and includes an electric utility steam generating unit...”).

consequences of pre permit construction are risks born by the owner/operators if no permit issues, or issues without the expected terms or conditions. The new interpretation significantly expands the scope of activity that an owner/operator willing to assume the risks may undertake prior to receiving an NSR permit when constructing a project that will include an emissions unit.

CAA: RICE

On January 14, 2013, the EPA signed a final rule amending its rules regulating emissions from a wide variety of stationary reciprocating internal combustion engines (RICE). RICE include certain types of electrical generation facilities like diesel engines typically used for backup, emergency or supplemental power, including facilities located behind the meter. These rules include: National Emission Standard for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE); New Source Performance Standards (NSPS) of Performance for Stationary Spark Ignition Internal Combustion Engines; and Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (collectively RICE Rules). The RICE Rules apply to emissions such as formaldehyde, acrolein, acetaldehyde, methanol, CO, NO_x, volatile organic compounds (VOCs) and PM.

EPA regulations require that RICE that do not meet EPA emissions standards (emergency stationary RICE) may operate for only 100 hours per year and only to provide emergency DR during an Energy Emergency Alert 2 (EEA2), or if there are five percent voltage/frequency deviations.⁵¹ Under PJM rules, an EEA2 is automatically triggered when PJM initiates an emergency load response event. Demand resources that rely on RICE to provide load reductions are constrained to a maximum of 100 hours.

PJM does not prevent emergency stationary RICE that does not meet emissions standards from participating in PJM markets as DR. Some emergency stationary RICE that does not meet emissions standards are now included in DR portfolios. Emergency stationary RICE should be prohibited from participation as DR either when registered individually or as part of a portfolio if it does not meet emissions standards. Emergency RICE with a limit of 100 hours per

⁵¹ Emergency Operations, EOP-011-1, North American Electric Reliability Corporation, <<https://www.nerc.com/pa/Stand/Reliability%20Standards/EOP-011-1.pdf>> (Accessed March 2, 2020).

year cannot comply with the requirement to be available during the entire delivery year to be a capacity resource. PJM should not allow locations that rely upon emergency stationary RICE to register individually or in portfolios. Registration of DR should be based on a finding that registered locations are capable of providing load reductions without an hourly limit. Reliance on the prospect of penalties to deter registration of ineligible resources as DR in lieu of a substantive ex ante review is not appropriate.

CAA: Greenhouse Gas Emissions

The EPA regulates CO₂ as a pollutant using CAA provisions that apply to pollutants not subject to NAAQS.^{52 53}

The U.S. Court of Appeals for the Seventh Circuit has determined that a government agency can reasonably consider the global benefits of carbon emissions reduction against costs imposed in the U.S. by regulations in analyses known as the “Social Costs of Carbon.”⁵⁴ The Court rejected claims raised by petitioners that raised concerns that the Social Cost of Carbon estimates were arbitrary, were not developed through transparent processes, and were based on inputs that were not peer reviewed.⁵⁵ Although the decision applies only to the Department of Energy’s regulations of manufacturers, it bolsters the ability of the EPA and state regulators to rely on Social Cost of Carbon analyses.

Executive Order 13990, Section 6, establishes an Interagency Working Group on the Social Cost of Greenhouse Gases. The group is tasked to develop estimates in the form of monetized damages for the “social cost of carbon” (SCC), the “social cost of nitrous oxide” (SCN), and the “social cost of methane” (SCM), associated with incremental increases in greenhouse gas emissions. The cost estimates would be used by EPA and other agencies to determine the

⁵² See CAA § 111.

⁵³ On April 2, 2007, the U.S. Supreme Court overruled the EPA’s determination that it was not authorized to regulate greenhouse gas emissions under the CAA and remanded the matter to the EPA to determine whether greenhouse gases endanger public health and welfare. *Massachusetts v. EPA*, 549 U.S. 497. On December 7, 2009, the EPA determined that greenhouse gases, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, endanger public health and welfare. See *Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*, 74 Fed. Reg. 66496, 66497 (Dec. 15, 2009). In a decision dated June 26, 2012, the U.S. Court of Appeals for the D.C. Circuit upheld the endangerment finding, rejecting challenges brought by industry groups and a number of states. *Coalition for Responsible Regulation, Inc. et al. v. EPA*, No 09-1322.

⁵⁴ See *Zero Zone, Inc. et al. v. U.S. Dept. of Energy, et al.*, Case Nos. 14-2147, et al., Slip Op. (Aug. 8, 2016).

⁵⁵ *Id.*

social benefits of reducing greenhouse gas emissions when conducting cost-benefit analyses of regulatory and other actions.

Effective October 23, 2015, the EPA placed national limits on the amount of CO₂ that new, modified or reconstructed fossil fuel fired steam power plants would be allowed to emit based on the best system of emission reductions (BSER) determined by the EPA (2015 GHG NSR Rule).⁵⁶ On December 12, 2018, the EPA proposed to revise the 2015 GHG NSR Rule by increasing the allowable emissions and eliminating the requirement for carbon capture for new coal units.⁵⁷

On January 19, 2021, the U.S. Court of Appeals for the District of Columbia Circuit vacated the EPA's Affordable Clean Energy (ACE) rule which would have permitted more CO₂ emissions than under the Clean Power Plan, which ACE had replaced. On February 12, 2021, EPA issue a memo stating that as a result of the court vacating ACE without reinstating the Clean Power Plan ("CPP"), there are no effective regulations under CAA section 111(d) with respect to greenhouse gas emissions from electric generating units at this time, and states are not currently required to submit plans.⁵⁸ The memo also noted: "ongoing changes in electricity generation mean that the emission reduction goals that the CPP set for 2030 have already been achieved."⁵⁹

CWA: WOTUS Definition and Effluents

WOTUS

The Clean Water Act (CWA) applies to the navigable waters, which are defined as waters of the United States (WOTUS).^{60 61}

⁵⁶ *Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units*, Proposed Rule, EPA-HQ-OAR-2013-0495, 90 Fed. Reg. 205 (October 23, 2015) ("2015 GHG NSR Rule"); 40 CFR Part 60, subpart TTTT.

⁵⁷ *Review of Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units*, EPA-HQ-OAR-2013-0495; FRL-9987-85- OAR, 83 Fed. Reg. 65424, 65427 (Dec. 20, 2018) ("2018 Proposed Rev. GHG NSR").

⁵⁸ See Joseph Goffman, Acting Assistant Administrator, EPA, Memo re Status of Affordable Clean Energy Rule and Clean Power Plan (February 12, 2021).

⁵⁹ *Id.*, citing "Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units," EPA-452/R-19-003 (June 2019), at 2-14 to 2-15.

⁶⁰ 33 U.S.C. 1251 et seq.; 33 U.S.C. § 1362(7) ("The term "navigable waters" means the waters of the United States, including the territorial seas.")

⁶¹ For more details, see the 2019 *State of the Market Report for PJM*, Volume II, Appendix H: "Environmental and Renewable Energy Regulations."

On October 22, 2019, the EPA issued a final rulemaking to rescind the definition of WOTUS proposed in the 2015 Clean Water Rule. The rule prevents the potential implementation of a broader definition of WOTUS included in the 2015 rule that was never implemented as the result of a stay issued by a reviewing Court.⁶² The U.S. Supreme Court reversed the stay, but the EPA amended the 2015 Clean Water Rule to establish an applicability date of February 6, 2020.⁶³

On April 21, 2020, the EPA and the Department of the Army published a final rule to define WOTUS, the Navigable Waters Protection Rule ("NWPR").⁶⁴ The NWPR became effective in PJM states on June 22, 2020. The replacement rule significantly narrows the scope of federal jurisdiction. The replacement rule does not include coal ash ponds in the definition of WOTUS.⁶⁵ Environmental groups have filed complaints seeking to overturn the NWPR, including in federal district court in Maryland.⁶⁶ The NWPR is among the actions under review pursuant to Executive Order 13990.

The scope of the CWA has expanded and the precise definition of WOTUS has become less important as a result of a decision of the U.S. Supreme Court in *County of Maui v. Hawaii Wildlife Fund*, which held that the discharge of pollutants via groundwater requires a CWA permit.⁶⁷ Groundwater is not itself WOTUS. However, if pollutants pass through groundwater from a point source to WOTUS, a permit may be required.⁶⁸ This holding invalidates the EPA's recent interpretive statement intended to establish a bright line rule excluding all releases of pollutants to groundwater from the permitting program.⁶⁹ The EPA may not interpret the CWA to require a direct discharge.⁷⁰ The Court held that discharge into groundwater "is the functional equivalent of a direct discharge."⁷¹ The existence of a functional discharge will depend on an

⁶² The stay was issued by the U.S. Court of Appeals for the Sixth Circuit on October 9, 2015.

⁶³ See *Definition of "Waters of the United States"—Addition of an Applicability Date to 2015 Clean Water Rule*, Final Rule, EPA Docket No. EPA-HQ-OW-2017-0644, 83 Fed. Reg. 5200 (Feb. 6, 2018); *National Assoc. of Mfg. v. Dept. of Defense*, No. 16-299 (S. Ct. Jan. 22, 2018).

⁶⁴ See *The Navigable Waters Protection Rule: Definition of "Waters of the United States"*, EPA Docket No. EPA-HQ-OW-2018-0149, 85 Fed. Reg. 22250.

⁶⁵ *Id.* at 22251-22252.

⁶⁶ See *Chesapeake Bay Foundation et al. v. Wheeler et al.*, Case 1:20-cv-01064-GLR (USDC Dist. of Md.).

⁶⁷ *Slip. Op. No. 18-260* (April 23, 2020).

⁶⁸ *Id.*

⁶⁹ See *Interpretive Statement on Application of the Clean Water Act National Pollutant Discharge Elimination System Program to Releases of Pollutants From a Point Source to Groundwater*, 84 Fed. Reg. 16810 (April 23, 2019).

⁷⁰ *Slip. Op. No. 18-260* at 5.

⁷¹ *Id.* at 1.

analysis including time and distance, and other factors.⁷² Additional litigation or administrative action may clarify the functional discharge analysis.⁷³ *County of Maui* reduces the importance of the precise definition of WOTUS because WOTUS is generally part of the watershed.⁷⁴

Discharges and Intakes

The EPA regulates discharges from and intakes to power plants, including water cooling systems at steam electric power generating stations, under the CWA.⁷⁵

RCRA: Coal Ash

The EPA administers the Resource Conservation and Recovery Act (RCRA), which governs the disposal of solid and hazardous waste.⁷⁶ Solid waste is regulated under subtitle D. Subtitle D criteria are not directly enforced by the EPA. Subtitle C governs the disposal of hazardous waste. Hazardous waste is subject to direct regulatory control by the EPA from the time it is generated until its ultimate disposal.

In April 2015, the EPA issued a rule under RCRA, the Coal Combustion Residuals rule (2015 CCRR), which sets criteria for the disposal of coal combustion residues (CCRs), or coal ash, produced by electric utilities and independent power producers.⁷⁷ CCRs include fly ash (trapped by air filters), bottom ash (scooped out of boilers) and scrubber sludge (filtered using wet limestone scrubbers). These residues are typically stored on site in ponds (surface impoundments) or sent to landfills.

⁷² *Id.* at 16 (“The difficulty with this approach, we recognize, is that it does not, on its own, clearly explain how to deal with middle instances. But there are too many potentially relevant factors applicable to factually different cases for this Court now to use more specific language. Consider, for example, just some of the factors that may prove relevant (depending upon the circumstances of a particular case): (1) transit time, (2) distance traveled, (3) the nature of the material through which the pollutant travels, (4) the extent to which the pollutant is diluted or chemically changed as it travels, (5) the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, (6) the manner by or area in which the pollutant enters the navigable waters, (7) the degree to which the pollution (at that point) has maintained its specific identity. Time and distance will be the most important factors in most cases, but not necessarily every case.”).

⁷³ *Id.*

⁷⁴ See *id.* at 5 (“Virtually all water, polluted or not, eventually makes its way to navigable water. This is just as true for groundwater.”).

⁷⁵ For more details, see the 2019 *State of the Market Report for PJM*, Volume II, Appendix H: “Environmental and Renewable Energy Regulations.”

⁷⁶ 42 U.S.C. §§ 6901 *et seq.*

⁷⁷ See *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities*, 80 Fed. Reg. 21302 (April 17, 2015).

In 2016, RCRA was amended to establish a permitting scheme allowing states to apply to the EPA for approval to operate a permit program that implements the CCR rule. Such state programs could include alternative state standards, provided that EPA determines that they are “at least as protective as” the EPA CCR regulations.⁷⁸

Effective August 9, 2018, the EPA approved certain revisions to the 2015 CCRR (“2018 CCRR Revisions”) partly in response to the 2016 amendments.⁷⁹

The 2018 CCRR Revisions provide for two types of alternative performance standards. The first type of standards allows a state director (if a state has EPA approved CCR permit program) or the EPA (if no state program) to suspend groundwater monitoring requirements if there is evidence that there is no potential for migration of hazardous constituents to the uppermost aquifer during the active life of the unit and during post closure care. The second type allows issuance of technical certifications by a state director in lieu of a professional engineer.

The 2018 CCRR Revisions revised the groundwater protection standards for health-based levels for four contaminants: cobalt at 6 mg/L; lithium at 40 mg/L; molybdenum at 100 mg/L and lead at 15 mg/L. Standards for other monitored contaminants follow the Maximum Contaminant Level (MCL) established under the Safe Water Drinking Act.

The 2018 CCRR Revisions extended the deadline for closing coal ash units in two situations: (i) detection of a statistically significant increase above a groundwater protection standard from an unlined surface impoundment; or (ii) inability to comply with the location restriction regarding placement above the uppermost aquifer. The exceptions in the 2018 CCRR to the standards in the 2015 CCRR and relaxation of the deadlines create a less stringent federal rule.

⁷⁸ The Water Infrastructure Improvements for the Nation Act (WIIN Act).

⁷⁹ See *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Amendments to the National Minimum Criteria (Phase One, Part One)*, EPA Docket No. EPA-HQ-OLEM-2017-0286, 83 Fed. Reg. 36435 (July 30, 2018).

The U.S. Court of Appeals for the D.C. Circuit invalidated certain provisions of the 2015 CCRR and remanded it to the EPA.⁸⁰ On July 29, 2020, the EPA finalized revisions to CCRR in compliance with the court orders (“Revised CCRR”).⁸¹ The Revised CCRR requires (i) unlined surface impoundments (ponds) and ponds failing restrictions on the minimum depth to or interaction with an aquifer to cease receiving waste as soon as technically feasible and no later than April 11, 2021; and (ii) removal of compacted soil lined and clay lined ponds from classification as lined and exempt from CCRR.⁸² Impoundment facilities unable to meet the earliest deadline would be able to obtain extensions until an alternative can be “technically feasibly implemented.”⁸³ Utilities had until November 30, 2020, to obtain an automatic extension upon certification of need for additional time.⁸⁴ Upon receipt of required documentation satisfying certain criteria, the EPA could grant certain extensions, including to as late as October 17, 2028, for a facility with a surface impoundment of 40 acres or greater that commits to a deadline for ending operations of its boiler.⁸⁶

In response to the RCRA amendments, the EPA proposed a new rule to implement a federal CCR permit program in non participating states, noticed February 20, 2020.⁸⁷ This proposal includes requirements for federal CCR permit applications, content and modification, as well as procedural requirements. The EPA would implement this permit program at CCR units located in states that have not submitted their own CCR permit program for approval. No PJM state has yet applied for EPA approval of a coal ash permitting program.

In Virginia, the Waste Management Board amended the Virginia Solid Waste Management Regulations in December 2015, to incorporate the EPA’s 2015 CCRR, and did not adopt the less stringent 2018 CCRR Revisions.⁸⁸ In 2019, Virginia enacted legislation directing the closure of coal ash ponds located in

80 Utility Solid Waste Activities Group, et al. v. EPA, No. 15-1219 (D.C. Cir. August 21, 2018); Waterkeeper Alliance Inc. et al. v. EPA, No. 18-1289 (D.C. Cir. March 13, 2019).

81 See *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part A: Deadline To Initiate Closure*, EPA-HQ-OLEM-2019-0172; FRL-10002-02-OLEM, 85 Fed. Reg. 53516 (August 28, 2020).

82 *Id.* at 53516-53517, 53536.

83 *Id.* at 53546.

84 *Id.* at 65942.

85 A number of plants in PJM timely filed for extensions.

86 *Id.*

87 See *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Federal CCR Permit Program*, 85 Fed. Reg. 9940 (Feb. 20, 2020).

88 The following Virginia power stations host coal ash ponds: Bremono Power Station, Chesapeake Energy Center, Chesterfield Power Station, Clinch River Plant and Possum Point Power Station, owned by Dominion Energy; and Glen Lyn Plant, owned by Appalachian Power.

the Chesapeake Bay Watershed and owned by Dominion Energy.⁸⁹ Effective July 1, 2019, coal ash ponds at power stations in the Chesapeake Bay Watershed had to be closed by removal of coal ash. The removed coal ash either had to be recycled (at least 6.8 million cubic yards) or disposed of in a modern, lined landfill. The Virginia DEQ is addressing closing ash ponds under two types of environmental permits: wastewater discharge permits covering the removal of treated water from the ponds; or solid waste permits covering the permanent closure of the ponds.

On March 30, 2020, in response to a statutory mandate,⁹⁰ the Illinois Environmental Protection Agency (Illinois EPA) proposed rules for coal combustion residual surface impoundments with the Illinois Pollution Control Board.⁹¹ The proposed rules contain standards for the storage and disposal of coal combustion residuals in surface impoundments. The proposed rules include a permitting program and are intended to meet federal standards.⁹² Presumably the rules, once finalized, would be the basis for an application under RCRA allowing the Illinois EPA to also administer the federal regulatory program. The Illinois EPA has identified 73 coal combustion residuals surface impoundments at power stations, some lined with impermeable materials and some not.⁹³ The Illinois EPA believes that as many as six lined surface impoundments may comply with the federal liner standards.⁹⁴

The North Carolina Department of Environmental Quality (NCDEQ) has initiated a rule making on rules for the disposal or recycling of coal combustion residuals. None of the affected power stations or power station impoundments are located in the PJM Dominion Zone (which includes a portion of northeast coastal North Carolina).

The Maryland Department of Environment (MDE) indicated in April 2020, that it would require GenOn Holdings Inc. to meet a November 1, 2020, deadline for compliance with effluent guidelines at Chalk Point Generating Station,

89 Va. Code § 10.1-1402.03.

90 Ill. Public Act 101-171 (a.k.a. SB 09).

91 The proposed rule amends the Illinois Administrative Code to create a new Part 845 in Title 35.

92 See *In the Matter of Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments*, No. R 2020-019 (March 30, 2020) at 1 [Proposed New 35 Ill. Adm. Code 845] (“Proposed Illinois CCR Rules”).

93 Proposed Illinois Rules at 3.

94 *Id.* at 3.

Dickerson Generating Station and Morgantown Generating Station.⁹⁵ On May 15, 2020, GenOn announced its decision to retire the Dickerson Generating Station.⁹⁶ Dickerson Generating Station was retired effective August 13, 2020. On August 10, 2020, Genon announced that the Chalk Point coal units would retire on June 1, 2021.⁹⁷ On December 18, 2020, GenOn reported that it would retire its Morgantown coal fired unit by October 1, 2027.⁹⁸

State Environmental Regulation

State Emissions Regulations

States have in some cases enacted emissions regulations more stringent or potentially more stringent than federal requirements:⁹⁹

- **New Jersey HEDD.** Units that run only during peak demand periods have relatively low annual emissions, and have less reason to make such investments under the EPA transport rules. New Jersey addressed the issue of NO_x emissions on peak energy demand days with a rule that defines peak energy usage days, referred to as high electric demand days or HEDD, and imposes operational restrictions and emissions control requirements on units responsible for significant NO_x emissions on such high energy demand days. New Jersey's HEDD rule, which became effective May 19, 2009, applies to HEDD units, which include units that have a NO_x emissions rate on HEDD equal to or exceeding 0.15 lbs/MMBtu and lack identified emission control technologies.
- **Illinois Air Quality Standards (NO_x, SO₂ and Hg).** The State of Illinois has promulgated its own standards for NO_x, SO₂ and Hg (mercury) known as Multi-Pollutant Standards (MPS) and Combined Pollutants Standards (CPS). MPS and CPS establish standards that are more stringent and take effect earlier than comparable Federal regulations, such as the EPA's MATS.

⁹⁵ See Potomac Riverkeeper Network, Press Release, "Maryland Proposes to Reject Effort to Delay Pollution Reductions" (Posted April 4, 2020), <<https://www.potomacriverkeepernetwork.org/maryland-proposes-to-reject-effort-to-delay-pollution-reductions/>>.

⁹⁶ See "GenOn Holdings, Inc. Announces Retirement of Dickerson Coal Plant" (May 15, 2020) <<https://www.genon.com/genon-news/genon-holdings-inc-announces-retirement-of-dickerson-coal-plant>>.

⁹⁷ See "GenOn Holdings, Inc. Announces Retirement of Chalk Point Coal Units" (August 10, 2020) <<https://www.genon.com/genon-news/genon-holdings-inc-announces-retirement-of-chalk-point-coal-units>>.

⁹⁸ See "GenOn Holdings, Inc. Announces Retirement of Morgantown Coal Units" (December 18, 2020) <<https://www.genon.com/genon-news/genon-holdings-inc-announces-retirement-of-morgantown-coal-units>>.

⁹⁹ For more details, see the 2019 *State of the Market Report for PJM*, Volume 2, Appendix H: "Environmental and Renewable Energy Regulations."

State Regulation of Greenhouse Gas Emissions

Clean Energy Standards

In April 2020, Virginia enacted the Virginia Clean Economy Act, which orders the closure of most coal generation in state by 2024, most fossil fuel generation by 2045, and adopts a 100 percent clean energy standard by 2045.¹⁰⁰ The legislation mandates Chesterfield Power Station Units 5 & 6 and Yorktown Power Station Unit 3 to be retired by the end of 2024, Altavista, Southampton and Hopewell to be retired by the end of 2028 and Virginia Power's remaining fossil fuel units to be retired by the end of 2045, unless the retirement of such generating units will compromise grid reliability or security.¹⁰¹ The legislation also imposes a temporary moratorium on Certificates of Public Convenience and Necessity for fossil fuel generation, unless the resources are needed for grid reliability.¹⁰²

RGGI

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey (as of January 1, 2020), New York, Rhode Island, Vermont and Virginia (as of January 1, 2021) to cap CO₂ emissions from power generation facilities.¹⁰³

Delaware, Maryland, New Jersey and Virginia are the only PJM states that are members of RGGI. New Jersey, a founding member of RGGI, opted out in 2011 but rejoined RGGI in 2020.¹⁰⁴ Virginia joined RGGI on January 1, 2021. Pennsylvania has also expressed interest in joining RGGI. Pennsylvania Governor Tom Wolf issued an executive order on October 3, 2019, directing the Pennsylvania Department of Environmental Protection (DEP) to develop a proposal to limit carbon emissions from fossil fuel generators that is

¹⁰⁰ Va. HB 1526/SB 851.

¹⁰¹ See Dominion Energy, Inc., et al., SEC Form 10-Q (Quarter ending June 30, 2020).

¹⁰² *Id.*

¹⁰³ RGGI provides a link on its website to state statutes and regulations authorizing its activities, which can be accessed at: <<http://www.rggi.org/design/regulations>>.

¹⁰⁴ "Statement on New Jersey Greenhouse Gas Rule," RGGI Inc., (June 17, 2019) <https://www.rggi.org/sites/default/files/Uploads/Press-Releases/2019_06_17_NJ_Announcement_Release.pdf>.

consistent with RGGI.¹⁰⁵ The Pennsylvania Environmental Quality Board (EQB), on September 15, 2020, approved a draft regulation developed by the Pennsylvania Department of Environmental Protection (DEP) that governs Pennsylvania's entry into RGGI in 2022. The draft regulation will be subject to public comment and then the DEP will hold a series of hearings prior to submitting a final regulation to the EQB.¹⁰⁶ The order also directs DEP to "engage with PJM Interconnection to promote the integration of this program in a manner that preserves orderly and competitive economic dispatch within PJM and minimizes emissions leakage."

Table 8-2 shows the RGGI CO₂ auction clearing prices and quantities, in short tons and metric tonnes, for the 2015/2018 compliance period, the 2018/2020 compliance period auctions, and the first auction of 2021 held on March 3, 2021.¹⁰⁷ The clearing price for the auction held March 3, 2021 was \$7.60 per allowance (equal to one short ton of CO₂).¹⁰⁸ The March auction clearing price increased 2.6 percent over the last auction clearing price of \$7.41 in December 2020.

Table 8-2 RGGI CO₂ allowance auction prices and quantities in short tons and metric tonnes: 2015/2018, 2018/2020 and 2021/2023 Compliance Periods¹⁰⁹

Auction Date	Short Tons			Metric Tonnes		
	Clearing Price	Quantity Offered	Quantity Sold	Clearing Price	Quantity Offered	Quantity Sold
March 11, 2015	\$5.41	15,272,670	15,272,670	\$5.96	13,855,137	13,855,137
June 3, 2015	\$5.50	15,507,571	15,507,571	\$6.06	14,068,236	14,068,236
September 3, 2015	\$6.02	25,374,294	25,374,294	\$6.64	23,019,179	23,019,179
December 2, 2015	\$7.50	15,374,274	15,374,274	\$8.27	13,947,311	13,947,311
March 9, 2016	\$5.25	14,838,732	14,838,732	\$5.79	13,461,475	13,461,475
June 1, 2016	\$4.53	15,089,652	15,089,652	\$4.99	13,689,106	13,689,106
September 7, 2016	\$4.54	14,911,315	14,911,315	\$5.00	13,527,321	13,527,321
December 7, 2016	\$3.55	14,791,315	14,791,315	\$3.91	13,418,459	13,418,459
March 8, 2017	\$3.00	14,371,300	14,371,300	\$3.31	13,037,428	13,037,428
June 7, 2017	\$2.53	14,597,470	14,597,470	\$2.79	13,242,606	13,242,606
September 8, 2017	\$4.35	14,371,585	14,371,585	\$4.80	13,037,686	13,037,686
December 8, 2017	\$3.80	14,687,989	14,687,989	\$4.19	13,324,723	13,324,723
March 14, 2018	\$3.79	13,553,767	13,553,767	\$4.18	12,295,774	12,295,774
June 13, 2018	\$4.02	13,771,025	13,771,025	\$4.43	12,492,867	12,492,867
September 9, 2018	\$4.50	13,590,107	13,590,107	\$4.96	12,328,741	12,328,741
December 5, 2018	\$5.35	13,360,649	13,360,649	\$5.90	12,120,580	12,120,580
March 13, 2019	\$5.27	12,883,436	12,883,436	\$5.81	11,687,660	11,687,660
June 5, 2019	\$5.62	13,221,453	13,221,453	\$6.19	11,994,304	11,994,304
September 4, 2019	\$5.20	13,116,447	13,116,447	\$5.73	11,899,044	11,899,044
December 4, 2019	\$5.61	13,116,444	13,116,444	\$6.18	11,899,041	11,899,041
March 11, 2020	\$5.65	16,208,347	16,208,347	\$6.23	14,703,969	14,703,969
June 3, 2020	\$5.75	16,336,298	16,336,298	\$6.34	14,820,045	14,820,045
September 2, 2020	\$6.82	16,192,785	16,192,785	\$7.52	14,689,852	14,689,852
December 2, 2020	\$7.41	16,237,495	16,237,495	\$8.17	14,730,412	14,730,412
March 3, 2021	\$7.60	23,467,261	23,467,261	\$8.38	21,289,147	21,289,147

The RGGI auction held on March 3, 2021, generated \$178.4 million in auction revenue. RGGI auctions have generated \$4.0 billion in auction revenue since 2008.¹¹⁰ RGGI auction revenue is returned to the states. RGGI reported that the RGGI states, cumulative through the 2018 reporting year, have spent approximately 56 percent of the revenue on energy efficiency, 14 percent on clean and renewable energy, 9 percent on greenhouse gas abatement and 15 percent on direct bill assistance.¹¹¹

¹⁰⁵ Executive Order No. 2019-07- Commonwealth Leadership in Addressing Climate Change through Electric Sector Emissions Reductions, Tom Wolf, Governor (Oct. 3, 2019), <<https://www.governor.pa.gov/newsroom/executive-order-2019-07-commonwealth-leadership-in-addressing-climate-change-through-electric-sector-emissions-reductions/>>.

¹⁰⁶ "Environmental Quality Board Approves Proposed Climate Change Regulation," DEP Newsroom, (September 15, 2020) <<https://www.ahs.dep.pa.gov/NewsRoomPublic/articleviewer.aspx?id=21865&typeid=1>>.

¹⁰⁷ The September 3, 2015, auction included additional Cost Containment Reserves (CCRs) since the clearing price for allowances was above the CCR trigger price of \$6.00 per ton in 2015. The auctions on March 5, 2014, and September 3, 2015, were the only auctions to use CCRs.

¹⁰⁸ RGGI measures carbon in short tons (short ton equals 2,000 pounds) while world carbon markets measure carbon in metric tonnes (metric tonne equals 1,000 kilograms or 2,204.6 pounds).

¹⁰⁹ See Regional Greenhouse Gas Initiative, "Auction Results," <http://www.rggi.org/market/co2_auctions/results> (Accessed April 14, 2021).

¹¹⁰ See Auction Results at <<https://www.rggi.org/>>.

¹¹¹ *The Investment of RGGI Proceeds in 2018*, The Regional Greenhouse Gas Initiative (RGGI), July 2020, <<https://www.rggi.org/investments/proceeds-investments>>.

If all PJM states joined RGGI, the total RGGI revenue to the PJM states would be significant. The estimated allowance revenue for PJM states based on 2020 CO₂ emission levels and the RGGI clearing price for the March 2021 auction ranges from \$1.3 billion per year to \$2.5 billion per year depending on associated reductions in carbon emission levels (Table 8-3).¹¹² Table 8-3 shows the estimated carbon allowance revenue for each PJM state based on the latest RGGI auction price and reductions below 2020 CO₂ emission levels ranging from five to 50 percent. A power plant owner must acquire an allowance for each ton of CO₂ emissions and the revenue values in Table 8-3 are computed by multiplying the carbon price by the emission cap level which is expressed as a reduction below the 2020 actual emissions level. States that participate in RGGI choose their emission cap. For example, New Jersey chose an emission cap of 18,000,000 short tons for reentry into RGGI in 2020, 5.3 percent below New Jersey's 2018 CO₂ emissions level; the New Jersey emission cap will be reduced by 540,000 short tons each year through 2030.¹¹³

Table 8-3 Estimated CO₂ allowance revenue at March 2021 RGGI price level^{114 115}

Jurisdiction	Estimated CO ₂ allowance revenue (\$ millions), carbon price \$7.60 per short ton						
	2020 power generation CO ₂ emissions (short tons)	5 percent reduction below 2020 emission levels	10 percent reduction below 2020 emission levels	15 percent reduction below 2020 emission levels	20 percent reduction below 2020 emission levels	25 percent reduction below 2020 emission levels	50 percent reduction below 2020 emission levels
Delaware	2,055,837.3	\$14.8	\$14.1	\$13.3	\$12.5	\$11.7	\$7.8
Illinois	18,801,034.9	\$135.7	\$128.6	\$121.5	\$114.3	\$107.2	\$71.4
Indiana	32,618,816.1	\$235.5	\$223.1	\$210.7	\$198.3	\$185.9	\$124.0
Kentucky	28,595,734.2	\$206.5	\$195.6	\$184.7	\$173.9	\$163.0	\$108.7
Maryland	10,160,364.6	\$73.4	\$69.5	\$65.6	\$61.8	\$57.9	\$38.6
Michigan	0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
New Jersey	11,765,032.5	\$84.9	\$80.5	\$76.0	\$71.5	\$67.1	\$44.7
North Carolina	40,388.7	\$0.3	\$0.3	\$0.3	\$0.2	\$0.2	\$0.2
Ohio	80,279,155.3	\$579.6	\$549.1	\$518.6	\$488.1	\$457.6	\$305.1
Pennsylvania	77,857,196.9	\$562.1	\$532.5	\$503.0	\$473.4	\$443.8	\$295.9
Tennessee	0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Virginia	32,755,841.7	\$236.5	\$224.0	\$211.6	\$199.2	\$186.7	\$124.5
Washington, D.C.	0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
West Virginia	53,818,573.2	\$388.6	\$368.1	\$347.7	\$327.2	\$306.8	\$204.5
Total	348,747,975.2	\$2,518.0	\$2,385.4	\$2,252.9	\$2,120.4	\$1,987.9	\$1,325.2

¹¹² This assumes that the PJM states would implement their RGGI rules consistent with the current RGGI states where owners of fossil fuel generators are required to purchase emission allowances in a regional centralized auction or purchase allowances in a secondary market.

¹¹³ "Governor Murphy Announces Adoption of Rules Returning New Jersey to Regional Greenhouse Gas Initiative," State of New Jersey, Governor Phil Murphy Press Release, June 17, 2019 <<https://nj.gov/governor/news/news/562019/approved/20190617a.shtml>>.

¹¹⁴ The 2020 CO₂ emissions data is from the EPA Continuous Emission Monitoring System (CEMS) from generators located within the PJM footprint.

¹¹⁵ Power generation companies subject to a RGGI emission cap can offset up to 3.3 percent of their allowance obligation by undertaking certain greenhouse gas emission reduction projects. The allowance revenue values in Table 8-2 do not reflect offset allowances.

The RGGI emissions cap is the sum of CO₂ allowances issued by each state. Table 8-4 shows the RGGI emission cap history. Compliance with the RGGI allowance obligation is evaluated at the end of each three year period which is called the control period. The first control period began in 2009. The 2021 compliance year is the first year of the fifth control period.

RGGI recently announced a third adjustment to the RGGI emissions cap to account for banked allowances from previous control periods.^{116 117} The first adjustment removed 57.5 million allowances that were banked or unused from the first control period. The reduction to the RGGI emissions cap was spread over a seven year period beginning in 2014 and ending with 2020.¹¹⁸ A second cap adjustment, corresponding to banked allowances for 2012 and 2013, began in 2015 with an adjustment of 13.7 million allowances per year and was in place through 2020.¹¹⁹ The third adjustment of 95.5 million allowances will be spread over a five year period beginning in 2021.¹²⁰ The base emissions cap for each of the next five years will be reduced by 19.1 allowances. The percent change columns in Table 8-4 show the year to year percent changes in the base RGGI cap and the adjusted RGGI cap.¹²¹ The adjusted emissions cap for 2021 marks the first year the adjusted carbon emissions cap has increased since the start of RGGI.¹²² Figure 8-2 shows the adjusted carbon budgets for the RGGI states. All states, with the exception of New Jersey, have a higher 2021 adjusted carbon budget relative to the corresponding 2020 budget. The RGGI clearing price since 2014 has been on average 113.7 percent higher than the prices prior to the emission cap adjustments.

Table 8-4 RGGI emissions cap history^{123 124 125}

Year	Control Period	RGGI Average	RGGI Cap (short tons)	Percent Change	RGGI	Percent Change
		Clearing Price (\$ per short ton)			Adjusted Cap (short tons)	
2009		\$2.77	188,076,976		188,076,976	
2010	1st	\$1.93	188,076,976	0.0%	188,076,976	0.0%
2011		\$1.89	188,076,976	0.0%	188,076,976	0.0%
2012	2nd	\$1.93	165,184,246	0.0%	165,184,246	0.0%
2013		\$2.92	165,184,246	0.0%	165,184,246	0.0%
2014		\$4.72	91,000,000	(44.9%)	82,792,336	(49.9%)
2015	3rd	\$6.10	88,725,000	(2.5%)	66,833,592	(19.3%)
2016		\$4.47	86,506,875	(2.5%)	64,615,467	(3.3%)
2017		\$3.42	84,344,203	(2.5%)	62,452,795	(3.3%)
2018		\$4.41	82,235,598	(2.5%)	60,344,190	(3.4%)
2019		\$5.43	80,363,945	(2.3%)	58,472,538	(3.1%)
2020	4th	\$6.41	96,354,847	(2.5%)	74,463,439	(3.4%)
2021		\$7.60	119,767,784	(3.9%)	100,677,454	4.5%
2022		5th		116,112,784	(3.1%)	97,022,454
2023			112,457,784	(3.1%)	93,367,454	(3.8%)

116 "Third Adjustment for Banked Allowances Announcement," Regional Greenhouse Gas Initiative (March 15, 2021) <<https://www.rggi.org/news-releases/rggi-releases>>.

117 A banked allowance is an allowance acquired during a previous control period that was not used to fulfill a RGGI allowance obligation.

118 *Id.* at 2. Due to rounding, the adjustment is 8,207,664 allowances for years 2014 through 2018, and 8,207,663 allowances for the remaining two years.

119 "Second Control Period Interim Adjustment for Banked Allowances Announcement," Regional Greenhouse Gas Initiative (March 17, 2014), <https://www.rggi.org/sites/default/files/uploads/Design-Archive/2012-Review/Adjustments/2014_03_17_SCP_Adjustment.pdf>.

120 "Third Adjustment for Banked Allowances Announcement", Regional Greenhouse Gas Initiative (March 15, 2021) <<https://www.rggi.org/news-releases/rggi-releases>>.

121 Percent changes for years with membership changes do not reflect the impacts of the change in membership. For example, the percent changes from 2019 to 2020 do not reflect the impact of New Jersey rejoining RGGI.

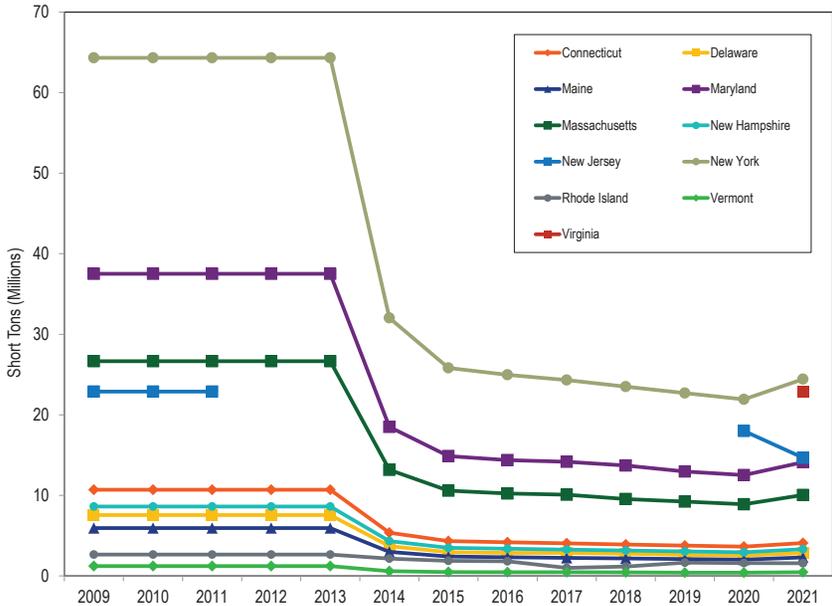
122 The increase of 4.5 percent does not reflect the addition of Virginia as a RGGI state.

123 See Regional Greenhouse Gas Initiative, "Allowance Distribution," <<https://www.rggi.org/allowance-tracking/allowance-distribution>> (Accessed April 13, 2021).

124 RGGI budgets for 2022 and 2023 are found in a RGGI press release, "Third Adjustment for Banked Allowances Announcement," March 15, 2021 <<https://www.rggi.org/news-releases/rggi-releases>>.

125 The increase in the RGGI Cap and the RGGI Adjusted Cap in 2020 is due to the reentry of New Jersey. The new cap is 18 million short tons higher than the previously published 2020 caps.

Figure 8-2 RGGI adjusted carbon budgets by state¹²⁶



If higher carbon prices were implemented in PJM, the associated revenues flowing to states would also increase. Table 8-5 shows the estimated allowance revenue for PJM states for carbon prices ranging from \$10 per short ton to \$50 per short ton and for emissions reductions ranging from five percent to 50 percent. Allowance revenues to states would be \$16.6 billion if the carbon price were \$50 per short ton and emission levels were five percent below 2020 levels. Allowance revenues to states would be \$1.7 billion if the carbon price were \$10 per short ton and emission levels were 50 percent below 2020.

¹²⁶ Data for the figure was collected from allowance distribution reports available on the RGGI website <<https://www.rggi.org/allowance-tracking/allowance-distribution>> (Accessed April 13, 2021).

Table 8-5 Estimated CO₂ allowance revenue at various carbon prices

Jurisdiction	Estimated CO ₂ allowance revenue (\$ millions)					
	5 percent reduction below 2020 emission levels	10 percent reduction below 2020 emission levels	15 percent reduction below 2020 emission levels	20 percent reduction below 2020 emission levels	25 percent reduction below 2020 emission levels	50 percent reduction below 2020 emission levels
	Carbon Price (\$ per short ton)					\$10.00
Delaware	\$19.5	\$18.5	\$17.5	\$16.4	\$15.4	\$10.3
Illinois	\$178.6	\$169.2	\$159.8	\$150.4	\$141.0	\$94.0
Indiana	\$309.9	\$293.6	\$277.3	\$261.0	\$244.6	\$163.1
Kentucky	\$271.7	\$257.4	\$243.1	\$228.8	\$214.5	\$143.0
Maryland	\$96.5	\$91.4	\$86.4	\$81.3	\$76.2	\$50.8
Michigan	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
New Jersey	\$111.8	\$105.9	\$100.0	\$94.1	\$88.2	\$58.8
North Carolina	\$0.4	\$0.4	\$0.3	\$0.3	\$0.3	\$0.2
Ohio	\$762.7	\$722.5	\$682.4	\$642.2	\$602.1	\$401.4
Pennsylvania	\$739.6	\$700.7	\$661.8	\$622.9	\$583.9	\$389.3
Tennessee	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Virginia	\$311.2	\$294.8	\$278.4	\$262.0	\$245.7	\$163.8
Washington, D.C.	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
West Virginia	\$511.3	\$484.4	\$457.5	\$430.5	\$403.6	\$269.1
Total	\$3,313.1	\$3,138.7	\$2,964.4	\$2,790.0	\$2,615.6	\$1,743.7
	Carbon Price (\$ per short ton)					\$25.00
Delaware	\$48.8	\$46.3	\$43.7	\$41.1	\$38.5	\$25.7
Illinois	\$446.5	\$423.0	\$399.5	\$376.0	\$352.5	\$235.0
Indiana	\$774.7	\$733.9	\$693.1	\$652.4	\$611.6	\$407.7
Kentucky	\$679.1	\$643.4	\$607.7	\$571.9	\$536.2	\$357.4
Maryland	\$241.3	\$228.6	\$215.9	\$203.2	\$190.5	\$127.0
Michigan	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
New Jersey	\$279.4	\$264.7	\$250.0	\$235.3	\$220.6	\$147.1
North Carolina	\$1.0	\$0.9	\$0.9	\$0.8	\$0.8	\$0.5
Ohio	\$1,906.6	\$1,806.3	\$1,705.9	\$1,605.6	\$1,505.2	\$1,003.5
Pennsylvania	\$1,849.1	\$1,751.8	\$1,654.5	\$1,557.1	\$1,459.8	\$973.2
Tennessee	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Virginia	\$778.0	\$737.0	\$696.1	\$655.1	\$614.2	\$409.4
Washington, D.C.	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
West Virginia	\$1,278.2	\$1,210.9	\$1,143.6	\$1,076.4	\$1,009.1	\$672.7
Total	\$8,282.8	\$7,846.8	\$7,410.9	\$6,975.0	\$6,539.0	\$4,359.3
	Carbon Price (\$ per short ton)					\$50.00
Delaware	\$97.7	\$92.5	\$87.4	\$82.2	\$77.1	\$51.4
Illinois	\$893.0	\$846.0	\$799.0	\$752.0	\$705.0	\$470.0
Indiana	\$1,549.4	\$1,467.8	\$1,386.3	\$1,304.8	\$1,223.2	\$815.5
Kentucky	\$1,358.3	\$1,286.8	\$1,215.3	\$1,143.8	\$1,072.3	\$714.9
Maryland	\$482.6	\$457.2	\$431.8	\$406.4	\$381.0	\$254.0
Michigan	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
New Jersey	\$558.8	\$529.4	\$500.0	\$470.6	\$441.2	\$294.1
North Carolina	\$1.9	\$1.8	\$1.7	\$1.6	\$1.5	\$1.0
Ohio	\$3,813.3	\$3,612.6	\$3,411.9	\$3,211.2	\$3,010.5	\$2,007.0
Pennsylvania	\$3,698.2	\$3,503.6	\$3,308.9	\$3,114.3	\$2,919.6	\$1,946.4
Tennessee	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Virginia	\$1,555.9	\$1,474.0	\$1,392.1	\$1,310.2	\$1,228.3	\$818.9
Washington, D.C.	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
West Virginia	\$2,556.4	\$2,421.8	\$2,287.3	\$2,152.7	\$2,018.2	\$1,345.5
Total	\$16,565.5	\$15,693.7	\$14,821.8	\$13,949.9	\$13,078.0	\$8,718.7

Table 8-6 shows the estimated impact of five different carbon prices on PJM load-weighted, LMP. For example, if the carbon price were \$5.00 per tonne, the PJM load-weighted, average LMP in the first three months of 2021 would have increased by 3.3 percent.¹²⁷

Table 8-6 Estimated impact of carbon price on LMP: January through March, 2020 and 2021

Scenario	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Carbon Price (\$/Metric Ton)	Actual LMP (\$/MWh)	Estimated LMP (\$/MWh)	Percent Change	Actual LMP (\$/MWh)	Estimated LMP (\$/MWh)	Percent Change	
Scenario 1	\$5.00	\$19.85	\$21.43	8.0%	\$30.84	\$31.84	3.3%	
Scenario 2	\$10.00	\$21.43	\$23.20	8.3%	\$31.84	\$33.91	6.5%	
Scenario 3	\$15.00	\$23.20	\$24.98	7.6%	\$33.91	\$35.98	6.1%	
Scenario 4	\$25.00	\$24.98	\$28.52	14.2%	\$35.98	\$40.13	11.5%	
Scenario 5	\$50.00	\$28.52	\$37.38	31.1%	\$40.13	\$50.48	25.8%	

Table 8-7 shows the impact of a range of carbon prices on the cost per MWh of producing energy from three basic unit types.^{128 129} For example, if the price of carbon were \$50.00 per tonne, the short run marginal costs would increase by \$24.52 per MWh for a new combustion turbine (CT) unit, \$16.71 per MWh for a new combined cycle (CC) unit and \$43.15 per MWh for a new coal plant (CP).

Table 8-7 Carbon price per MWh by unit type

Unit Type	Carbon Price per MWh						
	Carbon \$5/tonne	Carbon \$10/tonne	Carbon \$15/tonne	Carbon \$50/tonne	Carbon \$100/tonne	Carbon \$200/tonne	Carbon \$400/tonne
CT	\$2.45	\$4.90	\$7.36	\$24.52	\$49.04	\$98.08	\$196.17
CC	\$1.67	\$3.34	\$5.01	\$16.71	\$33.41	\$66.83	\$133.65
CP	\$4.32	\$8.63	\$12.95	\$43.15	\$86.30	\$172.60	\$345.21

Table 8-8 also illustrates the effective cost of carbon included in the price of a REC or SREC. For example, the average price of an SREC in New Jersey

¹²⁷ LMPs are recalculated to account for the defined cost of carbon emissions on marginal units' offer prices. The LMP calculation is not based on a counterfactual redispach of the system to determine the marginal units and the marginal costs that would have occurred if all units had made all offers at short run marginal cost. See Technical Reference for PJM Markets, "Calculation and Use of Generator Sensitivity/Unit Participation Factors," <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

¹²⁸ Heat rates from: 2019 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue, Table 7-4.

¹²⁹ Carbon emissions rates from: Table A.3. Carbon Dioxide Uncontrolled Emission Factors, Energy Information Administration, <https://www.eia.gov/electricity/annual/html/epa_a_03.html> (Accessed March 9, 2020).

was \$185.52 per credit in the first quarter of 2021. The SREC price is paid in addition to the energy price paid at the time the solar energy is produced. If the MWh produced by the solar resource resulted in avoiding the production of a MWh from a CT, the value of carbon reduction implied by the SREC price is a carbon price slightly less than \$400 per tonne. This result also assumes that the entire value of the SREC was based on reduced carbon emissions. The SREC price consistent with a carbon price of \$50.00 per tonne, assuming that a MWh from a CT is avoided, is \$24.52 per MWh.

Applying this method to tier I and class I REC and SREC price histories yields the implied carbon prices in Table 8-8. The carbon price implied by the average REC price during the first quarter of 2021 in Washington, DC is \$7.67 per tonne which is lower than the March 3, 2021 RGGI clearing price of \$8.38 per tonne. All other carbon prices implied by renewable RECs are well above the RGGI clearing price, and well below the social cost of carbon which is estimated to be in the range of \$50 per tonne.¹³⁰ The carbon prices implied by SREC prices have no apparent relationship to carbon prices implied by the REC clearing prices. The carbon prices implied by the SREC prices all exceed the carbon prices implied by the corresponding REC prices, and all exceed the social cost of carbon.

¹³⁰ "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12899," Interagency Working Group on the Social Cost of Greenhouse Gases, United States Government, (Aug. 2016), <https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf>.

Table 8-8 Implied carbon price based on REC and SREC prices: 2009 through 2021¹³¹

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jurisdiction with Tier I or Class I REC													
	Carbon Price (\$ per tonne) Implied by REC Prices												
Delaware					\$34.15	\$35.17	\$31.91	\$32.91	\$10.26	\$11.57	\$16.05	\$19.88	
Maryland	\$2.07	\$1.92	\$3.06	\$6.34	\$17.46	\$28.45	\$29.18	\$26.09	\$23.12	\$21.28	\$17.76	\$18.14	\$17.38
New Jersey	\$13.34	\$17.74	\$8.58	\$4.74	\$13.09	\$21.04	\$25.29	\$26.93	\$24.01	\$22.01	\$19.19	\$18.74	\$17.46
Ohio						\$10.16	\$8.52	\$5.29	\$6.27	\$11.17	\$14.00	\$15.49	\$17.88
Pennsylvania	\$6.82	\$8.13	\$3.33	\$4.29	\$15.87	\$26.66	\$28.88	\$26.35	\$23.35	\$21.47	\$17.91	\$18.25	\$17.11
Washington, D.C.							\$3.19	\$4.04	\$4.88	\$4.68	\$5.50	\$6.26	\$7.67
Jurisdiction with Solar REC													
	Carbon Price (\$ per tonne) Implied by Solar REC Prices												
Delaware						\$117.25	\$85.40	\$86.48	\$35.70	\$17.33			
Maryland		\$546.11	\$494.54	\$382.57	\$304.54	\$292.70	\$251.23	\$183.09	\$127.67	\$87.00	\$83.93	\$90.02	\$105.61
New Jersey	\$1,372.37	\$1,352.15	\$1,309.00	\$537.08	\$345.94	\$326.21	\$388.73	\$424.21	\$459.21	\$445.00	\$409.08	\$382.16	\$378.29
Ohio						\$82.32	\$45.12	\$36.15	\$31.82	\$21.67	\$26.57		
Pennsylvania	\$610.05	\$590.57	\$378.67	\$101.80	\$68.34	\$75.90	\$66.89	\$55.06	\$43.84	\$28.07	\$47.98	\$60.08	\$66.50
Washington, D.C.	\$712.98	\$436.28	\$501.62	\$655.52	\$956.55	\$957.46	\$994.05	\$993.49	\$866.17	\$840.35	\$848.82	\$881.62	\$882.33
Regional Greenhouse Gas Initiative													
	CO₂ Allowance Price (\$ per tonne)												
RGGI clearing price	\$3.06	\$2.12	\$2.08	\$2.13	\$3.22	\$5.21	\$6.72	\$4.93	\$3.77	\$4.86	\$5.98	\$7.06	\$8.38

State Renewable Portfolio Standards

Ten of 14 PJM jurisdictions have enacted legislation that requires that a defined percentage of retail load be served by renewable resources, for which there are many standards and definitions. These requirements are known as renewable portfolio standards, or RPS. In PJM jurisdictions that have adopted an RPS, load serving entities are required by law to meet defined shares of load using specific renewable and/or alternative energy sources commonly called eligible technologies. Load serving entities may generally fulfill these obligations in one of two ways: they may use their own generation resources classified as eligible technologies to produce power or they may purchase renewable energy credits (RECs) that represent a known quantity of power produced with eligible technologies by other market participants or in other geographical locations. Load serving entities that fail to meet the percent goals set in their jurisdiction's RPS must pay penalties (alternative compliance payments).

Renewable energy sources replenish naturally in a short period of time but are flow limited and include solar, geothermal, wind, biomass and hydropower

¹³¹ There were no trades in 2018 and 2019 for Ohio SRECs available in the Evomarkets data.

from flowing water. Renewable energy sources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Nonrenewable energy sources do not replenish in a short period of time and include crude oil, natural gas, coal and uranium (nuclear energy).¹³² Some state rules allow nonrenewable energy sources as part of their Renewable Portfolio Standard.

As of March 31, 2021, Delaware, Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia and Washington, DC had mandatory renewable portfolio standards that include penalties.

As of March 31, 2021, Indiana had voluntary renewable portfolio standards that do not require participation and do not include noncompliance penalties.¹³³ Incentives are offered to load serving entities to develop renewable generation or, to a more limited extent, purchase RECs. The voluntary standard was

¹³² *Renewable Energy Explained*, U.S. Energy Information Administration, <https://www.eia.gov/energyexplained/index.php?page=renewable_home> (Accessed October 23, 2019).

¹³³ Effective January 1, 2021 the Virginia voluntary RPS is being replaced with a mandatory RPS.

enacted by the Indiana legislature in 2011, but no load serving entities have volunteered to participate in the program.¹³⁴

As of March 31, 2021, Kentucky, Tennessee and West Virginia have no renewable portfolio standards.

How each state satisfies its renewable portfolio standard requirements should be more transparent. While some jurisdictions publish transparent information regarding total REC generation, how the standard is fulfilled and the total cost to the state, some jurisdictions do not provide the same level of detail and there can be a significant lag from the end of the compliance year to the publication of the information. Some states provide adequate information with respect to the total cost for the RPS, where the RECs originated that fulfill the RPS requirements, and if the state fulfilled the RPS goals. Pennsylvania and Maryland both provide more information than other states and serve as a model for other states. The MMU recommends that jurisdictions with a renewable portfolio standard make the compliance data and cost data available in a more complete and transparent manner.

Since a REC may be applied in years other than the year in which it was generated, each vintage of RECs for each state has a different price. For example, the Pennsylvania Alternative Energy Portfolio Standard allows an electric distribution company or generation supplier to retain RECs from the current reporting year for use toward satisfying their REC obligation in either of the two subsequent reporting years.¹³⁵

Table 8-9 shows the percent of retail electric load that must be served by renewable and/or alternative energy resources under each PJM jurisdictions' RPS by year.

Table 8-9 Renewable and alternative energy standards of PJM jurisdictions: 2021 to 2030^{136 137}

Jurisdiction with RPS	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Delaware	21.00%	22.00%	23.00%	24.00%	25.00%	25.50%	26.00%	26.50%	27.00%	28.00%
Illinois	19.00%	20.50%	22.00%	23.50%	25.00%	25.00%	25.00%	25.00%	25.00%	25.00%
Maryland	30.80%	33.10%	35.40%	37.70%	40.00%	42.50%	45.50%	47.50%	49.50%	50.00%
Michigan	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%
New Jersey	23.50%	24.50%	29.50%	37.50%	40.50%	43.50%	46.50%	49.50%	52.50%	52.50%
North Carolina	12.50%	12.50%	12.50%	12.50%	12.50%	12.50%	12.50%	12.50%	12.50%	12.50%
Ohio	6.00%	6.50%	7.00%	7.50%	8.00%	8.50%	0.00%	0.00%	0.00%	0.00%
Pennsylvania	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%
Virginia (Phase I utilities)	6.00%	7.00%	8.00%	10.00%	14.00%	17.00%	20.00%	24.00%	27.00%	30.00%
Virginia (Phase II utilities)	14.00%	17.00%	20.00%	23.00%	26.00%	29.00%	32.00%	35.00%	38.00%	41.00%
Washington, D.C.	26.25%	32.50%	38.75%	45.00%	52.00%	59.00%	66.00%	73.00%	80.00%	87.00%
Jurisdiction with Voluntary Standard										
Indiana	7.00%	7.00%	7.00%	7.00%	10.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Jurisdiction with No Standard										
Kentucky	No Renewable Portfolio Standard									
Tennessee	No Renewable Portfolio Standard									
West Virginia	No Renewable Portfolio Standard									

The Delaware General Assembly passed new RPS legislation on February 10, 2021. The new law updates the Delaware RPS targets from 25 percent in 2025 to 40 percent in 2035.¹³⁸ Additional details are provided in Table 8-10.

On April 11, 2020, the Virginia legislature passed a new law that replaces Virginia's current voluntary renewable portfolio standard (RPS) with a mandatory RPS.¹³⁹ The new law requires by 2050 that 100 percent of energy sold by phase I utilities must come from RPS eligible resources; and 100 percent of energy sold by phase II utilities must come from RPS eligible resources by 2045.^{140 141} Intermediate RPS targets begin in 2021 with a 6.0 percent standard for phase I utilities and a 14.0 percent standard for phase II utilities. Eligible RPS resources include wind, solar, hydroelectric, landfill gas and biomass resources.

¹³⁶ This shows the total standard of alternative resources in all PJM jurisdictions, including Tier I and Tier II.

¹³⁷ The table reflects calendar year standards for Maryland, Washington, DC, Ohio, and North Carolina. The standards for the remaining jurisdictions are for compliance years that begin on June 1, CCYY and end on May 31 of the following year.

¹³⁸ See Senate Bill 33, Delaware General Assembly (February 10, 2021) <<https://legis.delaware.gov/BillDetail?legislationId=48278>>.

¹³⁹ See "Virginia Clean Economy Act," (April 12, 2020) <<https://www.governor.virginia.gov/newsroom/all-releases/2020/april/headline-856056-en.html>>.

¹⁴⁰ A phase I utility is an investor-owned incumbent electric utility that was, as of July 1, 1999, not bound by a rate case settlement adopted by the Commission that extended in its application beyond January 1, 2002, and a phase II utility is an investor-owned incumbent electric utility that was bound by such a settlement (§ 56-585.1 of the Virginia Code).

¹⁴¹ APCO (AEP) is a phase I utility and Dominion Energy Virginia is a phase II utility. Cooperatives are not subject to the RPS

¹³⁴ See the Indiana Utility Regulatory Commission's "2020 Annual Report," at 41 (Oct. 2020) <<https://www.iurc.gov/iurc/2981.htm>>.
¹³⁵ Pennsylvania General Assembly, "Alternative Energy Portfolio Standards Act – Enactment Act of Nov. 30, 2004, P.L. 1672, No. 213," Section (c)(6).

In 2018, New Jersey passed legislation that included provisions promoting the development of solar power in the state.¹⁴² The Board of Public Utilities is directed to develop and provide an orderly transition to a new or modified program to support distributed solar. The Board must also design a Community Solar Energy Pilot Program that would “permit customers of an electric public utility to participate in a solar energy project that is remotely located from their properties but is within their electric public utility service territory to allow for a credit to the customer’s utility bill equal to the electricity generated that is attributed to the customer’s participation in the solar energy project.” The pilot program would convert into a permanent program within three years. The statute targets the development of 600 MW of electric storage by 2021 and 2,000 MW by 2030. Table 8-10 summarizes recent rules changes in Ohio, Maryland, New Jersey, and Washington, DC.

New Jersey and Maryland have taken significant steps to promote offshore wind. Both states enacted legislation for offshore wind renewable energy credits (ORECs) in 2010.¹⁴⁸ On May 24, 2018, New Jersey enacted a statute directing the Board of Public Utilities to create an OREC program targeting installation of at least 3,500 MW of offshore wind capacity by 2030 (plus 2,000 MW of energy storage capacity).¹⁴⁹ The New Jersey statute also reinstates certain tax incentives for offshore wind manufacturing activities. Governor Murphy has issued Executive Order No. 8, which calls for full implementation of the statute. The offshore wind target 3,500 MW by 2030 has since been replaced by a target of 7,500 MW by 2035.¹⁵⁰ The BPU opened a 100 day application window for qualified offshore wind projects on September 20, 2018, and on June, 21, 2019, the first award for a 1,100 MW offshore wind project was granted to Orsted.^{151 152}

Table 8-10 Recent changes in RPS rules^{143 144 145 146 147}

Jurisdiction	Legislation	Effective Date	Summary of changes
Delaware	151st General Assembly Senate Bill 33	February 1, 2021	Increases the RPS target from 25.0 percent in 2025 to 40.0 percent in 2035. Sets the solar carve out requirement to 10.0 percent in 2035. Establishes intermediary target levels for total RPS and the solar carve out for compliance years 2026 through 2034. Lowered the solar alternative compliance payment (SACP) from \$400 per credit to \$150 per credit.
Virginia	Virginia Clean Economy Act	April 11, 2020	Replaces the voluntary RPS with a mandatory RPS beginning in January 2021. The legislation requires 100 percent clean energy by 2050 for phase I utilities and 100 percent clean energy by 2045 for phase II utilities. Intermediate target levels begin in 2021 with 6 percent for phase I utilities and 14 percent for phase II utilities. Reduced the RPS percent for each year beginning in 2020. The 2020 standard was reduced from 6.5 percent to 5.5 percent; the 2026 standard was reduced from 12.5 percent to 8.5 percent. The legislation also removed language that had previously indicated that the standard would remain at the 2026 level for each year after 2026. The solar carve out was removed for compliance year 2020 and beyond. Prior to the recent legislation, the solar carve out was 0.26 percent for 2020, increased to 0.50 percent for 2026, and remained at 0.50 percent for subsequent years.
Ohio	House Bill 6	October 22, 2019	Established a new Tier I target of 50.0 percent in 2030; previously the 2030 Tier I standard was 25.0 percent. The 2019 Tier I standard increased from 20.4 percent to 20.7. The solar carve out percent for 2019 increased from 1.95 percent to 5.50 percent. The solar carve out percent for 2030 increased from 2.5 percent to 14.5 percent. The 2.5 percent Tier II standard, scheduled to end in 2018, was extended through 2020.
Maryland	Clean Energy Jobs Act	May 25, 2019	Established a 100 percent Tier I renewable standard by 2032. Previously, the 2032 target was 50.0 percent. Tier I increases start in 2020, going from 20.0 percent to 26.25 percent. The 2020 solar carve out will increase from 1.58 percent to 2.175 percent. The 2041 target for the solar carve out is 10.0 percent.
Washington, D.C.	CleanEnergy DC Omnibus Amendment Act of 2018	March 22, 2019	

142 N.J. S. 2314/A. 3723.

143 See “Virginia Clean Economy Act,” (April 12, 2020) <<https://www.governor.virginia.gov/newsroom/all-releases/2020/april/headline-856056-en.html>>.

144 See Ohio Legislature House, 133rd Assembly, Bill No. 6, “Ohio Clean Air Program,” effective Date October 22, 2019, <<https://www.legislature.ohio.gov/legislation/legislation-summary?id=GA133-HB-6>>.

145 See Maryland State Legislature, Senate Bill No. 516, “Clean Energy Jobs,” Passed May 25, 2019, <<https://legiscan.com/md/text/sb516/2019>>.

146 D.C. Law 22-257 “CleanEnergy DC Omnibus Amendment Act of 2018,” Effective March 22, 2019, <<https://code.dccouncil.us/dc/council/laws/22-257.html>>.

147 See Senate Bill 33, Delaware General Assembly (February 10, 2021) <<https://legis.delaware.gov/BillDetail?legislationId=48278>>.

148 See Offshore Wind Economic Development Act of 2010, P.L. 2010, c. 57, as amended, N.J.S.A. 48:3-87 to -87.2.

149 N.J. S. 2314/A. 3723.

150 Executive Order 92, Philip D. Murphy, Governor of New Jersey (November 19, 2019) <https://nj.gov/infobank/eo/056murphy/approved/eo_archive.html>.

151 BPU Docket No. Q018080851.

152 “New Jersey Board of Public Utilities Awards Historic 1,100 MW Offshore Wind Solicitation to Orsted’s Ocean Wind Project,” New Jersey BPU Press Release (June 21, 2019) <<https://nj.gov/bpu/newsroom/2019/approved/20190621.html>>.

In 2017, the Maryland Public Service Commission announced two awards of ORECs to two commercial wind projects, Deepwater Wind's 120-MW Skipjack Wind Farm and U.S. Wind's 248-MW project. Deepwater Wind has since been acquired by Orsted.¹⁵³ These project awards are the first under Maryland's 2010 OREC program.

On July 1, 2019, Dominion Energy announced the beginning of construction on an offshore wind demonstration project. The project consists of two 6 MW offshore wind turbines.¹⁵⁴ In September 2019, Dominion filed an interconnection agreement with PJM associated with its proposal to develop a 2,600 MW offshore wind farm.¹⁵⁵

Each PJM jurisdiction with an RPS identifies the type of generation resources that may be used for compliance. These resources are often called eligible technologies. Some PJM jurisdictions with RPS group different eligible technologies into tiers based on the magnitude of their environmental impact. Of the ten PJM jurisdictions with mandatory RPS, Maryland, New Jersey, Pennsylvania, and Washington, DC group the eligible technologies that must be used to comply with their RPS programs into Tier I and Tier II resources.¹⁵⁶ Although there are minor differences across these four jurisdictions' definitions of Tier I resources, technologies that use solar photovoltaic, solar thermal, wind, ocean, tidal, biomass, low-impact hydro, and geothermal sources to produce electricity are classified as Tier I resources. Table 8-11 shows the Tier I standards for PJM states.¹⁵⁷ All eligible technologies for the RPS standards in Table 8-11 satisfy the EIA definition of renewable energy.¹⁵⁸

Table 8-11 Tier I / Class I renewable standards of PJM jurisdictions: 2021 to 2030

Jurisdiction with RPS	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Maryland	30.80%	33.10%	35.40%	37.70%	40.00%	42.50%	45.50%	47.50%	49.50%	50.00%
New Jersey	21.00%	22.00%	27.00%	35.00%	38.00%	41.00%	44.00%	47.00%	50.00%	50.00%
Pennsylvania	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
Washington, D.C.	26.25%	32.50%	38.75%	45.00%	52.00%	59.00%	66.00%	73.00%	80.00%	87.00%

Delaware, Illinois, Michigan, North Carolina, Virginia and Ohio do not classify the resources eligible for their RPS standards by tiers. In these states eligible technologies are largely but not completely renewable resources.¹⁵⁹

RECs do not need to be used during the year in which they are generated. The result is that there may be multiple prices for a REC based on the year in which it was generated. RECs typically have a shelf life of five years during which they can be used to satisfy a state's RPS requirement. For example if a load serving entity (LSE) owns renewable generation and the renewable generation exceeds the LSE's RECs purchase obligation for the current year, the LSE can either sell the REC to another LSE or hold the REC for use in a subsequent year.

PJM GATS makes data available for the amount of eligible RECs by jurisdiction. Eligible RECs are not the amount of actual RECs generated for that timeframe. A REC that is created may be eligible in multiple jurisdictions resulting in an over representation of generated RECs. This means if one REC is retired in Pennsylvania, the total amount of eligible RECs will reduce by more than one REC.

The REC prices are the average price for each vintage of REC, defined by the year in which the associated power was generated, regardless of when the REC is consumed. REC prices are required to be publicly disclosed in Maryland, Pennsylvania and Washington, DC, but in the other states REC prices are not publicly available.

¹⁵³ "Orsted Acquires Deepwater Wind and creates leading US Offshore Wind Platform," ORSTED Press Release (August 10, 2018).

¹⁵⁴ "Construction Begins on Dominion Energy Offshore Wind Project," Dominion Energy News Release (July 1, 2019) <<https://news.dominionenergy.com/2019-07-01-Construction-Begins-on-Dominion-Energy-Offshore-Wind-Project>>.

¹⁵⁵ "Dominion Energy Announces Largest Offshore Wind Project in US," Dominion Energy News Release (September 19, 2019) <<https://news.dominionenergy.com/2019-09-19-Dominion-Energy-Announces-Largest-Offshore-Wind-Project-in-US>>.

¹⁵⁶ New Jersey separates technologies into Class I/Class II resources in a manner that is consistent with the other jurisdictions' Tier I/Tier II categorizations.

¹⁵⁷ This includes New Jersey's Class I renewable standard.

¹⁵⁸ *Renewable Energy Explained*, U.S. Energy Information Administration, <https://www.eia.gov/energyexplained/index.php?page=renewable_home> (Accessed October 17, 2019).

¹⁵⁹ Michigan's Public Act 342, effective April 20, 2017, removed nonrenewable technologies (e.g. coal gasification, industrial cogeneration, and coal with carbon capture) from the list of RPS eligible technologies.

Figure 8-3 shows the average Tier I REC price by jurisdiction from January 1, 2009, through March 31, 2021. Tier I REC prices are lower than SREC prices. For example, the average SREC price in Washington, DC in the first quarter of 2021 was \$432.71 and the average Tier I price in Washington, DC in first quarter of 2021 was \$3.76.

Figure 8-3 Average Tier I REC price by jurisdiction: January 2009 through March 2021

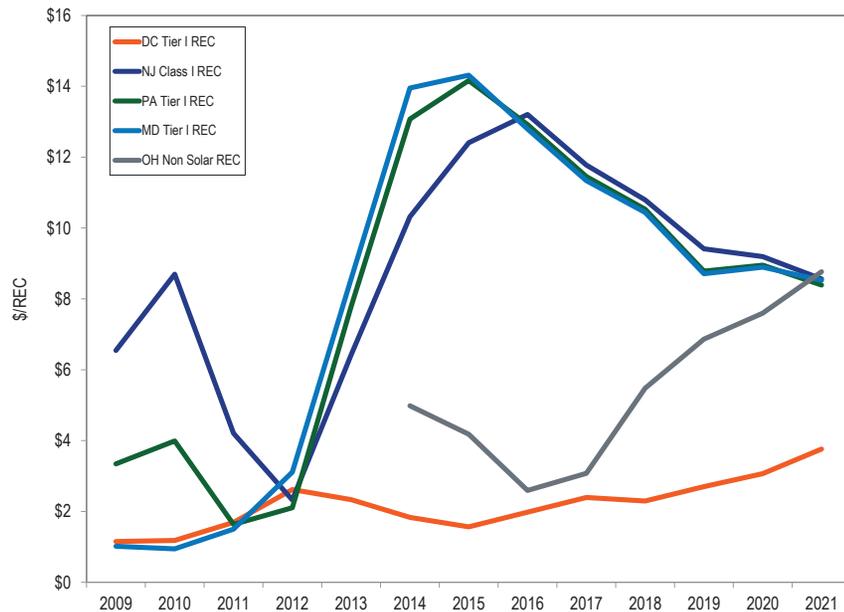


Figure 8-4 and Table 8-12 show the fulfillment of Tier I equivalent RPS requirement for 2016 through 2020 by state and by import and internal RECs and by carbon producing and noncarbon producing RECs.¹⁶⁰ Depending on the state, the RPS requirement can be fulfilled by wind, solar, hydro (“Noncarbon REC”) or with landfill gas, captured methane, wood, black liquor, and other fuels. (“Carbon Producing REC”). States’ Tier I requirements are not all carbon

¹⁶⁰ Retired REC information obtained through PJM GATS <<https://gats.pjm-eis.com/gats2/PublicReports/RPSRetiredCertificatesReportingYear>> (Accessed May 5, 2021). The timing of the REC retirement reports varies by state and the 2020 reporting year data is incomplete for several states.

free. The Delaware (DE) New Eligible requirement is fulfilled by noncarbon RECs, but all other state Tier I equivalent RPS requirements allow carbon producing RECs to fulfill the RPS requirements. Figure 8-4 shows the use of imported and local carbon producing RECs and imported and local noncarbon RECs by state to meet the RPS requirements. Table 8-12 shows the percent of imported and local carbon producing RECs and imported and local noncarbon RECs by state used to meet the RPS requirements. For example, Pennsylvania met its Tier I target using 75.8 percent imported RECs, and 24.2 percent State RECs for the 2019 compliance year. Pennsylvania met its Tier I target using 71.1 percent noncarbon producing RECs, and 28.9 percent carbon producing RECs for the 2019 compliance year. Illinois met its Tier I target using 29.5 percent imported RECs, and 70.5 percent State RECs for the 2019 compliance year. Illinois met its Tier I target using 100.0 percent noncarbon producing RECs for the 2019 compliance year.

Figure 8-4 State fulfillment of Tier I equivalent RPS: 2016 through 2020

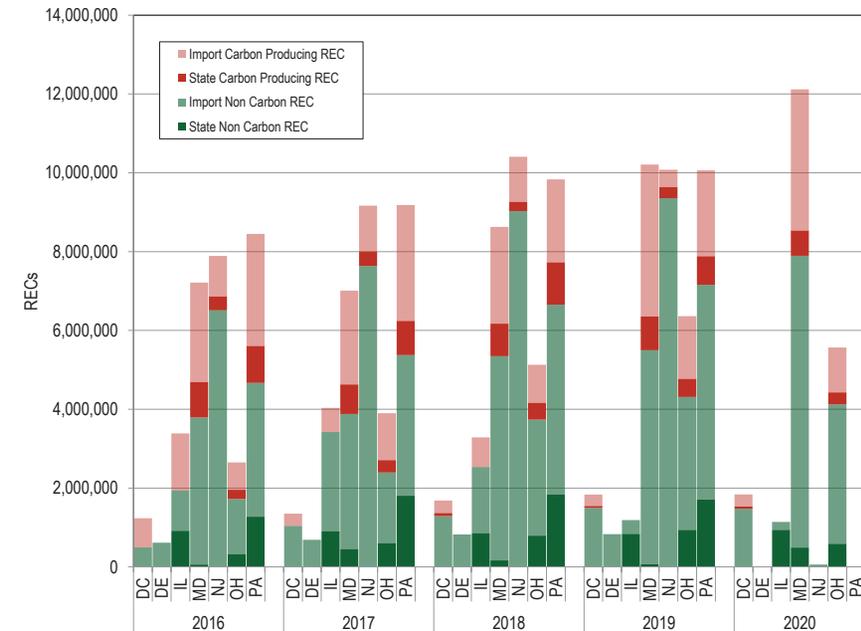


Table 8-12 State fulfillment of Tier I equivalent RPS: 2016 through 2020

Year	REC Type	State Non Carbon REC	Import Non Carbon REC	State Carbon Producing REC	Import Carbon Producing REC
2016	DE New Eligible	1.0%	99.0%	0.0%	0.0%
	DC Tier I	0.0%	40.5%	0.0%	59.5%
	OH Renewable Energy Source	12.3%	52.8%	8.7%	26.2%
	IL Renewable	27.1%	30.3%	0.1%	42.5%
	MD Tier I	0.8%	51.7%	12.5%	35.0%
	NJ Class I	0.0%	82.5%	4.5%	13.0%
	PA Tier I	15.1%	40.2%	11.1%	33.7%
2017	DE New Eligible	0.7%	99.3%	0.0%	0.0%
	DC Tier I	0.0%	77.2%	0.0%	22.8%
	OH Renewable Energy Source	15.6%	45.8%	8.1%	30.6%
	IL Renewable	22.5%	62.3%	0.0%	15.2%
	MD Tier I	6.5%	48.9%	10.7%	34.0%
	NJ Class I	0.1%	83.2%	3.9%	12.8%
	PA Tier I	19.6%	38.9%	9.4%	32.0%
2018	DE New Eligible	0.4%	99.6%	0.0%	0.0%
	DC Tier I	0.0%	76.5%	4.5%	19.0%
	OH Renewable Energy Source	15.4%	57.4%	8.3%	18.9%
	IL Renewable	26.1%	51.0%	0.0%	22.9%
	MD Tier I	1.9%	60.1%	9.6%	28.5%
	NJ Class I	0.0%	86.7%	2.3%	11.0%
	PA Tier I	18.7%	48.9%	10.9%	21.4%
2019	DE New Eligible	0.3%	99.7%	0.0%	0.0%
	DC Tier I	0.0%	81.5%	2.8%	15.7%
	OH Renewable Energy Source	14.7%	53.0%	7.3%	25.0%
	IL Renewable	70.5%	29.5%	0.0%	0.0%
	MD Tier I	0.7%	53.2%	8.4%	37.8%
	NJ Class I	0.1%	92.7%	2.8%	4.4%
	PA Tier I	17.0%	54.2%	7.2%	21.7%
2020	DE New Eligible				
	DC Tier I	0.0%	80.1%	3.3%	16.6%
	OH Renewable Energy Source	10.5%	63.5%	5.5%	20.5%
	IL Renewable	82.3%	17.7%	0.0%	0.0%
	MD Tier I	4.1%	61.1%	5.3%	29.6%
	NJ Class I	0.0%	100.0%	0.0%	0.0%
	PA Tier I	66.1%	33.9%	0.0%	0.0%

Table 8-13 shows the percent of retail electric load that must be served by Tier II or a specific type of resource under each PJM jurisdiction's RPS by year. Tier II resources are generally not renewable resources. Table 8-13 also shows specific technology requirements that PJM jurisdictions have added to their renewable portfolio standards. The standards shown in Table 8-13 are included in the total RPS requirements presented in Table 8-9. New Jersey and Pennsylvania have Tier II or Class II standards, which allow specific nonrenewable technology types, such as waste coal units located in Pennsylvania, to qualify for renewable energy credits. Maryland and Washington, DC previously had Tier II standards. The Maryland Tier II standard was discontinued at the end of the 2020 compliance year and the Washington, DC tier II standard was discontinued at the end of the 2019 compliance year. By 2024, North Carolina's RPS requires that 0.2 percent of power be generated using swine waste and that 900 GWh of power be produced by poultry waste in 2020. Maryland established a minimum standard for offshore wind in 2017 that takes effect in 2021 with a requirement that 1.37 percent of load be served by offshore wind. The standard increases to 2.03 percent in 2023.¹⁶¹

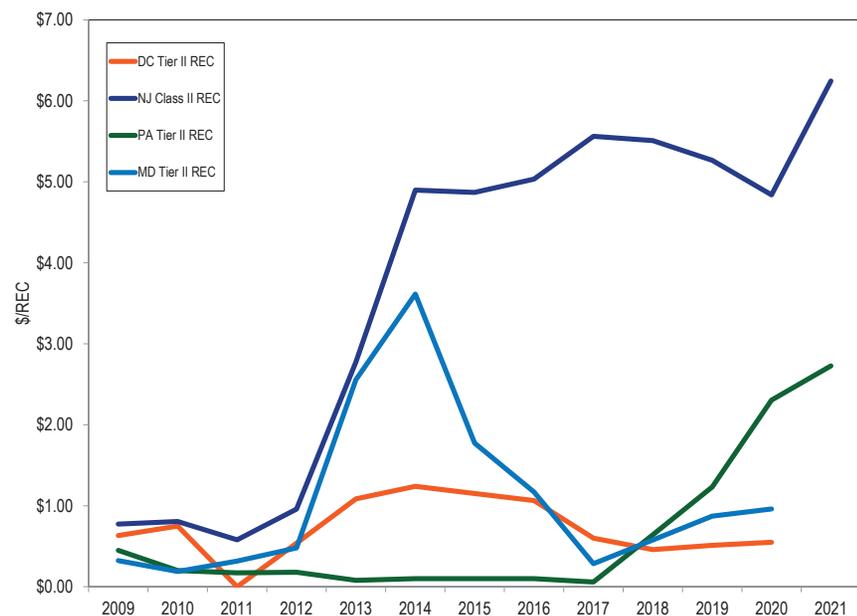
¹⁶¹ Public Service Commission of Maryland, Offshore Wind Projects, Order No. 88192 (May 11, 2017) at 8, Table 2, <<https://www.psc.state.md.us/wp-content/uploads/Order-No.-88192-Case-No.-9431-Offshore-Wind.pdf>>.

Table 8-13 Additional renewable standards of PJM jurisdictions: 2021 to 2030

Jurisdiction	Type of Standard	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Maryland	Off Shore Wind	1.37%	1.36%	2.03%	2.01%	2.01%	1.99%	1.98%	1.96%	1.94%	1.94%
New Jersey	Class II Standard	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
North Carolina	Swine Waste	0.14%	0.14%	0.14%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
North Carolina	Poultry Waste (in GWh)	900	900	900	900	900	900	900	900	900	900
Pennsylvania	Tier II Standard	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%

Tier II prices are lower than SREC and Tier I REC prices. Figure 8-5 shows the average Tier II REC price by jurisdiction for January 1, 2009, through March 31, 2021. New Jersey and Pennsylvania are the only states with a Tier II standard in 2021. In the first quarter of 2021, the average Pennsylvania Tier II REC price was \$2.73 and the average New Jersey Class II REC price was \$6.24.¹⁶²

Figure 8-5 Average Tier II REC price by jurisdiction: 2009 through March 2021



¹⁶² Tier II REC price information obtained through Evomarkets <<http://www.evomarkets.com>> (Accessed January 21, 2020).

Some PJM jurisdictions have specific solar resource RPS requirements. These solar requirements are included in the total requirements shown in Table 8-11 but must be met by solar RECs (SRECs) only. Table 8-14 shows the percent of retail electric load that must be served by solar energy resources under each PJM jurisdiction’s RPS by year. Delaware, Illinois, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, and Washington, DC have or have had requirements for the proportion of load to be served by solar. New Jersey closed registration for new SRECs on April 30, 2020, having met its milestone that solar power equal or exceed 5.1 percent of New Jersey electricity sales.¹⁶³ On December 6, 2019, the New Jersey Board of Public Utilities announced a transitional program for solar generators not eligible for New Jersey SRECs.¹⁶⁴ The new program establishes a 15 year fixed priced Transition REC (TREC). Pennsylvania allows only solar photovoltaic resources to fulfill their solar requirements. Solar thermal units like solar hot water heaters that do not generate electricity are Tier I resources in Pennsylvania. Indiana, Kentucky, Michigan, Tennessee, Virginia, and West Virginia have no specific solar standards. The New Jersey legislature in May 2018 increased the solar standard from 3.2 percent to 4.3 percent for 2018, 5.1 percent for 2020 through 2022 and the solar standard decreases to 1.1 percent for 2032.¹⁶⁵ Maryland legislation in 2019 increased the solar carve out percentages from 2.5 percent to 14.5 percent in 2030. Ohio HB 6 removed the solar carve out from the Ohio RPS.¹⁶⁶ The Delaware General Assembly passed new RPS legislation on February 10, 2021 that increased the solar carve out target from 3.5 percent in 2025 to 10.0 percent in 2035.¹⁶⁷

¹⁶³ See Clean Energy Act of 2019 (NJ AB-2723); N.J.A.C. 14:82.4(b)6; BPU, Monthly Report on Status toward Attainment of the 5.1 percent Milestone for Closure of the SREC Program (March 31, 2020).

¹⁶⁴ "New Jersey Board of Public Utilities Approves Solar Transition Program, Initiates a Cost Cap Proceeding", New Jersey Board of Public Utilities Press Release (December 6, 2019) <<https://www.bpu.state.nj.us/bpu/newsroom/2019/approved/20191206.html>>.

¹⁶⁵ "Assembly, No. 3723," State of New Jersey, 218th Legislature (March 22, 2018), <http://www.njleg.state.nj.us/2018/Bills/A4000/3723_11.PDF>.

¹⁶⁶ Ohio Legislature House, 133rd Assembly, Bill No. 6, "Ohio Clean Air Program," effective Date October 22, 2019, <<https://www.legislature.ohio.gov/legislation/legislation-summary?id=GA133-HB-6>>.

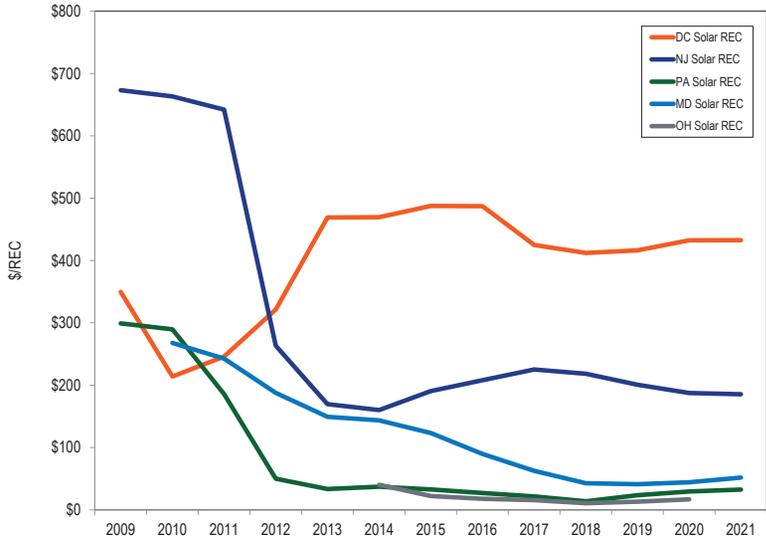
¹⁶⁷ See Senate Bill 33, Delaware General Assembly (February 10, 2021) <<https://legis.delaware.gov/BillDetail?legislationId=48278>>.

Table 8-14 Solar renewable standards by percent of electric load for PJM jurisdictions: 2021 to 2030¹⁶⁸

Jurisdiction with RPS	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Delaware	2.50%	2.75%	3.00%	3.25%	3.50%	3.75%	4.00%	4.25%	4.50%	5.00%
Illinois (RECs)	2,000,000	2,000,000	2,000,000	2,000,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	4,000,000
Maryland	7.50%	8.50%	9.50%	10.50%	11.50%	12.50%	13.50%	14.50%	14.50%	14.50%
Michigan	No Minimum Solar Requirement									
New Jersey	5.10%	5.10%	4.90%	4.80%	4.50%	4.35%	3.74%	3.07%	2.21%	1.58%
North Carolina	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
Ohio	No Minimum Solar Requirement									
Pennsylvania	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Washington, D.C.	2.50%	2.60%	2.85%	3.15%	3.45%	3.75%	4.10%	4.50%	4.75%	5.00%
Jurisdiction with Voluntary Standard										
Indiana	No Minimum Solar Requirement									
Virginia	No Minimum Solar Requirement									
Jurisdiction with No Standard										
Kentucky	No Renewable Portfolio Standard									
Tennessee	No Renewable Portfolio Standard									
West Virginia	No Renewable Portfolio Standard									

Figure 8-6 shows the average solar REC (SREC) price by jurisdiction for January 1, 2009, through March 31, 2021. The average NJ SREC prices dropped from \$673 per SREC in 2009 to \$186 per SREC in the first quarter of 2021. The limited supply of solar facilities in Washington, DC compared to the RPS requirement resulted in higher SREC prices. The average Washington, DC SREC price was \$433 per SREC for the first quarter of 2021.¹⁶⁹

Figure 8-6 Average SREC price by jurisdiction: January 2009 through March 2021



168 The Illinois solar standard currently requires 2 million RECs from solar photovoltaic projects energized after June 1, 2017. Illinois Public Act 099-0906, June 1, 2017.

169 Solar REC average price information obtained through Evomarkets, <<http://www.evomarkets.com>> (Accessed October 21, 2020).

Figure 8-7 and Table 8-15 shows where the SRECs originated that are used to satisfy the states' solar requirement by retiring RECs for 2016 through 2020.¹⁷⁰ Depending on the state, the solar RPS requirement can be fulfilled by in state or out of state SRECs. The SRECs purchased in some states are imported from other PJM states and from non PJM states. Table 8-15 shows the percent of imported and local SRECs used to meet the RPS requirements. Illinois, Maryland and New Jersey met their solar requirements using 100 percent in-state SRECs in 2019.

Figure 8-7 State fulfillment of Solar RPS: 2016 through 2020

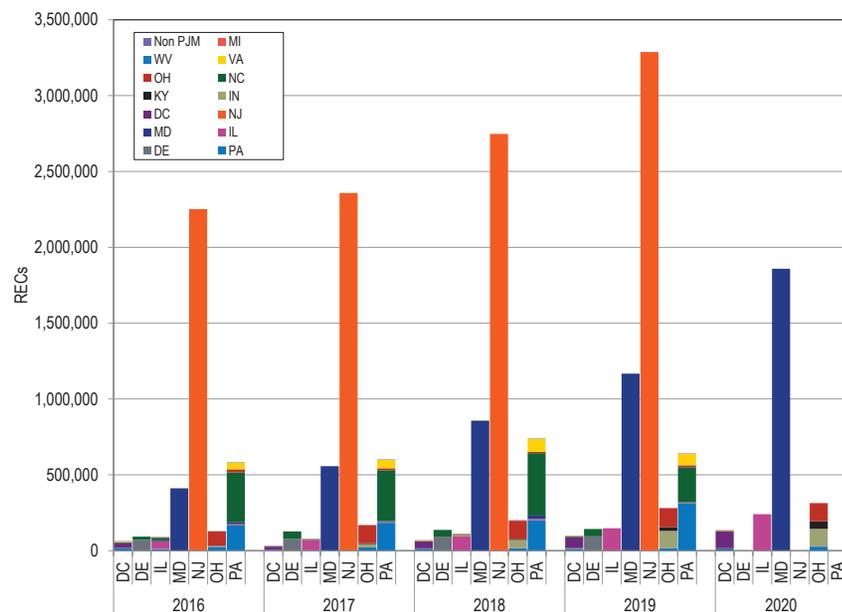


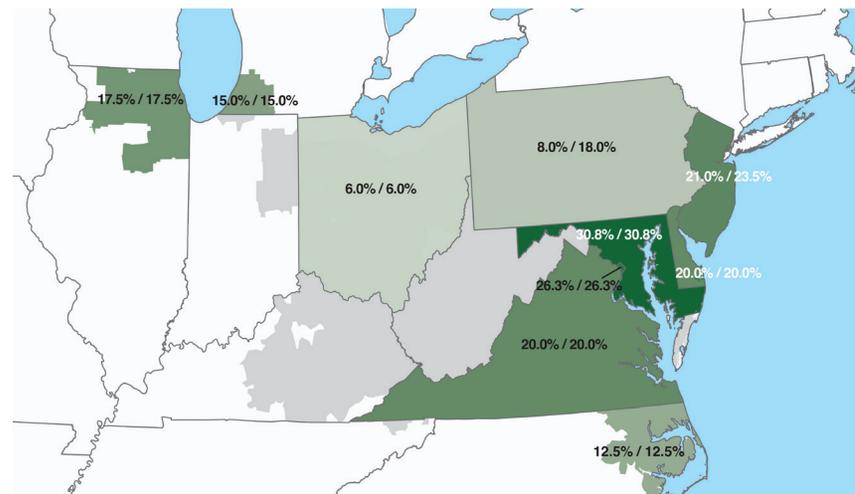
Table 8-15 State fulfillment of Solar RPS: 2016 through 2020

	State SREC	Import SREC	
2016	DC Solar	49.8%	50.2%
	DE Solar Eligible	76.5%	23.5%
	IL Solar Renewable	56.1%	43.9%
	MD Solar	100.0%	0.0%
	NJ Solar	100.0%	0.0%
	OH Solar Renewable Energy Source	73.3%	26.7%
	PA Solar	29.1%	70.9%
2017	DC Solar	63.8%	36.2%
	DE Solar Eligible	61.9%	38.1%
	IL Solar Renewable	87.5%	12.5%
	MD Solar	100.0%	0.0%
	NJ Solar	100.0%	0.0%
	OH Solar Renewable Energy Source	69.0%	31.0%
	PA Solar	30.6%	69.4%
2018	DC Solar	67.4%	32.6%
	DE Solar Eligible	67.7%	32.3%
	IL Solar Renewable	82.8%	17.2%
	MD Solar	100.0%	0.0%
	NJ Solar	100.0%	0.0%
	OH Solar Renewable Energy Source	59.5%	40.5%
	PA Solar	27.1%	72.9%
2019	DC Solar	72.4%	27.6%
	DE Solar Eligible	66.4%	33.6%
	IL Solar Renewable	100.0%	0.0%
	MD Solar	100.0%	0.0%
	NJ Solar	100.0%	0.0%
	OH Solar Renewable Energy Source	43.5%	56.5%
	PA Solar	48.8%	51.2%
2020	DC Solar	81.5%	18.5%
	DE Solar Eligible		
	IL Solar Renewable	100.0%	0.0%
	MD Solar	100.0%	0.0%
	NJ Solar	100.0%	0.0%
	OH Solar Renewable Energy Source	36.7%	63.3%
	PA Solar	100.0%	0.0%

¹⁷⁰ Retired REC information obtained through PJM GATS <<https://gats.pjm-eis.com/gats2/PublicReports/RPSRetiredCertificatesReportingYear>> (Accessed May 5, 2021). The timing of the REC retirement reports varies by state and the 2020 reporting year data is incomplete for several states.

Figure 8-8 shows the percent of retail electric load that must be served by Tier I resources and Tier 2 resources in each PJM jurisdiction with a mandatory RPS. For each state in Figure 8-8, the first number represents the RPS percent for Tier I or renewable energy resources; the second number represents the RPS percent for all eligible technologies which includes both renewable and alternative energy resources. States with higher percent requirements for renewable energy resources are shaded darker. Jurisdictions with no standards or with only voluntary RPS are shaded gray. Pennsylvania's RPS illustrates the need to differentiate between percent requirements for renewable and alternative energy resources. The Pennsylvania RPS identifies solar photovoltaic, solar thermal, wind, geothermal, biomass, and low-impact hydropower as Tier I resources. The Pennsylvania RPS identifies waste coal, demand side management, large-scale hydropower, integrated gasification combined cycle, clean coal and municipal solid waste as eligible Tier II resources. As a result, the 18.0 percent number in Figure 8-8 overstates the percent of retail electric load in Pennsylvania that must be served by renewable energy resources. The 8.0 percent number in Figure 8-8 is a more accurate measure of the percent of retail electric load in Pennsylvania that must be served by renewable energy resources.

Figure 8-8 Map of retail electric load shares under RPS – Renewable / Alternative Energy resources: 2021¹⁷¹



Under the existing state renewable portfolio standards, 15.4 percent of PJM load should have been served by Tier I and Tier II renewable and alternative energy resources in the first three months of 2021. Tier I resources consist of landfill gas, run of river hydro, wind and solar resources. Tier II resources consist of pumped storage, solid waste and waste coal resources. In the first three months of 2021, 8.4 percent of PJM generation was renewable and alternative energy resources, including carbon producing and noncarbon producing Tier I and Tier II generation as shown in Table 8-16. If the proportion of load among states remains constant, 31.1 percent of PJM load must be served by Tier I and Tier II renewable and alternative energy resources in 2030 under currently defined RPS rules. Approximately 13.2 percent of PJM load should have been served by Tier I or renewable energy resources in the first three months of 2021. In the first three months of 2021, 6.3 percent of PJM generation was Tier I or renewable energy. The current REC production from PJM generation resources was not enough to meet the first quarter 2021 state renewable requirements, and LSEs purchased RECs from outside the PJM

¹⁷¹ The standards in this chart include the Tier I standards used by some states in the PJM footprint, as well as the total alternative energy standard for states that do not classify eligible technologies into tiers.

footprint. LSEs that are unable to meet the RPS with RECs may use alternative compliance payments for unmet goals based on each state's requirements. If the proportion of load among states remains constant, 28.9 percent of PJM load must be served by Tier I or renewable energy resources in 2030 under defined RPS rules.

In jurisdictions with an RPS, load serving entities must either generate power from eligible technologies identified in each jurisdiction's RPS or purchase RECs from resources classified as eligible technologies. Table 8-16 shows generation by jurisdiction and resource type for the first three months of 2021. Wind output was 8,571.3 GWh of 13,154.3 Tier I GWh, or 65.2 percent, in the PJM footprint. As shown in Table 8-16, 17,584.9 GWh were generated by Tier I and Tier II resources, of which Tier I resources were 74.8 percent. Total wind and solar generation (noncarbon producing) was 4.6 percent of total generation in PJM for the first three months of 2021. Tier I generation was 6.3 percent of total generation in PJM and Tier II was 2.1 percent of total generation in PJM for the first three months of 2021. Biofuel, landfill gas, solid waste and waste coal (carbon producing) were 3,477.9 GWh, or 19.8 percent of the total Tier I and Tier II.

Table 8-16 Tier I and Tier II generation by jurisdiction and renewable resource type (GWh): January through March, 2021

Jurisdiction	Tier I						Tier II					Total Tier II Credit	Total GWh
	Biofuel	Landfill Gas	Tier I Hydro	Solar	Wind	Total Tier I Credit	Tier II Hydro	Pumped-Storage Hydro	Solid Waste	Waste Coal			
Delaware	0.0	13.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0
Illinois	0.0	39.5	0.0	2.1	4,025.1	4,066.7	0.0	0.0	0.0	0.0	0.0	0.0	4,066.7
Indiana	0.0	5.0	6.1	3.3	1,718.4	1,732.9	0.0	0.0	0.0	0.0	0.0	0.0	1,732.9
Kentucky	0.0	0.0	98.1	0.0	0.0	98.1	0.0	0.0	0.0	0.0	0.0	0.0	98.1
Maryland	0.0	12.4	0.0	99.6	209.6	321.5	0.0	0.0	166.8	0.0	166.8	0.0	488.3
Michigan	0.0	17.5	13.8	1.0	0.0	32.3	0.0	0.0	0.0	0.0	0.0	0.0	32.3
New Jersey	0.0	34.0	8.2	166.1	3.6	211.8	0.0	46.7	333.2	0.0	379.9	0.0	591.7
North Carolina	0.0	0.0	285.3	356.6	162.2	804.0	0.0	0.0	0.0	0.0	0.0	0.0	804.0
Ohio	0.0	86.3	255.6	61.6	731.0	1,134.5	0.0	0.0	0.0	0.0	0.0	0.0	1,134.5
Pennsylvania	0.0	111.7	1,402.2	63.1	1,129.9	2,706.9	0.0	481.1	393.2	1,520.2	2,394.6	0.0	5,101.5
Tennessee	0.0	0.0	0.0	0.0	0.0	0.0	400.4	0.0	0.0	0.0	400.4	0.0	400.4
Virginia	242.5	131.7	492.5	311.8	105.8	1,284.3	188.9	536.4	201.1	0.0	926.4	0.0	2,210.7
Washington, D.C.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	0.0	7.3	248.9	6.4	485.8	748.3	0.0	0.0	0.0	162.6	162.6	0.0	910.9
Total	242.5	458.4	2,810.7	1,071.5	8,571.3	13,154.3	589.2	1,064.3	1,094.3	1,682.8	4,430.6	0.0	17,584.9

Figure 8-9 shows the average hourly output by fuel type for for the first three months of years 2015 through 2021. Tier I includes landfill gas, run of river hydro, solar and wind resources, as defined by the relevant states. Tier II includes pumped storage, solid waste and waste coal resources, as defined by the relevant states. Other includes biomass, miscellaneous, heavy oil, light oil, coal gas, propane, diesel, distributed generation, other biogas, kerosene and batteries.¹⁷²

Figure 8-9 Average hourly output by fuel type: January through March, 2015 through 2021

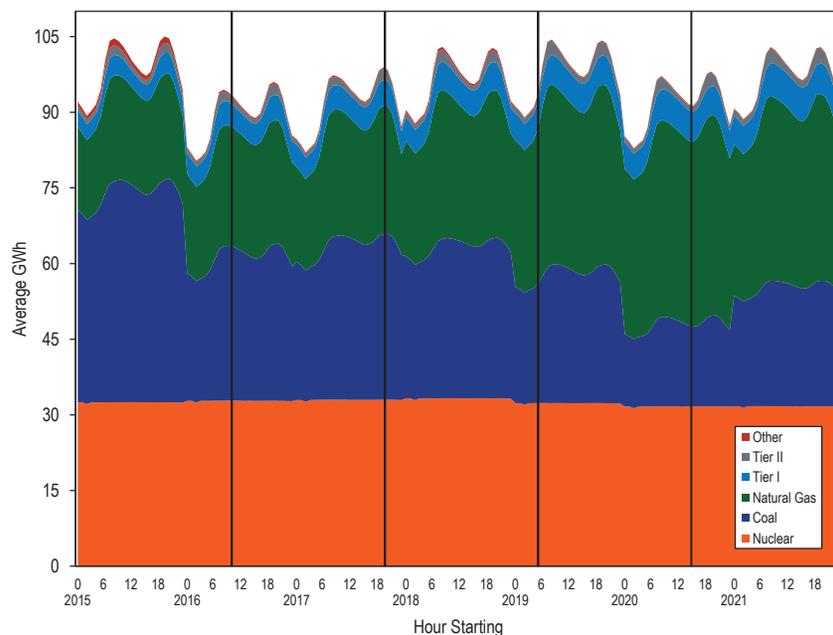


Table 8-17 shows the summer installed capacity rating of Tier I and Tier II resources in PJM by jurisdiction, as defined by primary fuel type. This capacity includes coal and natural gas units that qualify as Tier II because they have a renewable fuel as an alternative fuel. For example, a coal generator that

¹⁷² See the 2021 State of the Market Report for PJM: January through March, Section 3: Energy Market, Table 3-53.

can also burn waste coal to generate power could list the alternative fuel as waste coal. A REC is only generated when using the fuel listed as Tier I or Tier II. Virginia has the largest amount of solar capacity in PJM, 1,244.1 MW, or 30.8 percent of the total solar capacity. Wind resources are located primarily in western PJM, in Illinois and Indiana, which include 6,876.5 MW, or 64.4 percent of the total wind capacity.

PJM has proposed new rules for determining the capacity value of intermittent generators, based on the effective load carrying capability (ELCC) method.¹⁷³ The Commission rejected the proposal because the transition mechanism which locks in ELCC for prolonged periods is unsupported.¹⁷⁴ By June 1, 2021, PJM must either file a revised ELCC proposal or file a brief on the current rules for determining capacity values for different resource types.¹⁷⁵

The MMU recommends that PJM file the required brief and confirm the current rules while continuing to develop a complete and workable ELCC proposal. PJM's ELCC design proposal, even without the transition mechanism rejected by the Commission, is badly flawed and the current rules are preferable.¹⁷⁶

Under the current rules a generator's capacity value is derated from the installed capacity level by multiplying the generator's net maximum capability by a capacity factor. The capacity factor is either based on the generator's historical performance during summer peak hours or is a class average value calculated by PJM. The intent of the current method is to obtain a MW value the generator can reliably produce during the summer peak hours.¹⁷⁷ As of April 1, 2021, the derated capacity eligible for compensation in the PJM Capacity Market totaled 2,209.6 MW for wind generators and 1,032.2 MW for solar generators. This compares to installed wind capacity of 10,682.3 MW and installed solar capacity of 4,043.2 MW in Table 8-17. PJM posts class

¹⁷³ See FERC ER21-278-001, et al.

¹⁷⁴ See 175 FERC ¶ 61,084 (2021).

¹⁷⁵ *Id.* at P 4.

¹⁷⁶ See Comments and Motions of the Independent Market Monitor for PJM, (November 20, 2020); Answer and Motion for Leave to Answer of the Independent Market Monitor for PJM, (December 18, 2020); Comments and Motions of the Independent Market Monitor for PJM (March 22, 2021); Answer and motion for Leave to Answer of the Independent Market Monitor for PJM (April 29, 2021).

¹⁷⁷ See Appendix B in "PJM Manual 21: Rules and Procedures for Determination of Generating Capability," <<https://pjm.com/-/media/documents/manuals/m21.ashx>>.

average capacity factors for wind and solar generators. There are two classes of wind based on location with class average capacity factors of 14.7 percent and 17.6 percent.¹⁷⁸

Table 8-17 Renewable capacity by jurisdiction (MW): March 31, 2021

Jurisdiction	Coal / Biofuel	Biofuel	Hydro	Landfill Gas	Natural Gas / Biofuel	Natural Gas / Landfill Gas	Other Gas	Oil / Biofuel	Oil / Landfill Gas	Pumped-Storage Hydro	Solar	Solid Waste	Waste Coal	Wind	Total
Delaware	0.0	0.0	0.0	8.1	1,797.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	1,818.1
Illinois	0.0	0.0	0.0	39.2	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	4,526.1	4,574.3
Indiana	0.0	0.0	8.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0	2,350.5	2,372.0
Kentucky	0.0	0.0	132.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.7
Maryland	0.0	0.0	0.4	22.3	0.0	0.0	0.0	69.0	0.0	0.0	342.5	128.2	0.0	245.2	807.6
Michigan	0.0	0.0	13.9	12.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	30.5
Missouri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.0	146.0
New Jersey	0.0	0.0	11.0	61.1	0.0	0.0	0.0	0.0	0.0	453.0	685.9	204.6	0.0	4.5	1,420.0
North Carolina	0.0	0.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,180.1	0.0	0.0	208.0	1,713.1
Ohio	0.0	2,320.0	194.4	58.2	0.0	0.0	1.0	136.0	0.0	0.0	416.1	0.0	0.0	1,045.6	4,171.3
Pennsylvania	54.0	0.0	1,387.3	125.2	2,346.0	0.0	0.0	0.0	0.0	1,269.0	121.8	209.2	1,347.0	1,457.2	8,316.7
Tennessee	50.0	0.0	296.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	346.6
Virginia	241.9	585.0	436.4	127.7	0.0	0.0	88.0	17.0	0.0	5,386.0	1,244.1	123.0	0.0	12.0	8,261.0
Washington, D.C.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	0.0	0.0	209.9	8.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1	0.0	96.0	687.3	1,030.2
PJM Total	345.9	2,905.0	3,015.6	465.0	4,143.0	0.0	89.0	222.0	13.0	7,108.0	4,043.2	665.0	1,443.0	10,682.3	35,140.1

There are three classes of solar generators with capacity factors ranging from 38.0 percent to 60.0 percent.¹⁷⁹

¹⁷⁸ See "Class Average Capacity Factors Wind and Solar Resources," PJM, June 1, 2017 <<https://www.pjm.com/-/media/planning/res-adeq/class-average-wind-capacity-factors.ashx?la=en>>.

¹⁷⁹ *Id.*

Table 8-18 shows renewable capacity registered in the PJM generation attribute tracking system (GATS).¹⁸⁰ These resources are not PJM resources even though most are located in PJM states. For example, roof top solar panels within the PJM footprint generate SRECs but are not PJM units. This includes solar capacity of 7,488.6 MW of which 2,712.1 MW are in New Jersey. These resources can earn renewable energy credits, and can be used to fulfill the renewable portfolio standards in PJM jurisdictions. There are 1,738.4 MW of capacity located in jurisdictions outside PJM that may qualify for specific renewable energy credits in some PJM jurisdictions. For example, there are 54.0 MW of capacity registered with GATS located in Alabama.

Table 8-18 Renewable capacity by jurisdiction, non-PJM units registered in GATS (MW): March 31, 2021¹⁸¹

Jurisdiction	Coal /		Fuel Cell	Geothermal	Hydro	Natural Gas /		Other Gas	Solar	Solid Waste	Waste Coal	Waste Heat	Wind	Total
	Biofuel	Biofuel				Landfill Gas	Distributed Generation							
Alabama	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.0
Delaware	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	129.1	0.0	0.0	0.0	2.0	133.3
Georgia	0.0	0.0	0.0	0.0	0.0	27.1	0.0	0.0	152.2	0.0	0.0	0.0	0.0	179.3
Illinois	0.0	0.0	0.0	0.0	21.4	55.4	0.0	2.1	610.8	0.0	0.0	0.0	598.4	1,288.0
Indiana	0.0	0.0	0.0	0.0	0.0	48.0	0.0	5.2	130.2	0.0	0.0	94.6	180.0	458.0
Iowa	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	2.1	0.0	0.0	0.0	336.8	340.5
Kentucky	93.0	600.0	0.0	0.0	162.2	20.2	0.0	0.4	38.2	0.0	0.0	0.0	0.0	914.0
Maryland	3.8	65.0	0.0	2.1	0.0	12.7	0.0	0.0	1,171.4	10.0	0.0	0.0	0.3	1,265.3
Michigan	31.0	0.0	0.0	0.0	1.3	16.6	0.0	0.0	15.0	0.0	0.0	0.0	80.6	144.4
Missouri	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	61.2	0.0	0.0	0.0	693.0	759.8
New Jersey	0.0	0.0	0.0	0.0	0.0	45.8	0.0	11.4	2,712.1	0.0	0.0	0.0	4.7	2,773.9
New York	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4
North Carolina	151.5	0.0	0.0	0.0	520.4	0.0	0.0	0.0	1,231.9	0.0	0.0	0.0	0.0	1,903.8
North Dakota	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	360.0	360.0
Ohio	92.8	0.0	0.0	0.0	6.6	19.7	0.0	61.1	238.1	0.0	0.0	33.0	54.7	506.1
Pennsylvania	8.6	109.7	0.8	0.0	31.5	45.2	15.3	100.0	481.1	0.2	109.2	117.6	3.2	1,022.3
South Carolina	0.0	0.0	0.0	0.0	0.0	30.8	0.0	0.0	91.3	0.0	0.0	0.0	0.0	122.1
Tennessee	0.0	0.0	0.0	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.6
Virginia	287.6	0.0	0.0	0.0	30.8	11.3	0.0	2.6	292.3	0.0	0.0	0.0	0.0	624.6
Washington, D.C.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.4	127.1	0.0	0.0	13.5	0.0	190.0
West Virginia	0.0	0.0	0.0	0.0	102.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	106.1
Wisconsin	44.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	44.8
Total	766.9	774.7	0.8	2.1	975.8	342.1	15.3	232.0	7,488.6	10.2	109.2	258.7	2,313.7	13,290.2

Renewable energy credits are related to the production and purchase of wholesale power, but have not, when they constitute a transaction separate from a wholesale sale of power, been found subject to FERC regulation.¹⁸² RECs markets are, as an economic fact, integrated with PJM markets including energy and capacity markets, but are not formally recognized as part of PJM markets. Revenues from RECs markets are revenues for PJM resources earned in addition to revenues earned from the sale of the same MWh in PJM markets.

¹⁸⁰ PJM Environmental Information Services (EIS), an unregulated subsidiary of PJM, operates the generation attribute tracking system (GATS), which is used by many jurisdictions to track these renewable energy credits. GATS publishes details on every renewable generator registered within the PJM footprint and aggregate emissions of renewable generation, but does not publish generation data by unit and does not make unit data available to the MMU.

¹⁸¹ See PJM-EIS (Environmental Information Services), Generation Attribute Tracking System, "Renewable Generators Registered in GATS," <<https://gats.pjm-eis.com/gats2/PublicReports/RenewableGeneratorsRegisteredinGATS>> (Accessed January 19, 2021).

¹⁸² See *WSP, Inc.*, 139 FERC ¶ 61,051 at P 18 (2012) ("we conclude that unbundled REC transactions fall outside of the Commission's jurisdiction under sections 201, 205 and 206 of the FPA. We further conclude that bundled REC transactions fall within the Commission's jurisdiction under sections 201, 205 and 206 of the FPA"); citing *American Ref-Fuel Company, et al.*, 105 FERC ¶ 61,004 at PP 23-24 (2003) ("American Ref-Fuel, 105 FERC ¶ 61,004 at PP 23-24 ("RECs are created by the States. They exist outside the confines of PURPA... And the contracts for sales of QF capacity and energy, entered into pursuant to PURPA, ... do not control the ownership of RECs."); see also *Williams Solar LLC and Allico Finance Limited*, 156 FERC ¶ 61,042 (2016).

Delaware, North Carolina, Michigan and Virginia allow various types of resources to earn multiple RECs per MWh, though typically one REC is equal to one MWh. For example, Delaware provided a three MWh REC for each MWh produced by in-state customer sited photovoltaic generation and fuel cells using renewable fuels that are installed on or before December 31, 2014.¹⁸³ This is equivalent to providing a REC price equal to three times its stated value per MWh.

In addition to GATS, there are several other REC tracking systems used by states in the PJM footprint. Illinois, Indiana and Ohio use both GATS and M-RETS, the REC tracking system for resources located in the Midcontinent ISO, to track the sales of RECs used to fulfill their RPS requirements. Michigan and North Carolina have created their own state-wide tracking systems, MIRECS and NC-RETS, through which all RECs used to satisfy these states' RPS requirements must ultimately be traded. Table 8-19 shows the REC tracking systems used by each state within the PJM footprint. To ensure a REC is only used one time, REC tracking systems must keep an account of a REC from its creation until its retirement. A REC is considered to be retired when it has been used to satisfy an obligation associated with an RPS.

Table 8-19 REC tracking systems in PJM states with renewable portfolio standards

Jurisdiction with RPS	REC Tracking System Used	
Delaware	PJM-GATS	
Illinois	PJM-GATS	M-RETS
Maryland	PJM-GATS	
Michigan		MIRECS
New Jersey	PJM-GATS	
North Carolina		NC-RETS
Ohio	PJM-GATS	M-RETS
Pennsylvania	PJM-GATS	
Virginia	PJM-GATS	
Washington, D.C.	PJM-GATS	
Jurisdiction with Voluntary Standard		
Indiana	PJM-GATS	M-RETS

¹⁸³ See DSIRE, NC Clean Energy Technology Center. Delaware Renewable Portfolio Standard, <<http://programs.dsireusa.org/system/program/detail/1231>> [Accessed November 3, 2018].

All PJM states with renewable portfolio standards have specified geographical restrictions governing the source of RECs to satisfy states' standards. Table 8-20 describes these restrictions. Indiana, Illinois, Michigan, and Ohio all have provisions in their renewables standards that require all or a portion of RECs used to comply with each state's standards to be generated by in-state resources. North Carolina has provisions that require RECs to be purchased from in-state resources but Dominion, the only utility located in both North Carolina and PJM, is exempt from these provisions. Pennsylvania added a provision in 2017 that requires SRECs used to comply with Pennsylvania's solar photovoltaics carve out standard to be sourced from resources located in Pennsylvania.

Pennsylvania and Virginia require that RECs used for RPS compliance are produced from resources located within the PJM footprint. Delaware requires that RECs used for compliance with its RPS are produced from resources located within the PJM footprint or resources located elsewhere if these resources can demonstrate that the power they produce is directly deliverable to Delaware. The District of Columbia, Maryland and New Jersey allow RECs to be purchased from resources located within PJM in addition to large areas that adjoin PJM for compliance with their standards.

Table 8-20 Geographic restrictions on REC purchases for renewable portfolio standard compliance in PJM states

State with RPS	RPS Contains In-state Provision	Geographical Requirements for RPS Compliance
Delaware	No	RECs must be purchased from resources located either within PJM or from resources outside of PJM that are directly deliverable into Delaware.
Illinois	Yes	All RECs must be purchased from resources located within Illinois or from resources located in adjacent states that meet certain public interest criteria.
Maryland	No	RECs must come from within PJM, 10-30 miles offshore the coast of Maryland or from a control area adjacent to PJM that is capable of delivering power into PJM.
Michigan	Yes	RECs must either come from resources located within Michigan or anywhere in the service territory of retail electric provider in Michigan that is not an alternative electric supplier. There are many exceptions to these requirements (see Michigan S.B. 213).
New Jersey	No	RECs must either be purchased from resources located within PJM or from resources located outside of PJM for which the energy associated with the REC is delivered to PJM via dynamic scheduling.
North Carolina	Yes	Dominion, the only utility located in both the state of North Carolina and PJM, may purchase RECs from anywhere. Other utilities in North Carolina not located in PJM are subject to different REC requirements (see G.S. 62-113.8).
Ohio	Yes	All RECs must be generated from resources that are located in the state of Ohio or have the capability to deliver power directly into Ohio. Any renewable facility located in a state contiguous to Ohio has been deemed deliverable into the state of Ohio. For renewable resources in noncontiguous states, deliverability must be demonstrated to the Public Utilities Commission of Ohio.
Pennsylvania	Yes	RECs must be purchased from resources located within PJM. All SRECs used for compliance with the Solar PV standard must source from solar PV resources within the state of Pennsylvania.
Virginia	No	RECs must be purchased from resources located within PJM
Washington, D.C.	No	RECs must be purchased from either a PJM state or a state adjacent with PJM. A PJM state is defined as any state with a portion of their geographical boundary within the footprint of PJM. An adjacent state is defined as a state that lies next to a PJM state, i.e. SC, GA, AL, AR, IA, NY, MO, MS, and WI.
State with Voluntary Standard		
Indiana	Yes	At least 50 percent of RECs must be purchased from resources located within Indiana.

Alternative Compliance Payments

PJM jurisdictions have various methods for enforcing compliance with required renewable portfolio standards. If a retail supplier is unable to comply with the renewable portfolio standards required by the jurisdiction, suppliers may make alternative compliance payments (ACPs), with varying standards, to cover any shortfall between the RECs required by the state and those the retail supplier actually purchased. The ACPs, which are penalties, function as a cap on the market value of RECs. In New Jersey, solar ACPs are currently \$248.00 per MWh.¹⁸⁴ Pennsylvania requires that solar ACPs be 200 percent of the average credit price of Pennsylvania solar RECs sold during the reporting year plus the value of any solar rebates which was \$74.00 per MWh for reporting year ending May 31, 2020. Delaware recently reduced the solar ACP from \$400 per credit to \$150 per credit.¹⁸⁵

¹⁸⁴ N.J. S. 2314/A. 3723.

¹⁸⁵ See Senate Bill 33, Delaware General Assembly (February 10, 2021) <<https://legis.delaware.gov/BillDetail?legislationId=48278>>.

Figure 8-10 shows the historical relationship between SREC prices and ACP levels. The SREC price is represented by a solid line in the figure and the corresponding ACP level is represented by a dashed line. For each jurisdiction, the ACP is an upper bound for the price level. In Michigan and North Carolina, there are no defined values for ACPs. The public utility commissions in Michigan and North Carolina have discretionary power to assess what a load serving entity must pay for any RPS shortfalls.

Table 8-21 shows the alternative compliance standards for RPS in PJM jurisdictions.

Table 8-21 Tier I, Tier II, and Solar alternative compliance payments in PJM jurisdictions as of March 31, 2021^{186 187}

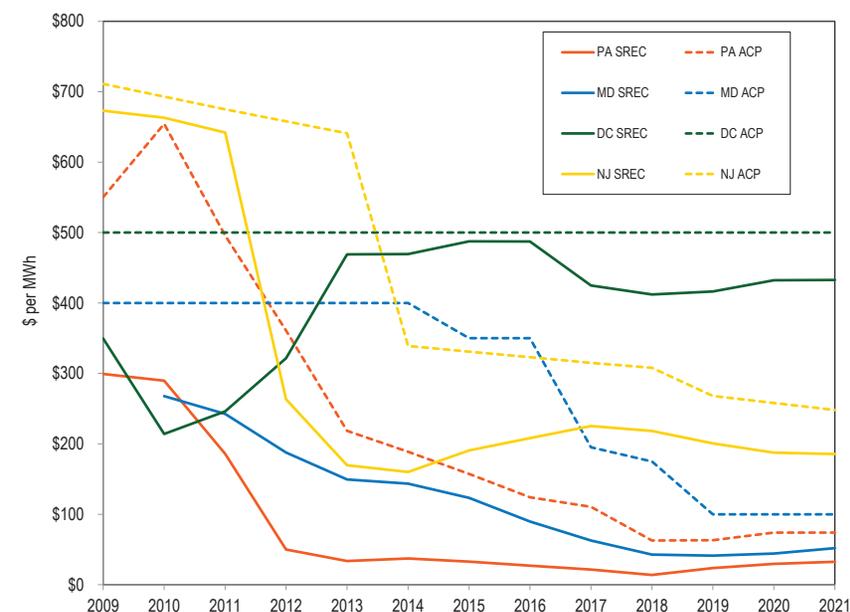
Jurisdiction with RPS	Standard Alternative Compliance (\$/MWh)	Tier II Alternative Compliance (\$/MWh)	Solar Alternative Compliance (\$/MWh)
Delaware	\$25.00		\$150.00
Illinois	\$0.35		
Maryland	\$30.00	\$15.00	\$100.00
Michigan	No specific penalties		
New Jersey	\$50.00	\$50.00	\$248.00
North Carolina	No specific penalties: At the discretion of the NC Utility Commission		
Ohio	\$52.62		
Pennsylvania	\$45.00	\$45.00	\$74.00
Washington, D.C.	\$50.00	\$10.00	\$500.00
Jurisdiction with Voluntary Standard			
Indiana	Voluntary standard - No Penalties		
Virginia	Voluntary standard - No Penalties		
Jurisdiction with No Standard			
Kentucky	No standard		
Tennessee	No standard		
West Virginia	No standard		

Load serving entities participating in mandatory RPS programs in PJM jurisdictions must submit compliance reports to the relevant jurisdiction's public utility commission.

¹⁸⁶ The Ohio standard alternative compliance payment (ACP) is updated annually <<https://www.puco.ohio.gov/industry-information/industry-topics/acp-non-solar-alternative-compliance-payment-under-orc-492864/>>. The Illinois Commerce Commission periodically publishes updates to the effective ACP amount <<https://www.icc.illinois.gov/electricity/RPSCompliancePaymentNotices.aspx>>. For updated Maryland ACPs, see Table 3 of the 2018 Renewable Energy Portfolio Standard Report <<https://www.psc.state.md.us/commission-reports/>>.

¹⁸⁷ The entry for Pennsylvania reflects the solar ACP for the compliance year ending May 31, 2020. See "Pricing," <<https://www.pennaep.com/reports/>> (Accessed October 22, 2020).

Figure 8-10 Comparison of SREC price and solar ACP: 2009 through 2021



In their submitted compliance reports, load serving entities must indicate the quantity of MWh that they have generated using eligible renewable or alternative energy resources. They must also identify the quantity of RECs they may have purchased to make up for renewable energy generation shortfalls or to comply with RPS provisions requiring that they purchase RECs. The public utility commissions then release RPS compliance reports to the public.

The Pennsylvania Public Utility Commission issued their 2020 compliance report for the Pennsylvania Alternative Energy Standards Act of 2004 in February of 2021.¹⁸⁸ Pennsylvania reported that the 614,926 SRECs, 10,086,046 Tier I RECs and 11,203,559 Tier II RECs were retired during the 2020 reporting year (June 1, 2019 through May 31, 2020). Supplier obligations for 1,435 SRECs, 34,737 Tier I RECs and 37,073 Tier II RECs were resolved through ACPs.

¹⁸⁸ "Alternative Energy Portfolio Standards Act of 2004 Compliance for Reporting Year 2020," (September 2020), <<https://www.puc.pa.gov/media/1410/aeps-annreport2020.pdf>>.

The Public Service Commission of the District of Columbia reported that 99,061 SRECs, 1,834,067 Tier I RECs and 54,953 Tier II RECs were retired during the 2019 compliance year. ACPs decreased from \$18.7 million for 2018 to \$12.1 million for 2019.¹⁸⁹

The Public Service Commission of Maryland reported that 1,167,329 SRECs were retired in 2019, an increase of 36.2 percent over the 2018 level. Tier 1 REC retirements increased to 10,210,275, 18.3 percent higher than in 2018, and 55,879 Tier 2 RECs were retired in 2019, a 96.5 percent decrease below the 2018 level.¹⁹⁰ ACPs totaled \$7.7 million for 2019, up from \$67,797 in 2018.¹⁹¹

The Public Utilities Commission of Ohio reported that 6,367,089 nonsolar RECs were retired in the 2019 compliance year, which is less than the nonsolar REC obligation of 6,509,239 RECs; and 377,665 SRECs were retired in the 2019 compliance year, exceeding the SREC obligation of 271,176 SRECs.¹⁹²

Delmarva Power is the only retail electric supplier that must file a compliance report with the Delaware Public Service Commission. Delmarva Power reported to the Delaware Public Service Commission that they satisfied their REC obligation of 719,261 credits for the compliance year ending May 31, 2020, with zero ACPs.¹⁹³ Delmarva Power satisfied their solar REC obligation of 135,771 credits with zero alternative compliance payments.

Prior to the 2017/2018 Delivery Year, the Illinois RPS had required electricity suppliers to satisfy at least 50 percent of their RPS obligation through ACPs. This requirement was removed for 2017/2018 Delivery Year and ACPs for ComEd decreased to \$74,148. The 2016–2017 ACPs for ComEd totaled \$40,575,311.¹⁹⁴

189 "Renewable Energy Portfolio Standard, A Report for Compliance Year 2019," Public Service Commission of the District of Columbia (May 1, 2020), <<https://dcpsc.org/Orders-and-Regulations/PSC-Reports-to-the-DC-Council/Renewable-Energy-Portfolio-Standard.aspx>>.

190 "Renewable Energy Portfolio Standard Report," Public Service Commission of Maryland (October 2020) at 9, <<https://www.psc.state.md.us/commission-reports/>>.

191 *Id.* at 9.

192 "Renewable Portfolio Standard Report to the General Assembly for Compliance Year 2019," Public Utilities Commission of Ohio (April 7, 2021), <<https://puco.ohio.gov/wps/portal/gov/puco/utilities/electricity/resources/ohio-renewable-energy-portfolio-standard/puco-annual-rps-reports>>.

193 "Retail Electricity Supplier's RPS Compliance Report, Compliance Period: June 1, 2019–May 31, 2020," Delmarva Power, (Sept. 25, 2020), <<https://depdc.delaware.gov/delawares-renewable-portfolio-standard-green-power-products/>>.

194 "Annual Report Fiscal Year 2018," Illinois Power Agency (Feb. 15, 2019) at 46, <https://www2.illinois.gov/sites/ipa/Pages/IPA_Reports.aspx>.

The North Carolina Utilities Commission reported that Dominion North Carolina Power submitted its 2018 compliance report on August 13, 2019. The compliance report stated that Dominion met its general RPS requirement by purchasing 397,643 credits that consisted of wind and hydro RECs and energy efficiency credits (EECs).¹⁹⁵ Dominion also met its solar, poultry waste, and swine waste requirements by purchasing RECs.

The Michigan Public Service Commission reported that Indiana Michigan Power Company met the 2018 standard by generating or acquiring 283,473 RECs.¹⁹⁶

New Jersey's Office of Clean Energy posted a summary of RPS compliance through the energy year ending May 31, 2020.¹⁹⁷ Electric power suppliers retired 10,078,927 class I RECs and 1,758,386 class II RECs. Twenty ACPs were submitted class I credits; 135 ACPs were submitted for class II. Electric power suppliers retired 3,287,327 solar RECs and 12 SACPs were submitted.

Table 8-22 shows the RPS compliance cost incurred by PJM jurisdictions as reported by the jurisdictions.¹⁹⁸ The compliance costs are the cost of acquiring RECs plus the cost of any alternative compliance payments. The cost by type in Table 8-22 is an estimate based on average REC prices and assigning the reported alternative compliance payments to the solar standard. The cost of complying with RPS, as reported by the states, was \$5.6 billion over the six year period from 2014 through 2019 for the nine jurisdictions that had RPS and reported compliance costs.¹⁹⁹ The average RPS compliance cost per year based on the reported compliance cost for the six year period from 2014 through 2019 was \$936.7 million. The compliance cost for 2019, the most recent year with almost complete data, was \$1.2 billion.

195 "Annual Report Regarding Renewable Energy and Energy Efficiency Portfolio Standard in North Carolina," North Carolina Utilities Commission (Oct. 1, 2019) at 38, <<https://www.ncuc.net/Reps/reps.html>>.

196 "Report on the Implementation and Cost-Effectiveness of the P.A. 295 Renewable Energy Standard," Michigan Public Service Commission (Feb. 18, 2020), <https://www.michigan.gov/mpsc/0,9535,7-395-93309_93438_93459_94932---,00.html>.

197 See RPS Report Summary 2005–2020, New Jersey's Clean Energy Program (Apr. 13, 2021), <<http://www.njcleanenergy.com/renewable-energy/program-updates/rps-compliance-reports>>.

198 RPS compliance cost totals for Illinois, Michigan, and North Carolina reflect the RPS compliance cost attributable to PJM load in each of the states.

199 The actual PJM RPS compliance cost exceeds the reported \$4.4 billion since this total does not include a value for Delaware in 2014 and a value for Pennsylvania in 2018.

Table 8-22 RPS Compliance Cost^{200 201 202 203 204 205 206 207 208 209 210}

Jurisdiction with RPS		2014	2015	2016	2017	2018	2019
Delaware	Total RPS		\$16,013,421	\$18,409,631	\$18,772,855	\$18,341,916	\$19,401,476
	Solar		\$7,070,254	\$7,748,073	\$7,105,726	\$6,565,240	\$8,121,914
	Non-Solar		\$8,943,167	\$10,661,557	\$11,667,129	\$11,776,676	\$11,279,562
Illinois	Total RPS	\$21,701,688	\$24,817,068	\$25,718,863	\$25,919,372	\$25,775,523	
Maryland	Total RPS	\$103,990,914	\$126,727,632	\$135,198,524	\$72,009,070	\$84,806,928	\$134,545,520
	Solar	\$29,372,737	\$39,055,714	\$45,556,987	\$21,275,664	\$27,351,388	\$55,166,116
	Tier I	\$70,630,620	\$85,054,001	\$88,200,121	\$50,045,621	\$56,406,247	\$79,320,505
	Tier II	\$3,987,557	\$2,617,917	\$1,441,416	\$687,785	\$1,049,293	\$58,899
Michigan	Total RPS	\$476,535	\$0	\$3,264,504	\$3,961,262	\$3,264,504	
New Jersey	Total RPS	\$395,782,297	\$524,761,382	\$593,441,037	\$606,312,461	\$653,810,457	\$763,108,366
	Solar	\$322,504,920	\$417,359,783	\$481,540,738	\$503,797,182	\$560,509,712	\$667,975,153
	Class I	\$66,071,749	\$98,185,431	\$100,910,465	\$91,872,615	\$83,474,335	\$85,522,028
	Class II	\$7,205,628	\$9,216,167	\$10,989,834	\$10,642,664	\$9,826,410	\$9,611,185
North Carolina	Total RPS	\$297,513	\$358,436	\$317,644	\$234,264	\$442,579	
Ohio	Total RPS	\$42,581,477	\$42,584,233	\$37,631,481	\$39,943,836	\$50,214,523	\$67,922,688
	Solar	\$17,666,730	\$14,843,052	\$11,564,584	\$9,435,730	\$9,419,092	\$9,578,048
	Non-Solar	\$24,914,747	\$27,741,181	\$26,066,897	\$30,508,106	\$40,795,431	\$58,344,639
Pennsylvania	Total RPS	\$86,184,477	\$114,586,932	\$125,041,911	\$115,585,212	\$99,681,713	\$112,691,066
	Solar	\$14,163,543	\$19,227,690	\$21,876,876	\$17,987,722	\$16,565,924	\$20,608,103
	Tier I	\$70,922,431	\$94,339,032	\$101,700,328	\$95,370,456	\$77,899,586	\$74,780,310
	Tier II	\$1,098,503	\$1,020,210	\$1,464,707	\$2,227,034	\$5,216,203	\$17,302,653
Washington D.C.	Total RPS	\$27,372,970	\$38,540,633	\$47,163,353	\$42,678,813	\$50,609,701	\$57,300,000
	Solar	\$25,145,143	\$36,526,662	\$44,897,161	\$38,571,061	\$45,673,261	\$51,982,914
	Tier I	\$2,140,860	\$1,899,232	\$2,132,072	\$3,960,018	\$4,809,857	\$5,262,354
	Tier II	\$86,966	\$114,738	\$134,119	\$147,734	\$126,583	\$54,733
PJM	Total RPS	\$678,387,871	\$888,389,738	\$986,186,949	\$925,417,144	\$986,947,843	\$1,154,969,115

200 Several states that have compliance periods that align with the PJM capacity market have not released compliance reports for the period June 1, 2019 through May 31, 2020.

201 "Delmarva Power & Light's 2018 RPS Compliance Report," Delmarva Power (Sept. 23, 2019), <<https://depsc.delaware.gov/delawares-renewable-portfolio-standard-green-power-products/>>.

202 "Fiscal Year 2018 Annual Report," February 15, 2019, "Report on Costs and Benefits of Renewable Resource Procurement," April 1, 2016, Illinois Power Agency (IPA), <https://www2.illinois.gov/sites/ipa/Pages/IPA_Reports.aspx>. The compliance cost entry for Illinois represents the ComEd cost of RECs as given in Section 11, Table 2.

203 "Renewable Energy Portfolio Standard Report," Public Service Commission of Maryland (Dec. 2019) at 8, <<https://www.psc.state.md.us/commission-reports/>>.

204 Appendix C in "Report on the Implementation and Cost-Effectiveness of the P.A. 295 Renewable Energy Standard," Michigan Public Service Commission, February 18, 2020, <https://www.michigan.gov/mpsc/0,9535,7-395-93309_93438_93459_94932---,00.html>. The compliance cost entry reflects the compliance cost of the Indiana Michigan Power Company, which is the only investor owned utilities whose service area is in the PJM footprint.

205 "RPS Report Summary 2005-2020," New Jersey's Clean Energy Program, April 13, 2021, <<http://njcleanenergy.com/renewable-energy/program-updates/rps-compliance-reports/>>.

206 "Renewable Portfolio Standard Report to the General Assembly for Compliance Year 2019," Public Utilities Commission of Ohio, April 7, 2021, <<https://puco.ohio.gov/wps/portal/gov/puco/utilities/electricity/resources/ohio-renewable-energy-portfolio-standard/puco-annual-rps-reports->>.

207 "2020 Annual Report Alternative Energy Portfolio Standards Act of 2004," Pennsylvania Public Utility Commission, February 2021 <<https://www.puc.pa.gov/media/1410/aeps-annrpt2020.pdf>>.

208 "Report on the Renewable Energy Portfolio Standard for Compliance Year 2018," Public Service Commission of the District of Columbia, Executive Summary, May 1, 2019, <<https://dcpsc.org/Orders-and-Regulations/PSC-Reports-to-the-DC-Council/Renewable-Energy-Portfolio-Standard.aspx>>.

209 "Application of Dominion Energy North Carolina for Approval of Cost Recovery for Renewable Energy and Energy Efficiency Portfolio Standard Compliance and Related Costs," Docket No. E-22, Sub 557, Sub 558, August 30, 2018 <<https://www.ncuc.net/>>. The North Carolina compliance cost entries reflects the compliance cost of Dominion Energy North Carolina.

210 The reporting period for RPS compliance in Delaware, Illinois, New Jersey, and Pennsylvania corresponds to PJM capacity market delivery years, June 1 through May 31. The compliance cost amounts reported by these states were converted to calendar year by assuming the compliance cost was evenly spread across the months in the compliance year.

Emission Controlled Capacity and Emissions

Emission Controlled Capacity

Environmental regulations affect decisions about emission control investments in existing units, investment in new units and decisions to retire units lacking emission controls.²¹¹ Most PJM units burning fossil fuels have installed emission control technology. All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS.²¹² ²¹³

Table 8-23 shows SO₂ emission controls by fossil fuel fired units in PJM.²¹⁴ ²¹⁵ Coal has the highest SO₂ emission rate, while natural gas and diesel oil have lower SO₂ emission rates.²¹⁷ Of the current 55,893.2 MW of coal capacity in PJM, 52,326.9 MW of capacity, 93.6 percent, has some form of FGD (flue-gas desulfurization) technology to reduce SO₂ emissions.

Table 8-23 SO₂ emission controls by fuel type (MW): March 31, 2021²¹⁸

	SO ₂ Controlled	No SO ₂ Controls	Total	Percent Controlled
Coal	52,326.9	3,566.3	55,893.2	93.6%
Diesel Oil	0.0	5,089.7	5,089.7	0.0%
Natural Gas	0.0	67,484.5	67,484.5	0.0%
Other	325.0	3,833.7	4,158.7	7.8%
Total	52,651.9	79,974.2	132,626.1	39.7%

Table 8-24 shows NO_x emission controls by fossil fuel fired units in PJM. Coal has the highest NO_x emission rate, while natural gas and diesel oil have lower NO_x emission rates. Of the current 55,893.2 MW of coal capacity in PJM,

211 See EPA, "National Ambient Air Quality Standards (NAAQS)," <<https://www.epa.gov/criteria-air-pollutants/naqs-table>> (Accessed March 7, 2020).

212 On April 16, 2020, the EPA issued a revised final finding regarding the Mercury and Air Toxics Standards. See EPA, "Regulatory Actions," <<https://www.epa.gov/mats/regulatory-actions-final-mercury-and-air-toxics-standards-mats-power-plants>> (Accessed May 7, 2020).

213 On April 9, 2020, the EPA created a new subcategory of six coal refuse power plants in Pennsylvania and West Virginia with reduced limits of HCl and SO₂ emissions under MATS. These units were all compliant with the previous MATS rules. "Mercury and Air Toxics Standards," <https://www.epa.gov/sites/production/files/2020-04/documents/frn_mats_coal_refuse_2060-au48_final_rule.pdf> (Accessed May 7, 2020).

214 See EPA, "Air Market Programs Data," <<http://ampd.epa.gov/ampd/>> (Accessed May 7, 2020).

215 Air Markets Programs Data is submitted quarterly. Generators have 60 days after the end of the quarter to submit data, and all data is considered preliminary and subject to change until it is finalized in June of the following year. The most recent complete set of emissions data is from the second quarter of 2020.

216 The total MW are less than the 183,778.6 reported in Section 5: Capacity Market, because EPA data on controls could not be matched to some PJM units. "Air Markets Program Data," <<http://ampd.epa.gov/ampd/QueryToolie.html>> (Accessed May 7, 2020).

217 Diesel oil includes number 1, number 2, and ultra-low sulfur diesel. See EPA, "Electronic Code of Federal Regulations, Title 40, Chapter 1, Subchapter C, Part 72, Subpart A, Section 72.2," <http://www.ecfr.gov/cgi-bin/text-idx?SID=4f18612541a393473efb13ac879d470fcm=true&node=se40.18.72_12&rgn=div8> (Accessed May 7, 2020).

218 The "other" category includes petroleum coke, wood, process gas, residual oil, other gas, and other oil. The EPA's "other" category does not have strict definitions for inclusion.

55,764.2 MW of capacity, 99.8 percent, has some form of emissions controls to reduce NO_x emissions. Most units in PJM have NO_x emission controls in order to meet each state's emission compliance standards, based on whether a state is part of CSAPR, Acid Rain Program (ARP) or a combination of the three. The NO_x compliance standards of MATS require the use of selective catalytic reduction (SCRs) or selective non-catalytic reduction (SCNRs) for coal steam units, as well as SCRs or water injection technology for peaking combustion turbine units.²¹⁹

Table 8-24 NO_x emission controls by fuel type (MW): As of March 31, 2021

	NO _x Controlled	No NO _x Controls	Total	Percent Controlled
Coal	55,764.2	129.0	55,893.2	99.8%
Diesel Oil	1,482.6	3,607.1	5,089.7	29.1%
Natural Gas	66,486.5	998.0	67,484.5	98.5%
Other	1,805.7	2,353.0	4,158.7	43.4%
Total	125,539.0	7,087.1	132,626.1	94.7%

Table 8-25 shows particulate emission controls by fossil fuel units in PJM. Almost all coal units (99.8 percent) in PJM have particulate controls, as well as a few natural gas units (4.3 percent) and units with other fuel sources (49.5 percent). Typically, technologies such as electrostatic precipitators (ESP) or fabric filters (baghouses) are used to reduce particulate matter from coal steam units.²²⁰ Fabric filters work by allowing the flue gas to pass through a tightly woven fabric which filters out the particulates. Of the current 55,893.2 MW of coal capacity in PJM, 55,808.2 MW of capacity, 99.8 percent, have some type of particulate emissions control technology. In order to achieve compliance with MATS, most coal steam units in PJM have particulate emission controls in the form of ESPs, but many units have also installed baghouse technology, or a combination of an FGD and SCR. Currently, 108 of the 120 coal steam units have baghouse or FGD technology installed, representing 51,026.9 MW out of the 55,893.2 MW total coal capacity, or 91.3 percent.

219 See EPA, "Mercury and Air Toxics Standards, Cleaner Power Plants," <<https://www.epa.gov/mats/cleaner-power-plants#controls>> (Accessed May 7, 2020).

220 See EPA, "Air Pollution Control Technology Fact Sheet," <<https://www3.epa.gov/ttn/catc/dir1/ff-pulse.pdf>> (Accessed May 7, 2020).

Table 8-25 Particulate emission controls by fuel type (MW): As of March 31, 2021

	Particulate Controlled	No Particulate Controls	Total	Percent Controlled
Coal	55,808.2	85.0	55,893.2	99.8%
Diesel Oil	0.0	5,089.7	5,089.7	0.0%
Natural Gas	2,912.0	64,572.5	67,484.5	4.3%
Other	2,058.5	2,100.2	4,158.7	49.5%
Total	60,778.7	71,847.4	132,626.1	45.8%

Emissions

Figure 8-11 shows the total CO₂ emissions and the CO₂ emissions per MWh within PJM for all CO₂ emitting units, for each quarter from 1999 to the first quarter of 2021. Figure 8-11 also shows the CO₂ emissions per MWh of total generation within PJM for each quarter from the third quarter of 2000 to the first quarter of 2021.^{221 222} For the period from the first quarter of 1999 through the first quarter of 2021, the minimum CO₂ produced per MWh was 0.66 short tons per MWh in the first quarter of 2020, and the maximum was 0.96 short tons per MWh in the first quarter of 2010. Total PJM generation increased from 200,334.8 GWh in the first quarter of 2020 to 209,700.7 GWh in the first quarter of 2021, while CO₂ produced increased from 81.0 million short tons in the first quarter of 2020 to 95.7 million short tons in the first quarter of 2021.²²³

²²¹ Unless otherwise noted, emissions are measured in short tons. A short ton is 2,000 pounds.

²²² Emissions data for the first quarter of 2021 was not yet finalized at the time of this report because generators have 60 days after the end of the quarter to submit their emissions data.

²²³ See the 2020 Quarterly State of the Market Report for PJM Section 3: Energy Market, Table 3-10.

Figure 8-11 CO₂ emissions by quarter (millions of short tons), by PJM units: January 1999 through March 2021^{224 225}

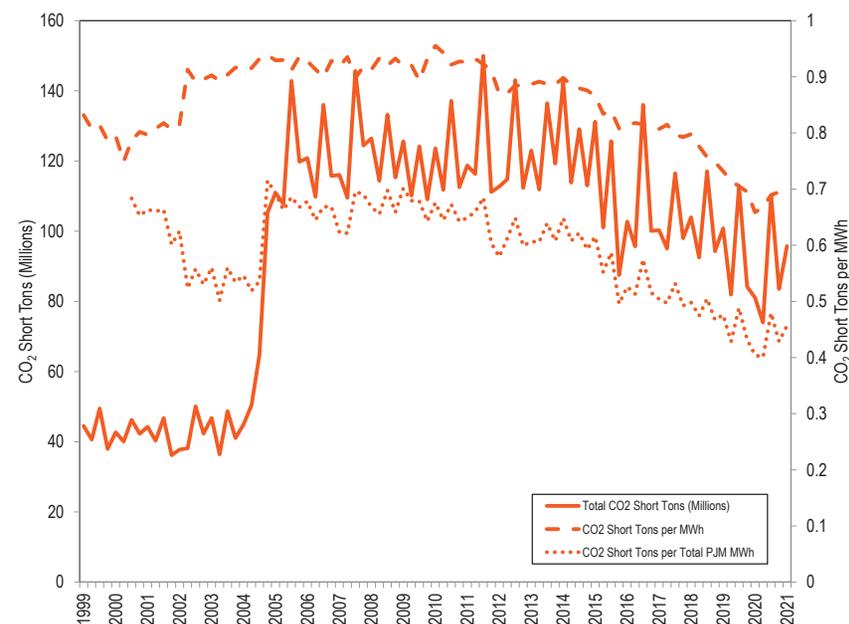


Figure 8-12 shows the total CO₂ emissions on peak and off peak and the CO₂ emissions per MWh for all CO₂ emitting units. Since the first quarter of 1999 the amount of CO₂ produced per MWh during off peak hours was at a minimum of 0.66 short tons per MWh in the first quarter of 2020, and a maximum of 0.97 short tons per MWh in the second quarter of 2010. Since the first quarter of 1999 the amount of CO₂ produced per MWh during on peak hours was at a minimum of 0.66 short tons per MWh in the first quarter of 2020, and a maximum of 0.94 short tons per MWh in the first quarter of 2010.

²²⁴ The emissions are calculated from the continuous emission monitoring system (CEMS) data from generators located within the PJM footprint.

²²⁵ In 2004 and 2005, PJM integrated the American Electric Power (AEP), ComEd, Dayton Power & Light Company (DAY), Dominion, and Duquesne Light Company (DLCO) Control Zones. The large increase in total emissions from 2004 to 2005 was a result of these integrations. In June 2011, PJM integrated the American Transmission Systems, Inc. (ATSI) Control Zone. In January 2012, PJM integrated the Duke Energy Ohio/Kentucky (DEOK) Control Zone. In June 2013, PJM integrated the Eastern Kentucky Power Cooperative (EKPC). In December 2018, PJM integrated the Ohio Valley Electric Corporation (OVEC).

In the first quarter of 2021, CO₂ emissions were 0.71 short tons per MWh for off peak hours and 0.71 for on peak hours.

Figure 8-12 Total CO₂ emissions during on and off peak hours by quarter (millions of short tons), by PJM units: January 1999 through March 2021²²⁶

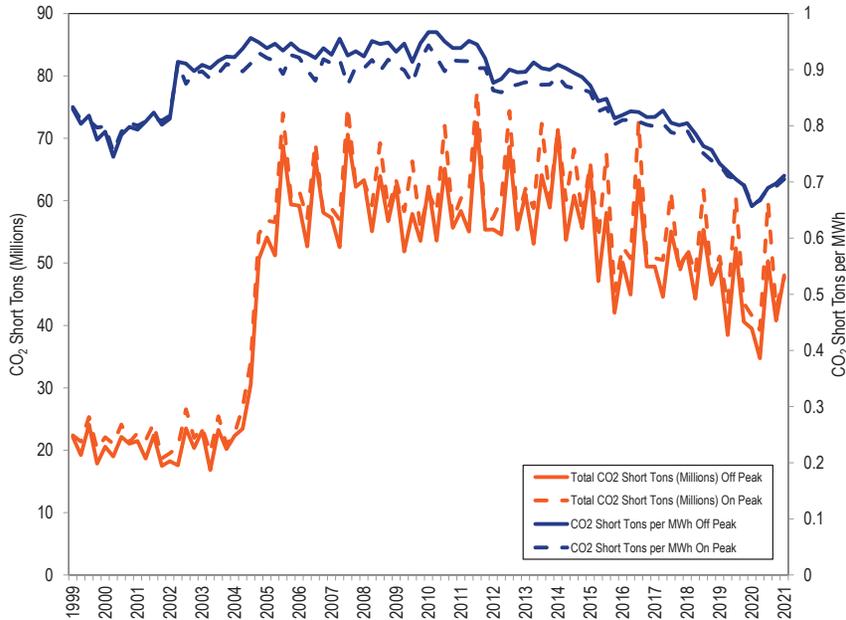
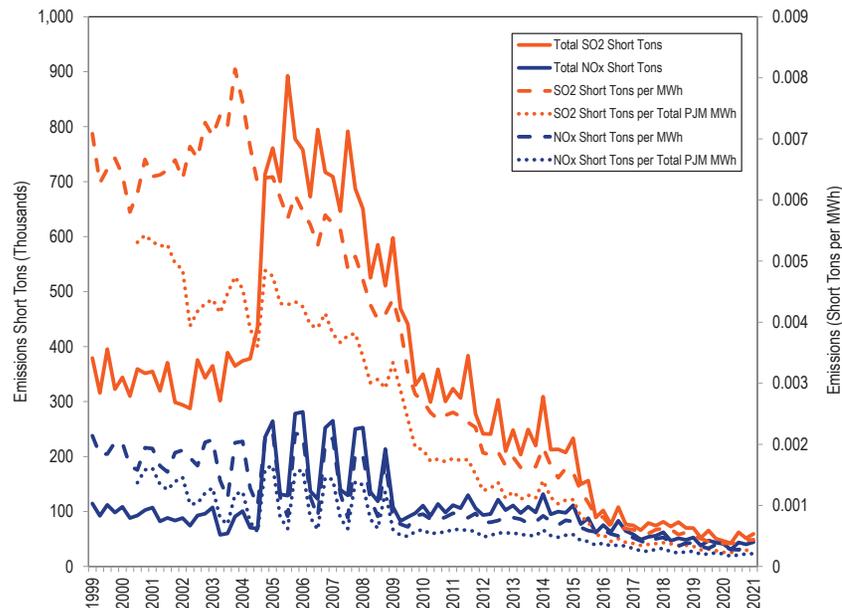


Figure 8-13 shows the total SO₂ and NO_x emissions and the short ton emissions per MWh for all SO₂ and NO_x emitting units, and the SO₂ and NO_x emissions per MWh of total PJM generation. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum SO₂ produced per MWh was 0.000378 short tons per MWh in the first quarter of 2020, and the maximum was 0.008141 short tons per MWh in the fourth quarter of 2003. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum NO_x produced per MWh was at a 0.000274 short tons per MWh in the third quarter of 2020, and the maximum was 0.002215 short tons per MWh in the

²²⁶ The emissions are calculated from the continuous emission monitoring system (CEMS) data from generators located within the PJM footprint.

first quarter of 2005. In the first quarter of 2021, SO₂ emissions were 0.000439 short tons per MWh and NO_x emissions were 0.000328 short tons per MWh. The consistent decline in SO₂ and NO_x emissions starting in 2006 is the result of a decline in the use of coal, an increase in the use of natural gas, and the installation of environmental controls from 2006 to 2021.^{227 228}

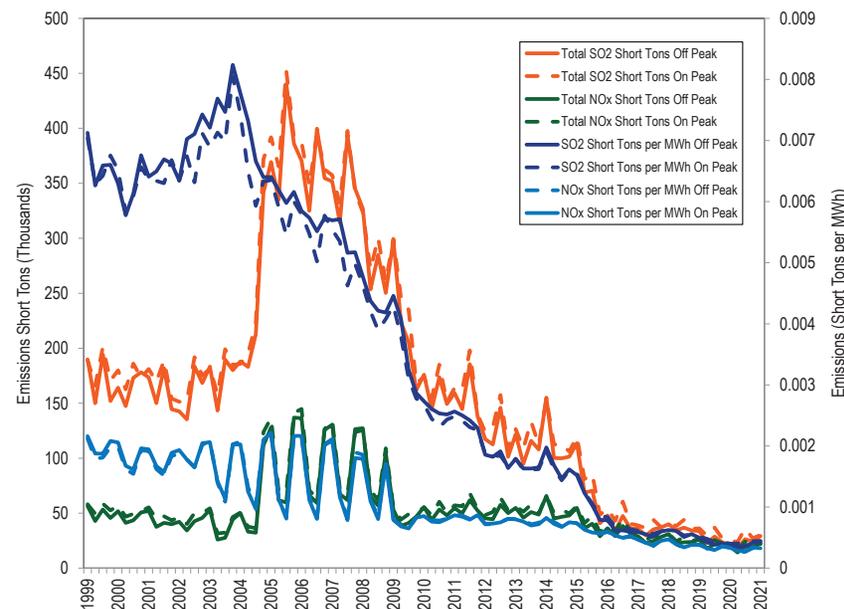
Figure 8-13 SO₂ and NO_x emissions by quarter (thousands of short tons), by PJM units: January 1999 through March 2021²²⁹



²²⁷ See EIA, "Changes in coal sector led to less SO₂ and NO_x emissions from electric power industry," <<https://www.eia.gov/todayinenergy/detail.php?id=37752>> (Accessed October 25, 2019).
²²⁸ See EIA, "Sulfur dioxide emissions from U.S. power plants have fallen faster than coal generation," <<https://www.eia.gov/todayinenergy/detail.php?id=29812>> (Accessed October 25, 2019).
²²⁹ The emissions are calculated from the continuous emission monitoring system (CEMS) data from generators located within the PJM footprint.

Figure 8-14 shows the total on peak hour and off peak hour SO₂ and NO_x emissions and the emissions per MWh from emitting resources for all SO₂ and NO_x emitting units. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum SO₂ produced per MWh during off peak hours was 0.000352 short tons per MWh in the second quarter of 2020, and the maximum was 0.008239 short tons per MWh in the fourth quarter of 2003. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum SO₂ produced per MWh during on peak hours was 0.000402 short tons per MWh in the first quarter of 2020, and the maximum was 0.008048 short tons per MWh in the fourth quarter of 2003. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum NO_x produced per MWh during off peak hours was 0.000267 short tons per MWh in the third quarter of 2020, and the maximum was 0.002215 short tons per MWh in the first quarter of 2005. For the period from the first quarter of 1999 through the first quarter of 2021, the minimum NO_x produced per MWh during on peak hours was 0.000279 short tons per MWh in the third quarter of 2020 and the maximum was 0.002215 short tons per MWh in the first quarter of 2005. In the first quarter of 2021, SO₂ emissions were 0.000432 short tons per MWh and 0.000446 short tons per MWh for off and on peak hours. In the first quarter of 2021, NO_x emissions were 0.000330 short tons per MWh and 0.000326 short tons per MWh for off and on peak hours.

Figure 8-14 SO₂ and NO_x emissions during on and off peak hours by quarter (thousands of short tons), by PJM units: January 1999 through March 2021²³⁰



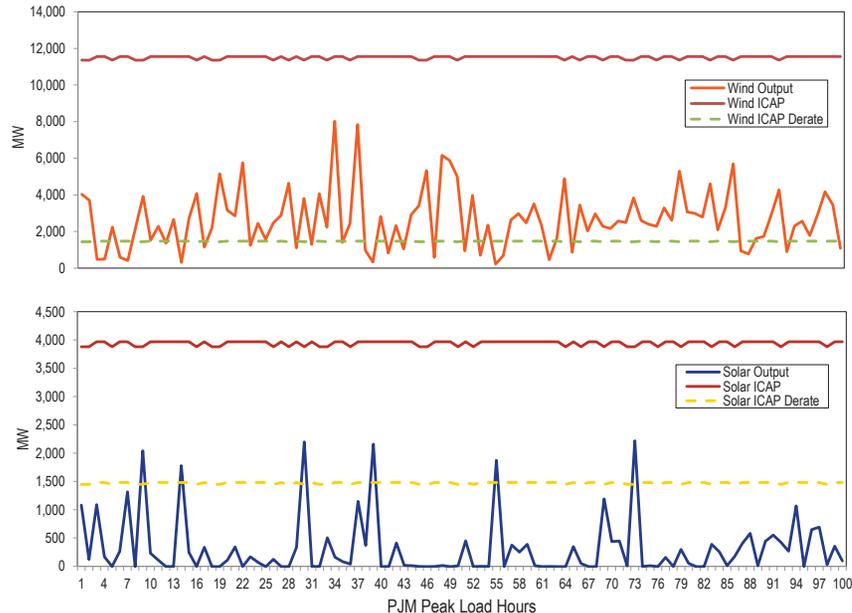
²³⁰ The emissions are calculated from the continuous emission monitoring system (CEMS) data from generators located within the PJM footprint.

Renewable Energy Output

Wind and Solar Peak Hour Output

The capacity of solar and wind resources are derated from the nameplate or installed capacity value to a level intended to reflect that the resources are a substitute for other capacity resources in the PJM Capacity Market. The derating percentages are intended to reflect expected performance during high load hours and are based on actual historical performance. Figure 8-15 shows the wind and solar output during the top 100 load hours in PJM in the first three months of 2021. Of the top 100 load hours in PJM in the first three months of 2021, 97 are PJM defined peak load hours. The hours are in descending order by load. The solid lines are the total ICAP of wind or solar PJM resources. The dashed lines are the total capacity committed for each unit, or the ICAP of wind and solar PJM resources derated to 14.7 and 38.0 percent if the unit does not participate in the capacity market.²³¹ The actual output of the wind and solar resources during the top 100 load hours ranges above and below the derated capacity values. Wind output was above the derated ICAP for 74 hours and below the derated ICAP for 26 hours of the top 100 load hours in the first three months of 2021. The wind capacity factor for the top 100 load hours in first three months of 2021 was 23.1 percent. Wind output was above the derated ICAP for 1,796 hours and below the derated ICAP for 363 hours in the first three months of 2021. The wind capacity factor in the first three months of 2021 was 34.2 percent. Solar output was above the derated ICAP for 6 hours and below the derated ICAP for 94 hours of the top 100 load hours in the first three months of 2021. The solar capacity factor for the top 100 load hours in the first three months of 2021 was 8.1 percent. Solar output was above the derated ICAP for 363 hours and below the derated ICAP for 1,796 hours in the first three months of 2021. The solar capacity factor in the first three months of 2021 was 17.6 percent.

Figure 8-15 Wind and solar output during the top 100 load hours: January through March, 2021



²³¹ PJM used derating factors of 13 and 38 percent until June 1, 2017. The current derating factors are 38.0 percent, 42 percent or 60.0 percent depending on installation type. PJM, Class Average Capacity Factors, <<https://www.pjm.com/-/media/planning/res-adeq/class-average-wind-capacity-factors.ashx?la=en>> (Accessed May 6, 2021).

Wind Units

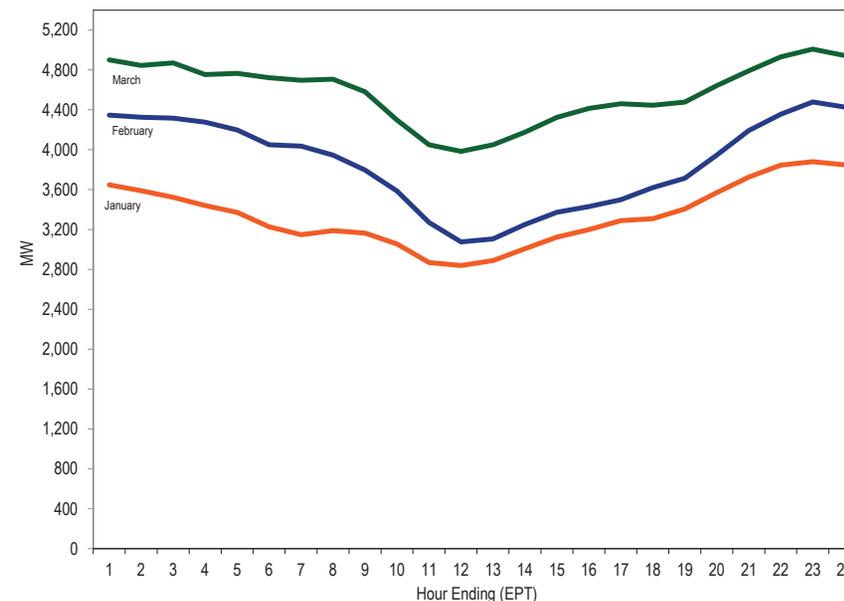
Table 8-26 shows the capacity factors of wind units in PJM. In the first three months of 2021, the capacity factor of wind units in PJM was 34.2 percent. Wind units that were capacity resources had a capacity factor of 35.9 percent and an installed capacity of 9,069 MW. Wind units that were energy only had a capacity factor of 28.0 percent and an installed capacity of 2,498 MW. Wind capacity in RPM is derated to 14.7 or 17.6 percent of nameplate capacity for the capacity market, based on the wind farm terrain, and energy only resources are not included in the capacity market.²³²

Table 8-26 Capacity factor of wind units: January through March, 2021²³³

Type of Resource	Capacity Factor	Installed Capacity (MW)
Energy-Only Resource	28.0%	2,498
Capacity Resource	35.9%	9,069
All Units	34.2%	11,567

Figure 8-16 shows the average hourly real-time generation of wind units in PJM, by month for the first three months of 2021. The hour with the highest average output in the first three months of 2021, 5,008.3 MW, occurred in April, and the hour with the lowest average output, 2,839.0 MW, occurred in January. Wind output in PJM is generally higher during off peak hours and lower during on peak hours.

Figure 8-16 Average hourly real-time generation of wind units: January through March, 2021



²³² PJM. Class Average Capacity Factors, <<https://www.pjm.com/-/media/planning/res-adeq/class-average-wind-capacity-factors.ashx?la=en>> (Accessed October 17, 2019).

²³³ Capacity factor is calculated based on online date of the resource.

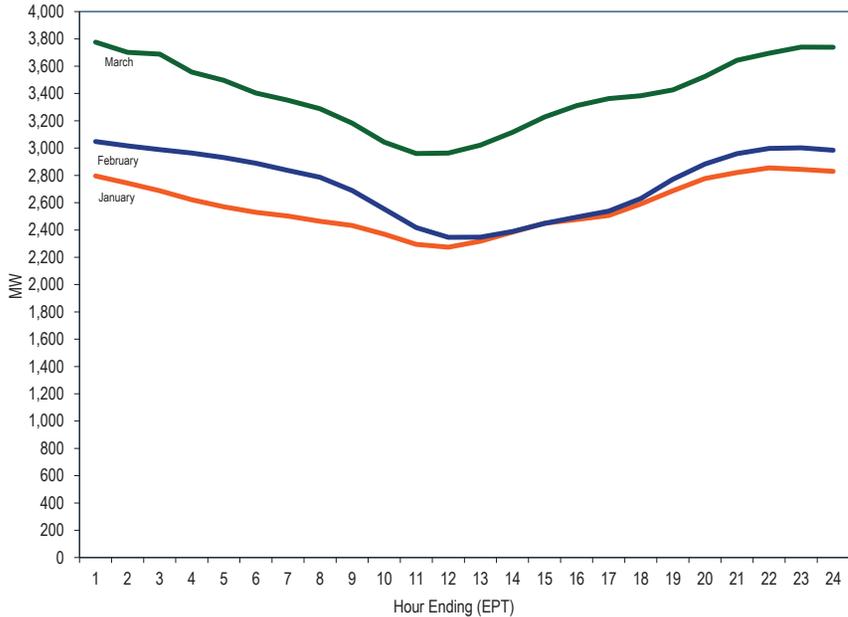
Table 8-27 shows the generation and capacity factor of wind units by month for 2020 and the first three months of 2021.

Table 8-27 Capacity factor of wind units in PJM by month: 2020 and January through March, 2021

Month	2020		2021	
	Generation (MWh)	Capacity Factor	Generation (MWh)	Capacity Factor
January	2,588,895.7	33.3%	2,486,383.6	29.4%
February	2,564,467.7	35.1%	2,595,187.7	33.4%
March	2,739,005.2	34.8%	3,399,080.7	39.6%
April	2,679,800.9	35.0%		
May	2,261,803.9	28.6%		
June	1,662,419.6	21.7%		
July	959,774.9	12.1%		
August	925,896.4	11.7%		
September	1,604,108.9	20.8%		
October	2,322,150.1	29.0%		
November	3,271,536.3	41.1%		
December	2,851,142.4	33.8%		
Annual	26,431,001.9	28.1%	8,480,652.0	34.2%

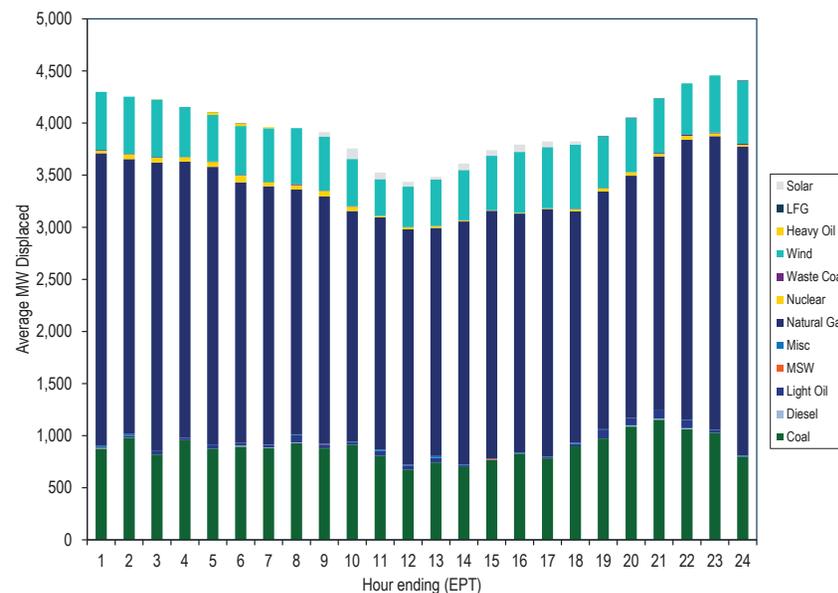
Wind units that are capacity resources are required, like all capacity resources except demand resources, to offer the energy associated with their cleared capacity in the day-ahead energy market and in the real-time energy market. Figure 8-17 shows the average hourly day-ahead generation offers of wind units in PJM, by month.

Figure 8-17 Average hourly day-ahead generation of wind units: January through March, 2021



Output from wind turbines displaces output from other generation types because, in general, wind turbines generate power when the wind is blowing, regardless of the price. This displacement affects the output of marginal units in PJM. The magnitude and type of effect on marginal unit output depends on the level of wind turbine output, its location, time and duration. One measure of this displacement is based on the mix of marginal units when wind is producing output.²³⁴ Figure 8-18 and Table 8-28 show the hourly average proportion of marginal units by fuel type mapped to the hourly average MW of real-time wind generation in the first three months of 2021. This is not an exact measure of displacement because it is not based on a redispatch of the system without wind resources. In the first three months of 2021, the dispatch instruction for marginal wind resources was to reduce output for 65.1 percent of the unit intervals. When wind appears as the displaced fuel at times when wind resources were on the margin this means that there was no displacement for those hours, if the dispatch instruction was to lower the generation. The level of wind displaced by wind is thus overstated.

Figure 8-18 Marginal fuel at time of wind generation: January through March, 2021



²³⁴ The measure is based on the principle that any incremental change in the wind output is balanced by the change in the output of marginal generators, while holding everything else equal.

Table 8-28 Marginal fuel MW at time of wind generation: January through March, 2021

Hour	Coal		Light			Natural		Waste		Heavy			0	Total
	Coal	Diesel	Oil	MSW	Misc	Gas	Nuclear	Coal	Wind	Oil	LFG	Solar		
0	873.6	2.0	9.4	2.3	16.8	2,805.9	23.5	8.9	556.7	0.0	0.0	0.0	0.0	4,299.1
1	980.0	1.0	17.4	0.0	17.1	2,638.7	45.7	4.3	549.1	0.0	0.0	0.0	0.0	4,253.3
2	818.5	0.0	38.4	0.0	0.0	2,764.2	46.5	7.4	551.2	2.9	0.0	0.0	0.0	4,229.1
3	956.2	0.0	23.3	0.0	0.0	2,650.1	44.0	2.1	479.3	0.0	0.0	0.0	0.0	4,155.0
4	875.0	0.0	39.6	0.0	1.5	2,663.6	47.3	4.2	449.0	26.1	1.3	0.0	0.0	4,107.5
5	895.2	7.8	29.6	0.0	0.0	2,498.8	65.6	5.3	470.0	26.0	2.6	0.0	0.0	4,000.9
6	878.4	6.0	27.9	0.0	2.2	2,478.2	37.3	3.8	516.4	10.0	0.0	0.0	0.0	3,960.3
7	925.8	7.8	74.8	0.0	4.7	2,349.5	40.8	11.6	536.4	0.0	0.0	0.0	0.0	3,951.4
8	877.2	2.3	35.3	3.0	3.1	2,374.4	52.7	3.8	520.2	0.0	0.0	40.7	0.0	3,912.6
9	912.7	0.0	22.3	0.0	5.0	2,215.9	41.0	6.1	453.1	0.0	0.0	100.9	0.0	3,757.1
10	805.0	0.0	47.1	0.0	14.1	2,229.8	12.4	1.0	351.5	0.0	1.5	63.2	0.0	3,525.5
11	674.8	0.0	38.2	0.0	7.2	2,260.2	18.3	3.8	388.1	0.0	0.0	44.7	0.0	3,435.5
12	742.6	0.0	41.8	1.4	17.6	2,190.2	17.4	1.4	444.3	0.0	2.4	23.7	0.0	3,482.7
13	697.3	0.0	17.4	0.0	7.9	2,332.4	8.5	5.4	481.3	0.0	0.0	61.7	0.0	3,611.9
14	765.8	0.0	0.0	9.5	3.1	2,380.0	5.4	0.2	521.6	0.0	0.0	54.8	0.0	3,740.5
15	826.6	0.0	0.2	1.2	8.7	2,294.5	7.3	0.0	584.9	0.0	0.0	70.9	0.0	3,794.3
16	780.9	0.0	10.0	0.0	5.8	2,379.4	6.9	0.0	584.9	0.0	1.2	55.6	0.0	3,824.6
17	897.7	0.0	23.6	0.0	9.4	2,221.6	19.7	4.6	616.9	0.0	0.0	30.9	0.0	3,824.4
18	972.2	0.0	86.2	0.0	2.6	2,281.7	29.3	3.9	497.2	0.0	3.7	2.6	0.0	3,879.3
19	1,086.9	12.2	70.7	0.0	0.0	2,325.5	32.2	2.7	517.2	0.0	4.5	0.0	0.0	4,051.7
20	1,152.8	11.0	78.4	0.0	0.0	2,437.4	25.4	8.2	522.5	0.0	4.0	0.0	0.0	4,239.7
21	1,062.0	8.8	81.0	0.0	0.8	2,688.9	35.5	10.1	494.0	0.0	0.0	0.0	0.0	4,381.2
22	1,025.3	0.0	25.3	0.0	3.0	2,821.0	26.4	8.8	547.3	0.0	0.0	0.0	0.0	4,457.2
23	797.2	0.0	6.9	0.0	4.2	2,967.0	16.4	9.2	601.9	0.0	5.9	0.0	0.0	4,408.6
Average	886.7	2.4	35.2	0.7	5.6	2,468.7	29.4	4.9	509.8	2.7	1.1	22.9	0.0	3,970.1

Solar Units

Solar units in PJM may be in front of or behind the meter. The data reported include all PJM solar units that are in front of the meter. As shown in Table 8-17, there are 4,043.2 MW capacity of solar registered in GATS that are PJM units. As shown in Table 8-18, there are 7,488.6 MW capacity of solar registered in GATS that are not PJM units. Some behind the meter generation exists in clusters, such as community solar farms, and serves dedicated customers. Such customers may or may not be located at the same node on the transmission system as the solar farm. When behind the meter generation and its associated load are at separate nodes, loads should pay for the appropriate level of transmission service, and should not be permitted to avoid their proper financial responsibility through badly designed rules, such as rules for netting. The MMU recommends that load and generation located at separate nodes be treated as separate resources.

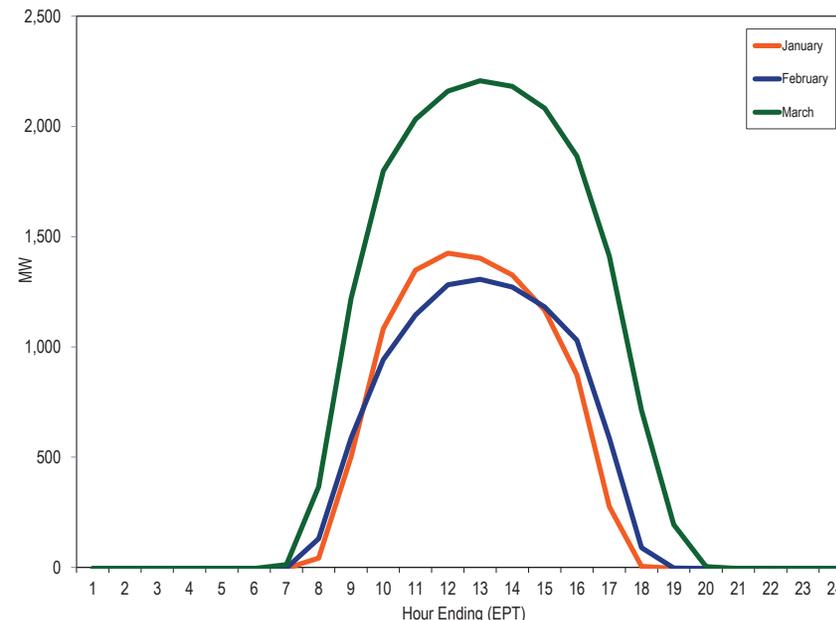
Table 8-29 shows the capacity factor of solar units in PJM. The capacity factor of solar units in PJM was 17.6 percent in the first three months of 2021. Solar units that were capacity resources had a capacity factor of 17.9 percent and an installed capacity of 1,967 MW. Solar units that were energy only had a capacity factor of 17.4 percent and an installed capacity of 2,170 MW. Solar capacity in RPM is derated to 38.0, 42.0 or 60.0 percent of nameplate capacity for the capacity market, based on the installation type, and energy only resources are not included in the capacity market.²³⁵

Table 8-29 Capacity factor of solar units: January through March, 2021

Type of Resource	Capacity Factor	Installed Capacity (MW)
Energy-Only Resource	17.4%	2,170
Capacity Resource	17.9%	1,967
All Units	17.6%	4,137

Figure 8-19 shows the average hourly real-time generation of solar units in PJM, by month. The hour with the highest peak average output in the first three months of 2021, 2,207.2 MW, occurred in March, and the hour with the lowest peak average output, 1,307.0 MW, occurred in February. Solar output in PJM is generally higher during peak hours and lower during off peak hours.

Figure 8-19 Average hourly real-time generation of solar units: January through March, 2021



²³⁵ PJM. Class Average Capacity Factors, <<https://www.pjm.com/-/media/planning/res-adeq/class-average-wind-capacity-factors.ashx?la=en>> [Accessed October 17, 2019].

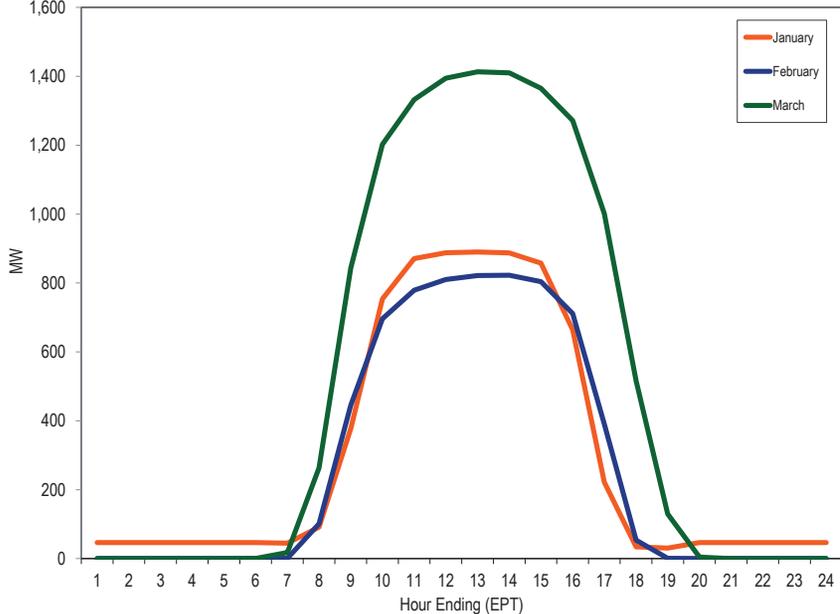
Table 8-30 shows the generation and capacity factor of solar units by month for 2020 and the first three months of 2021.

Table 8-30 Capacity factor of solar units by month: 2020 and January through March, 2021

Month	2020		2021	
	Generation (MWh)	Capacity Factor	Generation (MWh)	Capacity Factor
January	164,119.3	14.4%	181,391.8	14.4%
February	182,571.5	17.0%	152,855.9	13.4%
March	255,439.6	21.7%	324,152.3	25.1%
April	322,403.6	27.8%		
May	352,414.5	28.9%		
June	367,919.0	30.8%		
July	393,319.8	31.3%		
August	304,074.3	24.3%		
September	264,082.0	21.6%		
October	237,929.2	18.8%		
November	210,667.4	17.3%		
December	158,795.4	12.8%		
Annual	3,213,735.4	22.3%	658,400.0	17.9%

Solar units that are capacity resources are required, like all capacity resources except demand resources, to offer the energy associated with their cleared capacity in the day-ahead energy market and in the real-time energy market. Figure 8-20 shows the average hourly day-ahead generation offers of solar units in PJM, by month.²³⁶

Figure 8-20 Average hourly day-ahead generation of solar units: January through March, 2021



²³⁶ The average day-ahead generation of solar units in PJM is greater than 0 for hours when the sun is down due to some solar units being paired with landfill units.

Interchange Transactions

PJM market participants import energy from, and export energy to, external regions continuously. The transactions involved may fulfill long-term or short-term bilateral contracts or respond to price differentials. The external regions include both market and nonmarket balancing authorities.

Overview

Interchange Transaction Activity

- **Aggregate Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, PJM was a monthly net exporter of energy in the real-time energy market in all months.¹ In the first three months of 2021, the real-time net interchange was -9,240.5 GWh. The real-time net interchange in the first three months of 2020 was -7,557.3 GWh.
- **Aggregate Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, PJM was a monthly net exporter of energy in the day-ahead energy market in all months. In the first three months of 2021, the total day-ahead net interchange was -7,268.0 GWh. The day-ahead net interchange in the first three months of 2020 was -1,989.6 GWh.
- **Aggregate Imports and Exports in the Day-Ahead and the Real-Time Energy Market.** In the first three months of 2021, gross imports in the day-ahead energy market were 113.6 percent of gross imports in the real-time energy market (525.0 percent in the first three months of 2020). In the first three months of 2021, gross exports in the day-ahead energy market were 85.6 percent of the gross exports in the real-time energy market (140.1 percent in the first three months of 2020).
- **Interface Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, there were net scheduled exports at 16 of PJM's 19 interfaces in the real-time energy market.
- **Interface Pricing Point Imports and Exports in the Real-Time Energy Market.** In the first three months of 2021, there were net scheduled exports at six

of PJM's nine interface pricing points eligible for real-time transactions in the real-time energy market.²

- **Interface Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, there were net scheduled exports at 12 of PJM's 19 interfaces in the day-ahead energy market.
- **Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, there were net scheduled exports at six of PJM's nine interface pricing points eligible for day-ahead transactions in the day-ahead energy market.³
- **Up To Congestion Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In the first three months of 2021, up to congestion transactions were net exports at six of PJM's nine interface pricing points eligible for day-ahead transactions in the day-ahead energy market.⁴
- **Inadvertent Interchange.** In the first three months of 2021, net scheduled interchange was 9,240.5 GWh and net actual interchange was -9,240.8 GWh, a difference of 0.3 GWh. In the first three months of 2020, the difference was 38.1 GWh. This difference is inadvertent interchange.
- **Loop Flows.** In the first three months of 2021, the Northern Indiana Public Service (NIPS) Interface had the largest loop flows of any interface with -339 GWh of net scheduled interchange and -3,097 GWh of net actual interchange, a difference of 2,758 GWh. In the first three months of 2021, the SouthIMP interface pricing point had the largest loop flows of any interface pricing point with 1,121 GWh of net scheduled interchange and 6,200 GWh of net actual interchange, a difference of 5,079 GWh.

¹ Calculated values shown in Section 9, "Interchange Transactions," are based on unrounded, underlying data and may differ from calculations based on the rounded values in the tables.

² The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the real-time energy market and the day-ahead energy market and has been removed from the figures and tables. The removal of this pricing point reduces the number of real-time and day-ahead interface pricing points to nine.

³ Ibid.

⁴ Ibid.

Interactions with Bordering Areas

PJM Interface Pricing with Organized Markets

- **PJM and MISO Interface Prices.** In the first three months of 2021, the direction of the hourly flow was consistent with the real-time hourly price differences between the PJM/MISO Interface and the MISO/PJM Interface in 60.2 percent of the hours.
- **PJM and New York ISO Interface Prices.** In the first three months of 2021, the direction of the hourly flow was consistent with the real-time hourly price differences between the PJM/NYIS Interface and the NYISO/PJM proxy bus in 52.4 percent of the hours.
- **Neptune Underwater Transmission Line to Long Island, New York.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Neptune Interface and the NYISO Neptune bus in 53.8 percent of the hours.
- **Linden Variable Frequency Transformer (VFT) Facility.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Linden Interface and the NYISO Linden bus in 75.8 percent of the hours.
- **Hudson DC Line.** In the first three months of 2021, the hourly flow (PJM to NYISO) was consistent with the real-time hourly price differences between the PJM Hudson Interface and the NYISO Hudson bus in 62.3 percent of the hours.

Interchange Transaction Issues

- **PJM Transmission Loading Relief Procedures (TLRs).** PJM issued two TLRs of level 3a or higher in the first three months of 2021, compared to zero such TLRs issued in the first three months of 2020.
- **Up To Congestion.** The average number of up to congestion bids submitted in the day-ahead energy market decreased by 45.6 percent, from 49,461 bids per day in the first three months of 2020 to 26,918 bids per day in the first three months of 2021. The average cleared volume of up to congestion bids submitted in the day-ahead energy market decreased by

54.8 percent, from 464,019 MWh per day in the first three months of 2020, to 209,921 MWh per day in the first three months of 2021.

Recommendations

- The MMU recommends that PJM implement rules to prevent sham scheduling. The MMU recommends that PJM apply after the fact market settlement adjustments to identified sham scheduling segments to ensure that market participants cannot benefit from sham scheduling. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would prohibit market participants from breaking transactions into smaller segments to defeat the interface pricing rule by concealing the true source or sink of the transaction. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM implement a validation method for submitted transactions that would require market participants to submit transactions on paths that reflect the expected actual power flow in order to reduce unscheduled loop flows. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM end the practice of maintaining outdated definitions of interface pricing points, eliminate the NIPSCO, Southeast and Southwest interface pricing points from the day-ahead and real-time energy markets and, with VACAR, assign the transactions created under the reserve sharing agreement to the SouthIMP/EXP pricing point. (Priority: High. First reported 2013. Status: Partially adopted, Q2 2020.)⁵
- The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the locational price impact of flows between the DC tie line point of connection with the Eastern Interconnection and PJM. (Priority: High. First reported Q1, 2020. Status: Not adopted.)

⁵ The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the day-ahead or real-time energy markets. Effective June 1, 2020, PJM retired the NIPSCO interface pricing point.

- The MMU recommends changing the assignment of the Saskatchewan Power Company and Manitoba Hydro balancing authorities from the Northwest interface pricing point to the MISO interface pricing point and eliminating the Northwest interface pricing point from the day-ahead and real-time energy markets. (Priority: High. First reported Q1, 2020. Status: Adopted Q4, 2020.)
- The MMU recommends that PJM eliminate the IMO interface pricing point, and assign the transactions that originate or sink in the IESO balancing authority to the MISO interface pricing point. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM eliminate the NCMPAIMP and NCMPAEXP interface pricing points. It is not appropriate to have special pricing agreements between PJM and any external entity. The same market pricing should apply to all transactions. (Priority: High. First reported Q2, 2020. Status: Adopted Q4, 2020.)
- The MMU recommends that PJM monitor, and adjust as necessary, the weights applied to the components of the interfaces to ensure that the interface prices reflect ongoing changes in system conditions. The MMU also recommends that PJM review the mappings of external balancing authorities to individual interface pricing points to reflect changes to the impact of the external power source on PJM tie lines as a result of system topology changes. The MMU recommends that this review occur at least annually. (Priority: Low. First reported 2009. Status: Not adopted.)
- The MMU recommends that, in order to permit a complete analysis of loop flow, FERC and NERC ensure that the identified data are made available to market monitors as well as other industry entities determined appropriate by FERC. (Priority: Medium. First reported 2003. Status: Not adopted.)
- The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that would remove the need for market participants to schedule physical transactions across seams. Such a solution would include an optimized, but limited, joint dispatch approach that uses supply curves and treats seams between balancing authorities as constraints, similar to other constraints within an LMP market. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM permit unlimited spot market imports as well as unlimited nonfirm point to point willing to pay congestion imports and exports at all PJM interfaces in order to improve the efficiency of the market. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that the emergency interchange cap be replaced with a market based solution. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the submission deadline for real-time dispatchable transactions be modified from 1800 on the day prior, to three hours prior to the requested start time, and that the minimum duration be modified from one hour to 15 minutes. These changes would give PJM a more flexible product that could be used to meet load in the most economic manner. (Priority: Medium. First reported 2014. Status: Partially adopted, 2015.)
- The MMU recommends modifications to the FFE calculation to ensure that FFE calculations reflect the current capability of the transmission system as it evolves. The MMU recommends that the Commission set a deadline for PJM and MISO to resolve the FFE freeze date and related issues. (Priority: Medium. First reported 2019. Status: Not adopted.)

Conclusion

Transactions between PJM and multiple balancing authorities in the Eastern Interconnection are part of a single energy market. While some of these balancing authorities are termed market areas and some are termed nonmarket areas, all electricity transactions are part of a single energy market. Nonetheless, there are significant differences between market and nonmarket areas. Market areas, like PJM, include essential features of an energy market including locational marginal pricing, financial congestion offsets (FTRs and ARR in PJM) and transparent, least cost, security constrained economic dispatch for all available generation. Nonmarket areas do not include these features.

Pricing in the market areas is transparent and pricing in the nonmarket areas is not transparent.

The MMU's recommendations related to transactions with external balancing authorities all share the goal of improving the economic efficiency of interchange transactions. The standard of comparison is an LMP market. In an LMP market, redispatch based on LMP and competitive generator offers results in an efficient dispatch and efficient prices. The goal of designing interface transaction rules should be to match the outcomes that would exist in an LMP market across the interfaces.

It is not appropriate to have special pricing agreements between PJM and any external entity. The same market pricing should apply to all transactions. External entities wishing to receive the benefits of the PJM LMP market should join PJM.

In 2020, PJM terminated a number of interface pricing points, consistent with longstanding MMU recommendations. Following the termination of the Northwest pricing point on October 1, 2020, PJM failed to correctly map the pricing points to transactions that had been mapped to the Northwest pricing point to pricing points that are consistent with electrical impacts on the PJM system. The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the electrical impact of flows between the DC tie line point of connection with the Eastern Interconnection and PJM. The MMU continues to recommend the termination of the Southeast interface pricing point and the Ontario interface pricing point. The Southeast pricing point is inappropriately used to support a special agreement and the Ontario interface pricing point is noncontiguous to the PJM footprint that creates opportunities for market participants to engage in sham scheduling activities.

Interchange Transaction Activity

Charges and Credits Applied to Interchange Transactions

Interchange transactions are subject to various charges and credits. These charges and credits are dependent on whether the interchange transaction is submitted in the real-time or day-ahead energy market, the type of transaction, the transmission service used and whether the transaction is an import, export or wheel. Table 9-1 shows the billing line items that represent the charges and credits applied to real-time and day-ahead interchange transactions.⁶

⁶ For an explanation and current rate for each billing line item, see "Quick Reference Guide to Market Settlements By Type of Business" (November 1, 2020) <<https://pjm.com/markets-and-operations/-/media/0FE1D93C5E61457185BB7652F2F18668.ashx>>.

Table 9-1 Charges and credits applied to interchange transactions

Billing Item	Real-Time Transactions				Day-Ahead Transactions				Up to Congestion
	Import (Firm or Non Firm)	Import (Spot in)	Export	Wheel	Import (Firm or Non Firm)	Import (Spot in)	Export	Wheel	
Firm or Non-Firm Point-to-Point Transmission Service	X		X ¹	X ¹	X		X ¹	X ¹	
Spot Import Service		X ²				X ²			
Day-ahead Spot Market Energy					X	X	X		
Balancing Spot Market Energy	X	X	X						
Day-ahead Transmission Congestion					X	X	X	X	X
Balancing Transmission Congestion	X	X	X	X					X
Day-ahead Transmission Losses					X	X	X	X	X
Balancing Transmission Losses	X	X	X	X					X
PJM Scheduling, System Control and Dispatch Service - Control Area Administration	X		X	X	X		X	X	
PJM Scheduling, System Control and Dispatch Service - Market Support	X	X	X		X	X	X		X
PJM Scheduling, System Control and Dispatch Service - Advanced Second Control Center	X	X	X	X	X	X	X	X	X
PJM Scheduling, System Control and Dispatch Service - Market Support Offset	X	X	X		X	X	X		X
PJM Settlement, Inc.	X	X	X		X	X	X		X
Market Monitoring Unit (MMU) Funding	X	X	X		X	X	X		X
FERC Annual Recovery	X		X	X	X		X	X	
Organization of PJM States, Inc. (OPSI) Funding	X		X	X	X		X	X	
Synchronous Condensing			X				X		
Transmission Owner Scheduling, System Control and Dispatch Service	X		X	X	X		X	X	
Reactive Supply and Voltage Control from Generation and Other Sources Service	X		X	X	X		X	X	
Day-ahead Operating Reserve					X	X	X		X
Balancing Operating Reserve	X	X	X						X
Black Start Service	X		X	X	X		X	X	
Marginal Loss Surplus Allocation (for those paying for transmission service only)			X				X		

¹ No charge if Point of Delivery is MISO

² No charge for spot in transmission

Aggregate Imports and Exports

Table 9-2 shows the real-time and day-ahead scheduled interchange totals for the first three months of 2020 and 2021. In the first three months of 2021, gross imports in the day-ahead energy market were 113.6 percent of gross imports in the real-time energy market (525.0 percent in the first three months of 2020). In the first three months of 2021, gross exports in the day-ahead energy market were 85.6 percent of gross exports in the real-time energy market (140.1 percent in the first three months of 2020).

Table 9-2 Real-time and day-ahead scheduled interchange volumes (GWh): January through March, 2020 and 2021

Category	Jan-Mar 2020	Jan-Mar 2021	Percent Change
Real-Time Gross Imports	2,233.7	2,308.3	3.3%
Real-Time Gross Exports	9,791.0	11,548.8	18.0%
Real-Time Net Interchange	(7,557.3)	(9,240.5)	22.3%
Day-Ahead Gross Imports	11,727.0	2,622.2	(77.6%)
Day-Ahead Gross Exports	13,716.6	9,890.2	(27.9%)
Day-Ahead Net Interchange	(1,989.6)	(7,268.0)	265.3%
Monthly Average Real-Time Gross Exports	3,263.7	3,849.6	18.0%
Monthly Average Real-Time Gross Imports	744.6	769.4	3.3%
Monthly Average Day-Ahead Gross Exports	4,572.2	3,296.7	(27.9%)
Monthly Average Day-Ahead Gross Imports	3,909.0	874.1	(77.6%)

In the first three months of 2021, PJM was a monthly net exporter of energy in the real-time energy market in all months. In the first three months of 2021, PJM was a monthly net exporter of energy in the day-ahead energy market in all months (Figure 9-1).⁷

Figure 9-1 shows real-time and day-ahead import, export and net interchange volumes. The day-ahead totals include fixed, dispatchable and up to congestion transaction totals. The net interchange of up to congestion transactions are represented by the orange line.

Transactions in the day-ahead energy market create financial obligations to deliver in the real-time energy market and to pay operating reserve charges based on differences between the transaction MWh in the day-ahead and

⁷ Calculated values shown in Section 9, "Interchange Transactions," are based on unrounded, underlying data and may differ from calculations based on the rounded values in the tables.

real-time energy markets times the applicable operating reserve rates. Up to congestion transactions also create financial obligations to deliver in real time, but did not pay operating reserve charges until November 1, 2020. In 2020, the total day-ahead gross imports and exports were higher than the real-time gross imports and exports, the day-ahead imports net of up to congestion transactions were less than the real-time imports, and the day-ahead exports net of up to congestion transactions were less than real-time exports.

Figure 9-1 Scheduled imports and exports: January through March, 2021

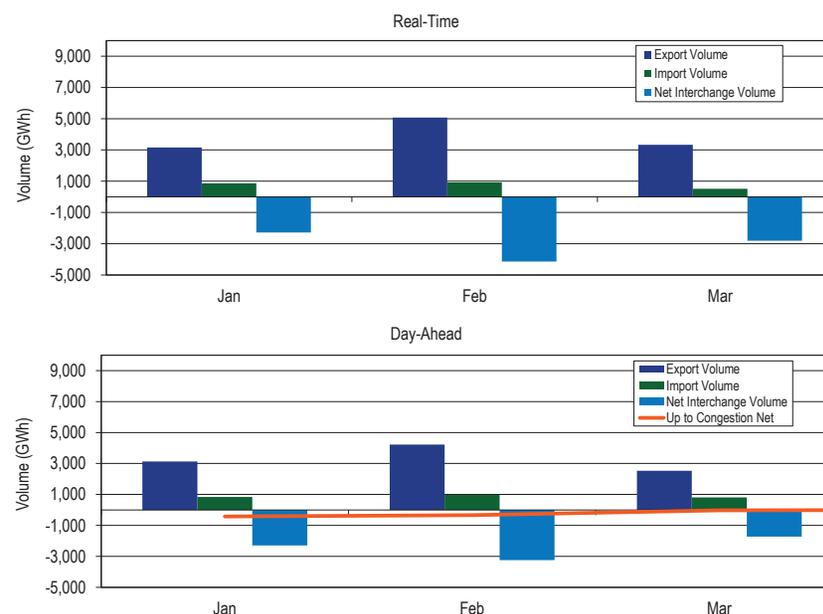


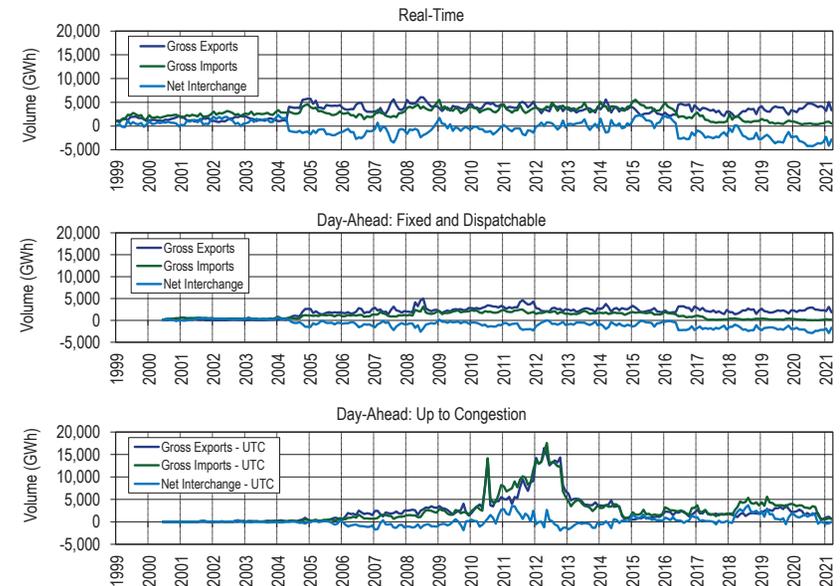
Figure 9-2 shows the real-time and day-ahead import and export volume for PJM from January 1999 through March 2021. PJM shifted from a consistent net importer of energy to relatively consistent net exporter of energy in 2004 in both the real-time and day-ahead energy markets, coincident with the expansion of the PJM footprint that included the integrations of Commonwealth Edison, American Electric Power and Dayton Power and Light into PJM. The net direction of power flows is generally a function of price differences net of

transactions costs. Since the modification of the up to congestion product in September 2010, up to congestion transactions have played a significant role in power flows between PJM and external balancing authorities in the day-ahead energy market. On November 1, 2012, PJM eliminated the requirement that every up to congestion transaction include an interface pricing point as either the source or sink. As a result, the volume of import and export up to congestion transactions decreased, and the volume of internal up to congestion transactions increased. While the gross import and export volumes in the day-ahead energy market decreased, PJM has remained primarily a net exporter in the day-ahead energy market. The requirement for external capacity resources to be pseudo tied into PJM has affected the real-time and day-ahead import volumes. Prior to June 1, 2016, these units were dynamically scheduled into PJM or were block scheduled into PJM and were part of scheduled interchange as imports. Pseudo tied units are treated as internal generation and therefore do not affect interchange volume. The reduction of the import volume based on the switch to pseudo tie status contributed to PJM remaining a net exporter in the real-time and day-ahead energy markets. On February 20, 2018, FERC issued an order limiting the eligible bidding points for up to congestion transactions to hubs, residual metered load and interfaces.⁸ As a result, the volume of import and export up to congestion transactions increased, contributing to PJM becoming a net importer in the day-ahead energy market starting in March 2018. On July 16, 2020, FERC issued an order directing PJM to revise uplift allocation rules to allocate uplift to up to congestion transactions.⁹ The Order requires PJM to treat an up to congestion transaction, for uplift allocation purposes, as if the up to congestion transaction were equivalent to a DEC at its sink point. On November 1, 2020, PJM began allocating uplift to up to congestion transactions. As a result, the volume of up to congestion transactions decreased. In February 2021, winter storms caused significant generation outages in Texas and resulted in power outages across the Electric Reliability Council of Texas (ERCOT) region. These outages occurred between February 10, 2021, and February 27, 2021. During this time, ERCOT imported generation from neighboring regions. While PJM did not have any scheduled exports directly to the ERCOT region, PJM exports during this time increased from an average hourly export of 4,772 MW per hour

⁸ 162 FERC ¶ 61,139.
⁹ 172 FERC ¶ 61,046 (2020).

between February 1 and February 10, 2021, to 7,003 MW per hour between February 10 and February 27, 2021.

Figure 9-2 Scheduled import and export transaction volume history: January 1, 1999 through March 31, 2021



Real-Time Interface Imports and Exports

In the real-time energy market, scheduled imports and exports are defined by the scheduled path, which is the transmission path a market participant selects from the original source to the final sink. These scheduled flows are measured at each of PJM's interfaces with neighboring balancing authorities. Table 9-18 includes a list of active interfaces in the first three months of 2021. Figure 9-3 shows the approximate geographic location of the interfaces. In the first three months of 2021, PJM had 19 interfaces with neighboring balancing authorities. While the Linden (LIND) Interface, the Hudson (HUDS) Interface and the Neptune (NEPT) Interface are separate from the NYIS Interface,

all four are interfaces between PJM and the NYISO. There are 10 separate interfaces that make up the MISO Interface between PJM and MISO. Table 9-3 through Table 9-5 show the real-time energy market scheduled interchange totals at the individual NYISO interfaces, as well as with the NYISO as a whole. Similarly, the scheduled interchange totals at the individual interfaces between PJM and MISO are shown, as well as with MISO as a whole. Net scheduled interchange in the real-time energy market is shown by interface for the first three months of 2021 in Table 9-3, while gross scheduled imports and exports are shown in Table 9-4 and Table 9-5.

In the real-time energy market, in the first three months of 2021, there were net scheduled exports at 16 of PJM's 19 interfaces. The top three net exporting interfaces in the real-time energy market accounted for 54.2 percent of the total net scheduled exports: PJM/Cinergy (CIN) with 24.9 percent, PJM/NYIS with 16.1 percent and PJM/MidAmerican Energy Company (MEC) with 13.3 percent of the net scheduled export volume. The four separate interfaces that connect PJM to the NYISO (PJM/NYIS, PJM/NEPT, PJM/HUDS and PJM/Linden (LIND)) together represented 35.6 percent of the total net PJM scheduled exports in the real-time energy market. There were net scheduled exports in the real-time energy market at nine of the 10 separate interfaces that connect PJM to MISO. Those nine exporting interfaces represented 62.3 percent of the total net PJM scheduled exports in the real-time energy market.

In the real-time energy market, in the first three months of 2021, there were net scheduled imports at two of PJM's 19 interfaces. The top importing interface in the real-time energy market was the PJM/Duke Energy Corp. (DUK) interface, which accounted for 99.7 percent of the total net scheduled import volume.¹⁰ The four separate interfaces that connect PJM to the NYISO (PJM/NYIS, PJM/NEPT, PJM/HUDS and PJM/Linden (LIND)) had net scheduled exports in the real-time energy market. There were net scheduled imports in the real-time energy market at none of the 10 separate interfaces that connect PJM to MISO.

Table 9-3 Real-time scheduled net interchange volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLP	(71.6)	7.3	11.8	(52.5)
CPLW	0.3	0.0	0.8	1.0
DUK	180.3	126.0	39.5	345.8
LGEE	(70.3)	(2.9)	(75.6)	(148.9)
MISO	(1,366.6)	(2,572.4)	(2,031.4)	(5,970.4)
ALTE	(45.6)	(493.6)	(222.7)	(761.9)
ALTW	(18.8)	(40.5)	(22.9)	(82.3)
AMIL	(28.4)	(86.5)	(43.2)	(158.2)
CIN	(419.0)	(1,123.5)	(842.1)	(2,384.5)
CWLP	0.0	0.0	0.0	0.0
IPL	(22.3)	(166.0)	(101.3)	(289.6)
MEC	(462.2)	(445.3)	(367.0)	(1,274.5)
MECS	17.7	(126.8)	(396.3)	(505.3)
NIPS	(334.6)	(4.8)	0.0	(339.3)
WEC	(53.5)	(85.4)	(35.9)	(174.8)
NYISO	(1,043.4)	(1,602.5)	(763.5)	(3,409.4)
HUDS	(212.7)	(354.6)	(150.3)	(717.6)
LIND	(226.3)	(211.2)	(191.8)	(629.2)
NEPT	(5.3)	(243.3)	(275.1)	(523.7)
NYIS	(599.2)	(793.4)	(146.3)	(1,538.8)
TVA	89.0	(102.1)	6.9	(6.2)
Total	(2,282.4)	(4,146.5)	(2,811.5)	(9,240.5)

¹⁰ In the real-time energy market, one PJM interface had a net interchange of zero (PJM/City Water Light & Power (CWLP)). CWLP is a balancing authority on the western side of MISO.

Table 9-4 Real-time scheduled gross import volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLC	9.3	112.1	101.8	223.2
CPLW	0.3	0.0	0.8	1.0
DUK	237.0	221.9	98.3	557.2
LGEE	7.6	84.9	0.9	93.4
MISO	354.2	304.5	142.4	801.1
ALTE	135.5	70.4	44.2	250.1
ALTW	0.0	3.8	0.0	3.8
AMIL	2.2	13.8	0.0	15.9
CIN	63.7	44.1	31.7	139.5
CWLP	0.0	0.0	0.0	0.0
IPL	9.3	19.2	0.5	29.0
MEC	19.5	0.0	18.9	38.4
MECS	123.9	153.2	47.2	324.3
NIPS	0.0	0.1	0.0	0.1
WEC	0.1	0.0	0.0	0.1
NYISO	123.7	142.3	138.7	404.8
HUDS	0.0	0.0	0.0	0.0
LIND	0.1	0.0	0.5	0.6
NEPT	0.0	0.1	0.0	0.1
NYIS	123.6	142.2	138.3	404.1
TVA	138.7	55.4	33.5	227.5
Total	870.8	921.1	516.4	2,308.3

Table 9-5 Real-time scheduled gross export volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLC	80.9	104.8	90.1	275.7
CPLW	0.0	0.0	0.0	0.0
DUK	56.7	95.8	58.8	211.4
LGEE	77.9	87.8	76.5	242.3
MISO	1,720.8	2,876.9	2,173.8	6,771.5
ALTE	181.1	564.0	266.9	1,012.0
ALTW	18.8	44.2	22.9	86.0
AMIL	30.6	100.3	43.2	174.1
CIN	482.6	1,167.6	873.7	2,524.0
CWLP	0.0	0.0	0.0	0.0
IPL	31.7	185.2	101.8	318.7
MEC	481.7	445.3	385.9	1,312.9
MECS	106.2	280.0	443.4	829.6
NIPS	334.6	4.8	0.0	339.4
WEC	53.6	85.4	35.9	174.9
NYISO	1,167.2	1,744.8	902.2	3,814.2
HUDS	212.7	354.6	150.3	717.6
LIND	226.4	211.2	192.3	629.8
NEPT	5.3	243.4	275.1	523.8
NYIS	722.8	935.6	284.5	1,942.9
TVA	49.7	157.4	26.6	233.7
Total	3,153.2	5,067.6	3,327.9	11,548.8

Real-Time Interface Pricing Point Imports and Exports

Interfaces differ from interface pricing points. An interface is a point of interconnection between PJM and a neighboring balancing authority which market participants may designate as a path on which scheduled imports or exports will flow.¹¹ An interface pricing point defines the price at which transactions are priced, and is based on the path of the actual, physical transfer of energy. While a market participant designates a scheduled path from a generation control area (GCA) to a load control area (LCA), this path reflects the scheduled path as defined by the transmission reservations only, and may not reflect how the energy actually flows from the GCA to LCA. For example, the import transmission path from LG&E Energy, L.L.C. (LGEE), through MISO and into PJM would show the transfer of power into PJM at the

¹¹ There are multiple paths between any generation and load balancing authority. Market participants select the path based on transmission service availability and the transmission costs for moving energy from generation to load and interface prices.

PJM/MISO Interface based on the scheduled path of the transaction. However, the physical flow of energy does not enter the PJM footprint at the PJM/MISO Interface, but enters PJM at the southern boundary. For this reason, PJM prices an import with the GCA of LGEE at the SouthIMP interface pricing point rather than the MISO pricing point.

Interfaces differ from interface pricing points. The challenge is to create interface prices, composed of external pricing points, which accurately represent the locational price impact of flows between PJM and external sources of energy and that reflect the underlying economic fundamentals across balancing authority borders.¹²

Transactions can be scheduled to an interface based on a contract transmission path, but pricing points are developed and applied based on the estimated electrical impact of the external power source on PJM tie lines, regardless of the contract transmission path.¹³ PJM establishes prices for transactions with external balancing authorities by assigning interface pricing points to individual balancing authorities based on the generation control area and load control area as specified on the NERC Tag. Dynamic interface pricing calculations use actual system conditions to determine a set of weights for each external pricing point in an interface price definition. The weights are designed so that the interface price reflects actual system conditions. However, the weights are an approximation given the complexity of the transmission network outside PJM and the dynamic nature of power flows. Table 9-19 presents the interface pricing points used in the first three months of 2021. On October 21, 2020, PJM updated the mappings of external balancing authorities to individual pricing points. Figure 9-4 shows a map of the default interface pricing point assignments for all external balancing authorities. Figure 9-4 shows that the balancing authorities in the Western Interconnection are mapped to either the MISO interface pricing point or the SouthIMP/EXP interface pricing point. This determination was made by PJM based on geographic location rather than the electrical impact on the PJM system. When power is scheduled across a DC tie line, its effects on the PJM system are as if a generator is

¹² See the *2007 State of the Market Report for PJM*, Volume II, Appendix D, "Interchange Transactions," for a more complete discussion of the development of pricing points.

¹³ See "Interface Pricing Point Assignment Methodology," (October 21, 2020) <<http://www.pjm.com/~media/etools/exschedule/interface-pricing-point-assignment-methodology.ashx>>. PJM periodically updates these definitions on its website.

located at the point in the Eastern Interconnection where the DC tie line connects. The electrical impact on PJM tie lines from sources in the Western Interconnection differ based on the relevant DC tie line and could vary from the MISO interface pricing point to the SouthIMP interface pricing point. The MMU recommends that transactions sourcing in the Western Interconnection be priced at either the MISO interface pricing point or the SouthIMP/EXP interface pricing point based on the locational price impact of flows between the DC tie line point of connection with the Eastern Interconnection and PJM rather than geographical location. The MMU recommends that PJM review the mappings of external balancing authority pricing points at least annually to reflect the fact that changes to the system topology can affect the electrical impact of external power sources on PJM.

The interface pricing method implies that the weighting factors reflect the actual system flows in a dynamic manner. In fact, the weightings are static, and are modified by PJM only occasionally.¹⁴ The MMU recommends that PJM monitor, and adjust as necessary, the weights applied to the components of the interfaces to ensure that the interface prices reflect ongoing changes in system conditions.

The contract transmission path only reflects the path of energy into or out of PJM to one neighboring balancing authority. The NERC Tag requires the complete path to be specified from the generation control area (GCA) to the load control area (LCA), but participants do not always do so. The NERC Tag path is used by PJM to determine the interface pricing point that PJM assigns to the transaction. This approach will correctly identify the interface pricing point only if the market participant provides the complete path in the Tag.

In the real-time energy market, in the first three months of 2021, there were net scheduled exports at six of PJM's nine interface pricing points eligible for real-time transactions. The top three net exporting interface pricing points in the real-time energy market accounted for 82.6 percent of the total net scheduled exports: PJM/MISO with 56.8 percent, PJM/NYIS with 14.4 percent and PJM/SouthEXP with 11.5 percent of the net scheduled export volume. The four separate interface pricing points that connect PJM to the NYISO

¹⁴ On June 1, 2015, PJM began using a dynamic weighting factor in the calculation for the Ontario interface pricing point.

(PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) together represented 31.8 percent of the total net PJM scheduled exports in the real-time energy market.

In the real-time energy market, in the first three months of 2021, there were net scheduled imports at two of PJM's nine interface pricing points eligible for real-time transactions. The top importing interface pricing point in the real-time energy market was the PJM/SouthIMP interface pricing point, which accounted for 72.8 percent of the total net scheduled import volume. The four separate interface pricing points that connect PJM to the NYISO (PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) had net scheduled exports in the real-time energy market.¹⁵

Table 9-6 Real-time scheduled net interchange volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	152.7	219.7	46.9	419.2
MISO	(1,514.5)	(2,527.6)	(2,077.8)	(6,119.9)
NYISO	(1,043.6)	(1,619.0)	(763.5)	(3,426.1)
HUDSONTP	(212.7)	(354.6)	(150.3)	(717.6)
LINDENVFT	(226.3)	(211.2)	(191.8)	(629.2)
NEPTUNE	(5.3)	(243.3)	(275.1)	(523.7)
NYIS	(599.4)	(809.9)	(146.3)	(1,555.5)
Southern Imports	395.2	488.0	237.7	1,120.9
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	395.2	488.0	237.7	1,120.9
Southern Exports	(272.1)	(707.5)	(254.8)	(1,234.5)
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	(272.1)	(707.5)	(254.8)	(1,234.5)
Total	(2,282.4)	(4,146.5)	(2,811.5)	(9,240.5)

¹⁵ In the real-time energy market, one PJM interface pricing point had a net interchange of zero (Southeast).

Table 9-7 Real-time scheduled gross import volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	152.7	219.7	47.0	419.3
MISO	199.4	87.6	93.0	380.0
NYISO	123.5	125.8	138.7	388.1
HUDSONTP	0.0	0.0	0.0	0.0
LINDENVFT	0.1	0.0	0.5	0.6
NEPTUNE	0.0	0.1	0.0	0.1
NYIS	123.4	125.7	138.3	387.4
Southern Imports	395.2	488.0	237.7	1,120.9
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	395.2	488.0	237.7	1,120.9
Southern Exports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	0.0	0.0	0.0	0.0
Total	870.8	921.1	516.4	2,308.3

Table 9-8 Real-time scheduled gross export volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	0.0	0.0	0.1	0.1
MISO	1,713.9	2,615.2	2,170.8	6,500.0
NYISO	1,167.2	1,744.8	902.2	3,814.2
HUDSONTP	212.7	354.6	150.3	717.6
LINDENVFT	226.4	211.2	192.3	629.8
NEPTUNE	5.3	243.4	275.1	523.8
NYIS	722.8	935.6	284.5	1,942.9
Southern Imports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	0.0	0.0	0.0	0.0
Southern Exports	272.1	707.5	254.8	1,234.5
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	272.1	707.5	254.8	1,234.5
Total	3,153.2	5,067.6	3,327.9	11,548.8

Day-Ahead Interface Imports and Exports

In the day-ahead energy market, as in the real-time energy market, scheduled imports and exports are determined by the scheduled path, which is the transmission path a market participant selects from the original source to the final sink. Entering external energy transactions in the day-ahead energy market requires fewer steps than in the real-time energy market. Market participants need to acquire a valid, willing to pay congestion (WPC) OASIS reservation to prove that their day-ahead schedule could be supported in the real-time energy market.¹⁶ Day-ahead energy market schedules need to be cleared through the day-ahead energy market process in order to become an approved schedule. The day-ahead energy market transactions are financially binding, but will not physically flow unless they are also submitted in the real-time energy market. In the day-ahead energy market, a market participant is not required to acquire a ramp reservation, a NERC Tag, or to go through a neighboring balancing authority checkout process.

There are three types of day-ahead external energy transactions: fixed; up to congestion; and dispatchable.¹⁷

In the day-ahead energy market, transaction sources and sinks are determined solely by market participants. In Table 9-9, Table 9-10, and Table 9-11, the scheduled interface designation is determined by the transmission reservation that was acquired and associated with the day-ahead market transaction, and does not bear any necessary relationship to the pricing point designation selected at the time the transaction is submitted to PJM in real time. For example, if market participants want to import energy from the Southwest Power Pool (SPP) to PJM, they are likely to choose a scheduled path with the fewest transmission providers along the path and therefore the lowest transmission costs for the transaction, regardless of whether the resultant path is related to the physical flow of power. The lowest cost transmission path runs from SPP, through MISO, and into PJM, requiring only three transmission reservations, two of which are available at no cost (MISO transmission would be free based on the regional through and out rates, and the PJM transmission

would be free, if using spot import transmission). Any other transmission path entering PJM, where the generating control area is to the south, would require the market participant to acquire transmission through nonmarket balancing authorities, and thus incur additional transmission costs. PJM's interface pricing method recognizes that transactions sourcing in SPP and sinking in PJM will create flows across the southern border and prices those transactions at the SouthIMP interface price. As a result, a market participant who plans to submit a transaction from SPP to PJM may have a transmission reservation with a point of receipt of MISO and a point of delivery of PJM but may select SouthIMP as the import pricing point when submitting the transaction in the day-ahead energy market. In the scheduled interface tables, the import transaction would appear as scheduled through the MISO Interface, and in the scheduled interface pricing point tables, the import transaction would appear as scheduled through the SouthIMP/EXP interface pricing point, which reflects the expected power flow.

Table 9-9 through Table 9-11 show the day-ahead scheduled interchange totals at the individual interfaces. Net scheduled interchange in the day-ahead energy market is shown by interface for the first three months of 2021 in Table 9-9, while gross scheduled imports and exports are shown in Table 9-10 and Table 9-11.

In the day-ahead energy market, in the first three months of 2021, there were net scheduled exports at 12 of PJM's 19 interfaces. The top three net exporting interfaces in the day-ahead energy market accounted for 61.6 percent of the total net scheduled exports: PJM/NYIS with 26.1 percent, PJM/MidAmerican Energy Company (MEC) with 19.7 percent and PJM/Cinergy (CIN) with 15.7 percent of the net scheduled export volume. The four separate interfaces that connect PJM to the NYISO (PJM/NYIS, PJM/NEPT, PJM/HUDS and PJM/Linden (LIND)) together represented 40.0 percent of the total net PJM scheduled exports in the day-ahead energy market. In the first three months of 2021, there were net exports in the day-ahead energy market at six of the 10 separate interfaces that connect PJM to MISO. Those six interfaces represented 52.3 percent of the total net PJM exports in the day-ahead energy market.

¹⁶ Effective September 17, 2010, up to congestion transactions no longer required a willing to pay congestion transmission reservation.

¹⁷ See the 2010 State of the Market Report for PJM, Volume II, Section 4, "Interchange Transactions," for details.

In the day-ahead energy market, in the first three months of 2021, there were net scheduled imports at three of PJM's 19 interfaces. The top importing interface in the day-ahead energy market was the PJM/Duke Energy Corp. (DUK) interface, which accounted for 73.8 percent of the net scheduled import volume. The four separate interfaces that connect PJM to the NYISO (PJM/NYIS, PJM/NEPT, PJM/HUDS and PJM/Linden (LIND)) had net scheduled exports in the day-ahead energy market. In the first three months of 2021, there were net imports in the day-ahead energy market at one of the 10 separate interfaces that connect PJM to MISO (PJM/MECS), which accounted for 25.6 percent of the total net PJM imports in the day-ahead energy market.¹⁸

Table 9-9 Day-ahead scheduled net interchange volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLD	(61.9)	(86.3)	(51.5)	(199.8)
CPLW	0.0	0.0	0.8	0.8
DUK	47.6	28.7	21.3	97.7
LGEE	(74.7)	(91.9)	(79.8)	(246.5)
MISO	(1,016.7)	(1,386.7)	(1,022.2)	(3,425.6)
ALTE	(69.6)	(363.9)	(151.9)	(585.4)
ALTW	(17.4)	(25.7)	(10.6)	(53.8)
AMIL	0.0	0.0	0.0	0.0
CIN	(103.1)	(475.7)	(463.4)	(1,042.2)
CWLP	0.0	0.0	0.0	0.0
IPL	0.0	0.0	0.0	0.0
MEC	(481.6)	(438.3)	(383.8)	(1,303.7)
MECS	39.2	(21.4)	16.1	33.8
NIPS	(334.4)	(4.8)	0.0	(339.2)
WEC	(49.9)	(56.9)	(28.5)	(135.3)
NYISO	(754.4)	(1,326.6)	(563.5)	(2,644.4)
HUDS	(79.7)	(210.9)	(80.5)	(371.0)
LIND	0.0	0.0	0.0	0.0
NEPT	(10.7)	(249.4)	(285.2)	(545.3)
NYIS	(663.9)	(866.4)	(197.8)	(1,728.1)
TVA	(10.9)	(52.6)	(4.9)	(68.5)
Total without Up To Congestion	(1,871.0)	(2,915.4)	(1,699.9)	(6,486.3)
Up To Congestion	(421.3)	(332.8)	(27.7)	(781.7)
Total	(2,292.3)	(3,248.1)	(1,727.6)	(7,268.0)

¹⁸ In the day-ahead energy market, four PJM interfaces had a net interchange of zero (PJM/Ameren Illinois (AMIL), PJM/City Water Light & Power (CWLP), PJM/Indianapolis Power & Light (IPL) and PJM/Linden (LIND)).

Table 9-10 Day-ahead scheduled gross import volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLD	2.4	4.6	18.4	25.3
CPLW	0.0	0.0	0.8	0.8
DUK	55.8	43.8	32.7	132.3
LGEE	0.0	0.0	0.0	0.0
MISO	187.8	107.6	95.5	390.9
ALTE	102.1	46.0	52.2	200.2
ALTW	0.0	2.6	0.0	2.6
AMIL	0.0	0.0	0.0	0.0
CIN	40.4	26.0	8.6	75.0
CWLP	0.0	0.0	0.0	0.0
IPL	0.0	0.0	0.0	0.0
MEC	0.0	0.0	0.0	0.0
MECS	45.4	33.0	34.7	113.0
NIPS	0.0	0.0	0.0	0.0
WEC	0.0	0.0	0.0	0.0
NYISO	0.0	0.4	5.4	5.7
HUDS	0.0	0.0	0.0	0.0
LIND	0.0	0.0	0.0	0.0
NEPT	0.0	0.0	0.0	0.0
NYIS	0.0	0.4	5.4	5.7
TVA	6.0	7.0	0.0	12.9
Total without Up To Congestion	251.9	163.3	152.7	567.9
Up To Congestion	590.6	809.5	654.2	2,054.3
Total	842.5	972.7	806.9	2,622.2

Table 9-11 Day-ahead scheduled gross export volume by interface (GWh): January through March, 2021

	Jan	Feb	Mar	Total
CPLP	64.3	90.8	69.9	225.1
CPLW	0.0	0.0	0.0	0.0
DUK	8.1	15.1	11.4	34.6
LGEE	74.7	91.9	79.8	246.5
MISO	1,204.5	1,494.2	1,117.7	3,816.5
ALTE	171.6	409.8	204.1	785.6
ALTW	17.4	28.3	10.6	56.4
AMIL	0.0	0.0	0.0	0.0
CIN	143.4	501.7	472.0	1,117.2
CWLP	0.0	0.0	0.0	0.0
IPL	0.0	0.0	0.0	0.0
MEC	481.6	438.3	383.8	1,303.7
MECS	6.2	54.4	18.6	79.2
NIPS	334.4	4.8	0.0	339.2
WEC	49.9	56.9	28.5	135.3
NYISO	754.4	1,326.9	568.8	2,650.1
HUDES	79.7	210.9	80.5	371.0
LIND	0.0	0.0	0.0	0.0
NEPT	10.7	249.4	285.2	545.3
NYIS	663.9	866.7	203.1	1,733.8
TVA	16.9	59.6	4.9	81.4
Total without Up To Congestion	2,123.0	3,078.6	1,852.6	7,054.2
Up To Congestion	1,011.9	1,142.2	681.9	2,836.0
Total	3,134.9	4,220.9	2,534.4	9,890.2

Day-Ahead Interface Pricing Point Imports and Exports

Table 9-12 through Table 9-17 show the day-ahead scheduled interchange totals at the interface pricing points. In the first three months of 2021, up to congestion transactions accounted for 78.3 percent of all scheduled import MW transactions and 28.7 percent of all scheduled export MW transactions in the day-ahead energy market. The day-ahead net scheduled interchange in the first three months of 2021, including up to congestion transactions, is shown by interface pricing point in Table 9-12. Scheduled up to congestion transactions by interface pricing point in the first three months of 2021 are shown in Table 9-13. Day-ahead gross scheduled imports and exports, including up to congestion transactions, are shown in Table 9-14 and Table

9-16, while gross scheduled import and export up to congestion transactions are shown in Table 9-15 and Table 9-17.

PJM consolidated the Southeast and Southwest interface pricing points to a single interface pricing point with separate import and export prices (SouthIMP and SouthEXP) on October 31, 2006. At that time, the real-time Southeast and Southwest interface pricing points remained only to support certain grandfathered agreements with specific generating units and to price energy under the reserve sharing agreement with VACAR. The reserve sharing agreement allows for the transfer of energy during emergencies. Interchange transactions created as part of the reserve sharing agreement are currently settled at the Southeast interface price. PJM also kept the day-ahead Southeast and Southwest interface pricing points to facilitate long-term day-ahead positions that were entered prior to the consolidation.

Maintaining outdated definitions of interface pricing points is unnecessary, inconsistent with the tariff and creates artificial opportunities for gaming by virtual transactions and FTRs. The MMU recommends that PJM end the practice of maintaining outdated definitions of interface pricing points, eliminate the Southeast and Southwest interface pricing points from the day-ahead and real-time energy markets and, with VACAR, assign the transactions created under the reserve sharing agreement to the SouthIMP/EXP pricing point.¹⁹ PJM should immediately eliminate interface pricing points when changes to the market mean that the pricing points can no longer be used to price actual transactions and do not reflect actual price formation.

In the day-ahead energy market, in the first three months of 2021, there were net scheduled exports at six of PJM's nine interface pricing points eligible for day-ahead transactions. The top three net exporting interface pricing points in the day-ahead energy market accounted for 84.8 percent of the total net scheduled exports: PJM/MISO with 49.9 percent, PJM/NYIS with 26.2 percent and PJM/HUDSONTP with 8.7 percent of the net scheduled export volume. The four separate interface pricing points that connect PJM to the NYISO (PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) together

¹⁹ The grandfathered agreements associated with the Southwest interface pricing point expired in 2012. The Southwest interface pricing point is no longer an eligible pricing point in the day-ahead or real-time energy markets.

represented 41.5 percent of the total net PJM scheduled exports in the day-ahead energy market. However, the PJM/LINDENVFT interface pricing point had net scheduled imports in the day-ahead energy market.

In the day-ahead energy market, in the first three months of 2021, there were net scheduled imports at three of PJM's nine interface pricing points eligible for day-ahead transactions. The top importing interface pricing point in the day-ahead energy market was the PJM/SouthIMP interface pricing point, which accounted for 91.6 percent of the total net scheduled import volume. The four separate interface pricing points that connect PJM to the NYISO (PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) together represented 6.8 percent of the total net PJM scheduled imports in the day-ahead energy market. However, the PJM/NYIS, PJM/NEPTUNE and PJM/HUDSONTP interface pricing points had net scheduled exports in the day-ahead energy market.

In the day-ahead energy market, in the first three months of 2021, up to congestion transactions had net scheduled exports at six of PJM's nine interface pricing points eligible for day-ahead transactions. The top three net exporting interface pricing points eligible for up to congestion transactions accounted for 85.1 percent of the total net up to congestion scheduled exports: PJM/MISO with 36.5 percent, PJM/NYIS with 27.2 percent and PJM/HUDSONTP with 21.3 percent of the net up to congestion scheduled export volume. The four separate interface pricing points that connect PJM to the NYISO (PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) together represented 48.7 percent of the total net scheduled up to congestion exports in the day-ahead energy market. However, the PJM/LINDENVFT interface pricing points had net up to congestion scheduled imports in the day-ahead energy market.

In the day-ahead energy market, in the first three months of 2021, up to congestion transactions had net scheduled imports at two of PJM's nine interface pricing points eligible for day-ahead transactions. The top importing interface pricing point eligible for up to congestion transactions was the PJM/SouthIMP interface pricing point, which accounted for 91.8 percent of

the total net up to congestion scheduled import up to congestion volume. The four separate interface pricing points that connect PJM to the NYISO (PJM/NYIS, PJM/NEPTUNE, PJM/HUDSONTP and PJM/LINDENVFT) together represented 8.2 percent of the total net scheduled up to congestion imports in the day-ahead energy market. However, the PJM/HUDSONTP, PJM/NEPTUNE and PJM/NYIS interface pricing points had net up to congestion scheduled exports in the day-ahead energy market.²⁰

Table 9-12 Day-ahead scheduled net interchange volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	55.3	(17.0)	(20.3)	18.0
MISO	(1,410.2)	(1,951.1)	(821.9)	(4,183.1)
NYISO	(990.5)	(1,597.1)	(812.8)	(3,400.4)
HUDSONTP	(207.5)	(293.2)	(232.4)	(733.1)
LINDENVFT	51.2	18.8	5.8	75.9
NEPTUNE	(11.3)	(256.4)	(280.0)	(547.7)
NYIS	(822.9)	(1,066.4)	(306.2)	(2,195.4)
Southern Imports	239.9	635.7	145.5	1,021.1
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	239.9	635.7	145.5	1,021.1
Southern Exports	(186.9)	(318.6)	(218.1)	(723.5)
SOUTHEAST	0.0	(4.3)	(1.0)	(5.3)
SOUTHEXP	(186.9)	(314.3)	(217.1)	(718.3)
Total	(2,292.3)	(3,248.1)	(1,727.6)	(7,268.0)

²⁰ In the day-ahead energy market, one PJM interface pricing point had up to congestion net interchange of zero [Southeast].

Table 9-13 Up to congestion scheduled net interchange volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	(1.3)	(71.1)	(54.8)	(127.2)
MISO	(336.7)	(521.5)	234.9	(623.4)
NYISO	(236.2)	(270.6)	(249.3)	(756.1)
HUDSONTP	(127.8)	(84.7)	(152.0)	(364.5)
LINDENVFT	51.2	18.8	5.8	75.9
NEPTUNE	(0.6)	(7.1)	5.3	(2.4)
NYIS	(159.1)	(197.6)	(108.4)	(465.1)
Southern Imports	175.8	580.3	93.7	849.8
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	175.8	580.3	93.7	849.8
Southern Exports	(22.8)	(50.0)	(52.1)	(124.8)
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	(22.8)	(50.0)	(52.1)	(124.8)
Total Interfaces	(421.3)	(332.8)	(27.7)	(781.7)
INTERNAL	3,896.8	5,150.6	5,248.0	14,295.4
Total	3,475.6	4,817.8	5,220.3	13,513.6

Table 9-14 Day-ahead scheduled gross import volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	74.2	76.0	56.2	206.4
MISO	416.1	208.0	521.5	1,145.7
NYISO	112.3	53.0	83.7	249.0
HUDSONTP	15.8	8.5	6.0	30.3
LINDENVFT	61.1	30.1	44.2	135.4
NEPTUNE	0.0	6.2	14.5	20.8
NYIS	35.4	8.1	19.0	62.5
Southern Imports	239.9	635.7	145.5	1,021.1
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	239.9	635.7	145.5	1,021.1
Southern Exports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	0.0	0.0	0.0	0.0
Total	842.5	972.7	806.9	2,622.2

Table 9-15 Up to congestion scheduled gross import volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	17.5	20.1	21.7	59.2
MISO	285.0	156.4	460.5	902.0
NYISO	112.3	52.7	78.3	243.3
HUDSONTP	15.8	8.5	6.0	30.3
LINDENVFT	61.1	30.1	44.2	135.4
NEPTUNE	0.0	6.2	14.5	20.8
NYIS	35.4	7.8	13.6	56.8
Southern Imports	175.8	580.3	93.7	849.8
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	175.8	580.3	93.7	849.8
Southern Exports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	0.0	0.0	0.0	0.0
Total Interfaces	590.6	809.5	654.2	2,054.3

Table 9-16 Day-ahead scheduled gross export volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	18.9	93.1	76.5	188.4
MISO	1,826.3	2,159.1	1,343.4	5,328.8
NYISO	1,102.8	1,650.1	896.5	3,649.4
HUDSONTP	223.3	301.7	238.5	763.5
LINDENVFT	9.9	11.3	38.4	59.6
NEPTUNE	11.3	262.7	294.5	568.5
NYIS	858.3	1,074.5	325.2	2,257.9
Southern Imports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	0.0	0.0	0.0	0.0
Southern Exports	186.9	318.6	218.1	723.5
SOUTHEAST	0.0	4.3	1.0	5.3
SOUTHEXP	186.9	314.3	217.1	718.3
Total	3,134.9	4,220.9	2,534.4	9,890.2

Table 9-17 Up to congestion scheduled gross export volume by interface pricing point (GWh): January through March, 2021

	Jan	Feb	Mar	Total
IMO	18.8	91.1	76.5	186.4
MISO	621.8	677.9	225.7	1,525.3
NYISO	348.6	323.2	327.7	999.5
HUDSONTP	143.6	93.2	158.0	394.8
LINDENVFT	9.9	11.3	38.4	59.6
NEPTUNE	0.6	13.3	9.2	23.2
NYIS	194.5	205.4	122.0	521.9
Southern Imports	0.0	0.0	0.0	0.0
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHIMP	0.0	0.0	0.0	0.0
Southern Exports	22.8	50.0	52.1	124.8
SOUTHEAST	0.0	0.0	0.0	0.0
SOUTHEXP	22.8	50.0	52.1	124.8
Total Interfaces	1,011.9	1,142.2	681.9	2,836.0

Table 9-18 Active scheduling interfaces: January through March, 2021²¹

	Jan	Feb	Mar
ALTE	Active	Active	Active
ALTW	Active	Active	Active
AMIL	Active	Active	Active
CIN	Active	Active	Active
CPLW	Active	Active	Active
CWLP	Active	Active	Active
DUK	Active	Active	Active
HUDES	Active	Active	Active
IPL	Active	Active	Active
LGEE	Active	Active	Active
LIND	Active	Active	Active
MEC	Active	Active	Active
MECS	Active	Active	Active
NEPT	Active	Active	Active
NIPS	Active	Active	Active
NYIS	Active	Active	Active
TVA	Active	Active	Active
WEC	Active	Active	Active

²¹ On July 2, 2012, Duke Energy Corp. (DUK) completed a merger with Progress Energy Inc. (CPLW and CPLW). As of March 31, 2021, DUK, CPLW and CPLW continued to operate as separate balancing authorities, and are still defined as distinct interfaces in the PJM energy market.

Figure 9-3 PJM's footprint and its external scheduling interfaces

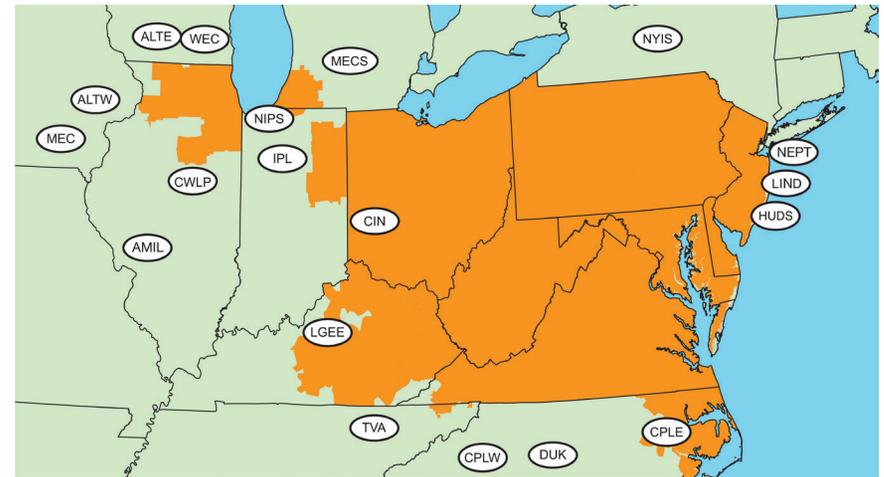
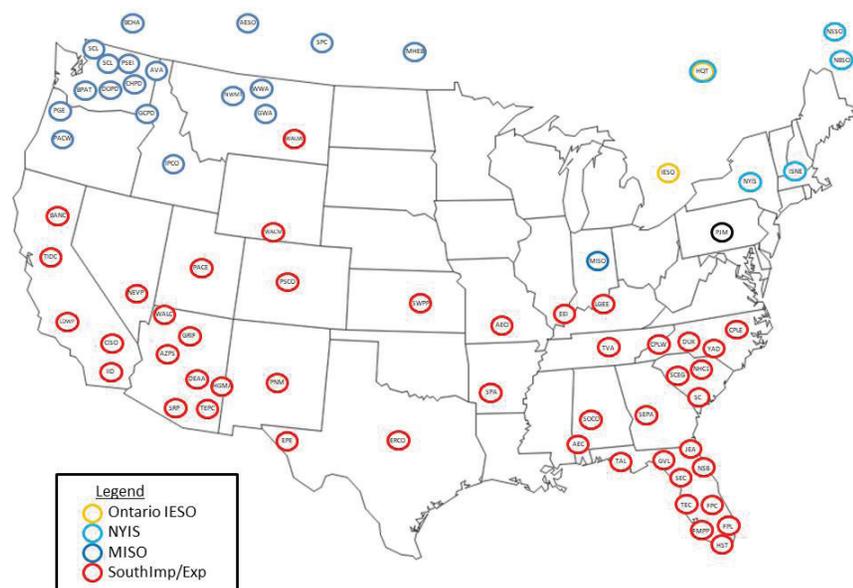


Table 9-19 Active scheduled interface pricing points: January through March, 2021

	Jan	Feb	Mar
HUDSONTP	Active	Active	Active
LINDENVFT	Active	Active	Active
MISO	Active	Active	Active
NEPTUNE	Active	Active	Active
NYIS	Active	Active	Active
Ontario IESO	Active	Active	Active
Southeast	Active	Active	Active
SOUTHEXP	Active	Active	Active
SOUTHIMP	Active	Active	Active

Figure 9-4 External balancing authority default interface pricing point assignments



Loop Flows

Actual energy flows are the real-time metered power flows at an interface for a defined period. The comparable scheduled flows are the real-time power flows scheduled at an interface for a defined period. Inadvertent interchange is the difference between the total actual flows for the PJM system (net actual interchange) and the total scheduled flows for the PJM system (net scheduled interchange) for a defined period. Loop flows are the difference between actual and scheduled power flows at a specific interface. Loop flows can exist at the same time that inadvertent interchange is zero. For example, actual imports could exceed scheduled imports at one interface and actual exports could exceed scheduled exports at another interface by the same amount. The

result is loop flow, despite the fact that system actual and scheduled power flow net to a zero difference.²²

Loop flows result, in part, from a mismatch between incentives to use a particular scheduled transmission path and the market-based price differentials at interface pricing points that result from the actual physical flows on the transmission system.

PJM's approach to interface pricing attempts to match prices with physical power flows and their impacts on the transmission system. For example, if market participants want to import energy from the Southwest Power Pool (SPP) to PJM, they are likely to choose a scheduled path with the fewest transmission providers along the path and therefore the lowest transmission costs for the transaction, regardless of whether the resultant path is related to the physical flow of power. The lowest cost transmission path runs from SPP, through MISO, and into PJM, requiring only three transmission reservations, two of which are available at no cost (MISO transmission would be free based on the regional through and out rates, and the PJM transmission would be free, if using spot import transmission). Any other transmission path entering PJM, where the generating control area is to the south, would require the market participant to acquire transmission through nonmarket balancing authorities, and thus incur additional transmission costs. PJM's interface pricing method recognizes that transactions sourcing in SPP and sinking in PJM will create flows across the southern border and prices those transactions at the SouthIMP interface price. As a result, the transaction is priced appropriately, but a difference between scheduled and actual flows is created at PJM's borders. For example, if a 100 MW transaction were submitted, there would be 100 MW of scheduled flow at the PJM/MISO interface border, but there would be no actual flows on the interface. Correspondingly, there would be no scheduled flows at the PJM/Southern interface border, but there would be 100 MW of actual flows on the interface. In the first three months of 2021, there were net scheduled flows of -253 GWh through MISO that received an interface pricing point associated with the southern interface but there were

²² See the 2012 State of the Market Report for PJM, Volume II, Section 8, "Interchange Transactions," for a more detailed discussion.

no net scheduled flows across the southern interface that received the MISO interface pricing point.

In the first three months of 2021, net scheduled interchange was -9,240.5 GWh and net actual interchange was -9,240.8 GWh, a difference of 0.3 GWh. In the first three months of 2020, net scheduled interchange was -7,557.3 GWh and net actual interchange was -7,519.3 GWh, a difference of 38.1 GWh. This difference is inadvertent interchange. PJM attempts to minimize the amount of accumulated inadvertent interchange by continually monitoring and correcting for inadvertent interchange. PJM can reduce the accumulation of inadvertent interchange using unilateral or bilateral paybacks. Inadvertent interchange accumulations that are paid back unilaterally are paid by controlling to a non-zero area control error (ACE). For example, Table 9-20 shows that PJM had 0.3 GW of inadvertent interchange in the first three months of 2021. To reduce this inadvertent interchange, PJM can control to an ACE less than zero, which would result in under generating. By way of the power balance equation, power would flow into PJM from its neighboring balancing authority areas. This would create additional actual imports that were not scheduled, thus reducing the overall inadvertent. To maintain reliability, unilateral paybacks are accounted for in the control performance standard calculations. Bilateral paybacks are scheduled with other balancing authority areas by scheduling a correction and incorporating that amount as a bias in the energy management system.²³

Table 9-20 shows that in the first three months of 2021, the Northern Indiana Public Service (NIPS) Interface had the largest loop flows of any interface with -339 GWh of net scheduled interchange and -3,097 GWh of net actual interchange, a difference of 2,758 GWh.

Table 9-20 Net scheduled and actual PJM flows by interface (GWh): January through March, 2021

	Actual	Net Scheduled	Difference (GWh)
CPLP	(174)	(52)	(121)
CPLW	(126)	1	(127)
DUK	291	346	(55)
LGEE	456	(149)	604
MISO	(7,279)	(5,970)	(1,309)
ALTE	(688)	(762)	74
ALTW	(718)	(82)	(635)
AMIL	(1,479)	(158)	(1,321)
CIN	(1,628)	(2,385)	757
CWLP	(116)	0	(116)
IPL	(443)	(290)	(154)
MEC	(1,746)	(1,275)	(471)
MECS	885	(505)	1,390
NIPS	(3,097)	(339)	(2,758)
WEC	1,750	(175)	1,925
NYISO	(3,375)	(3,409)	34
HUDS	(718)	(718)	0
LIND	(629)	(629)	0
NEPT	(524)	(524)	0
NYIS	(1,504)	(1,539)	34
TVA	967	(6)	973
Total	(9,240.8)	(9,240.5)	(0.3)

Every external balancing authority is mapped to an import and export interface pricing point. The mapping is designed to reflect the physical flow of energy between PJM and each balancing authority. The net scheduled values for interface pricing points are defined as the MWh of scheduled transactions that will receive the interface pricing point based on the external balancing authority mapping.²⁴ For example, the MWh for a transaction whose transmission path is SPP through MISO and into PJM would be reflected in the SouthIMP interface pricing point net schedule totals because SPP is mapped to the SouthIMP interface pricing point. The actual flow on an interface pricing point is defined as the metered flow across the transmission lines that are included in the interface pricing point.

²⁴ The terms balancing authority and control area are used interchangeably in this section. The NERC Tag applications maintained the terminology of generation control area (GCA) and load control area (LCA) after the implementation of the NERC functional model. The NERC functional model classifies the balancing authority as a reliability service function, with, among other things, the responsibility for balancing generation, demand and interchange balance.

²³ See PJM, "Manual 12: Balancing Operations," Rev. 42 (January 27, 2021).

The differences between the scheduled MWh mapped to a specific interface pricing point and actual power flows at the interface pricing points provide a better measure of loop flows than differences at the interfaces. The scheduled transactions are mapped to interface pricing points based on the expected flow from the generation balancing authority and load balancing authority, whereas scheduled transactions are assigned to interfaces based solely on the OASIS path that the market participants reflect the transmission path into or out of PJM to one neighboring balancing authority. Power flows at the interface pricing points provide a more accurate reflection of where scheduled power flows actually enter or leave the PJM footprint based on the complete transaction path. Table 9-21 shows the net scheduled and actual PJM flows by interface pricing point.

Because the SouthIMP and SouthEXP interface pricing points are the same physical point, if there are net actual exports from the PJM footprint to the southern region, by definition, there cannot be net actual imports into the PJM footprint from the southern region and therefore there will not be actual flows at the SouthIMP interface pricing point. In the case of PJM's southern border, loop flows can be analyzed by comparing the net scheduled and net actual flows as a sum of the pricing points, rather than the individual pricing points. To accurately calculate the loop flows from the southern region, the net actual flows from the southern region are compared to the net scheduled flows from the southern region. The net actual flows from the southern region are determined by summing the total southern import actual flows (6,200 GWh) and the total southern export actual flows (-4,786 GWh) for 1,414 GWh of net imports. The net scheduled flows from the southern region are determined by summing the total southern import scheduled flows (1,121 GWh) and the total southern export scheduled flows (-1,235 GWh) for 114 GWh of net exports. In the first three months of 2021, the loop flows at the southern region were the difference between the southern region net scheduled flows (-114 GW) and the southern region net actual flows (1,414 GWh) for a total of 1,527 GWh of loop flows.

The IMO interface pricing point with the Ontario IESO was created to reflect the fact that transactions that originate or sink in the Ontario Independent

Electricity System Operator (IMO) balancing authority create physical flows that are split between the MISO and NYISO interface pricing points depending on transmission system conditions, so a mapping to a single interface pricing point does not reflect the actual flows. PJM created the IMO interface pricing point to reflect the actual power flows across both the MISO/PJM and NYISO/PJM interfaces. The IMO does not have physical ties with PJM because it is not contiguous. Table 9-21 shows actual flows associated with the IMO interface pricing point as zero because there is no PJM/IMO Interface. The actual flows between IMO and PJM are included in the actual flows at the MISO and NYISO interface pricing points.

Table 9-21 PJM flows by interface pricing point (GWh): January through March, 2021

	Actual	Net Scheduled	Difference (GWh)
IMO	0	419	(419)
MISO	(7,279)	(6,120)	(1,160)
NYISO	(3,375)	(3,426)	51
HUDSONTP	(718)	(718)	0
LINDENVFT	(629)	(629)	0
NEPTUNE	(524)	(524)	0
NYIS	(1,504)	(1,556)	51
Southern Imports	6,200	1,121	5,079
SOUTHEAST	0	0	0
SOUTHIMP	6,200	1,121	5,079
Southern Exports	(4,786)	(1,235)	(3,551)
SOUTHEAST	0	0	0
SOUTHEXP	(4,786)	(1,235)	(3,551)
Total	(9,240.8)	(9,240.5)	(0.3)

Table 9-22 shows the net scheduled and actual PJM flows by interface pricing point, with adjustments made to the MISO and NYISO scheduled interface pricing points based on the quantities of scheduled interchange where transactions from the IMO entered the PJM energy market. For example, Table 9-24 shows that 402 of the 419 GWh (95.9 percent) of gross scheduled transactions that were mapped to the IMO interface pricing point were scheduled as imports through MISO.

Table 9-22 shows that in the first three months of 2021, the SouthIMP interface pricing point had the largest loop flows of any interface pricing

point with 1,121 GWh of net scheduled interchange and 6,200 GWh of net actual interchange, a difference of 5,079 GWh.

Table 9-22 PJM flows by interface pricing point (GWh) (Adjusted for IMO Scheduled Interfaces): January through March, 2021

	Actual	Net Scheduled	Difference (GWh)
MISO	(7,279)	(5,717)	(1,562)
NYISO	(3,375)	(3,409)	34
HUDSONTP	(718)	(718)	0
LINDENVFT	(629)	(629)	0
NEPTUNE	(524)	(524)	0
NYIS	(1,504)	(1,539)	34
Southern Imports	6,200	1,121	5,079
SOUTHEAST	0	0	0
SOUTHIMP	6,200	1,121	5,079
Southern Exports	(4,786)	(1,235)	(3,551)
SOUTHEAST	0	0	0
SOUTHEXP	(4,786)	(1,235)	(3,551)
Total	(9,240.8)	(9,240.5)	(0.3)

The NERC Tag requires the complete path to be specified from the generation control area (GCA) to the load control area (LCA), but participants do not always do so. The NERC Tag path is used by PJM to determine the interface pricing point that PJM assigns to the transaction. This approach will correctly identify the interface pricing point only if the market participant provides the complete path in the Tag. This approach will not correctly identify the interface pricing point if the market participant breaks the transaction into portions, each with a separate Tag. The breaking of transactions into portions can be a way to manipulate markets and the result of such behavior can be incorrect and noncompetitive pricing of transactions.

PJM attempts to ensure that external energy transactions are priced appropriately through the assignment of interface prices based on the expected actual flow from the generation balancing authority (source) and load balancing authority (sink) as specified on the NERC Tag. Assigning prices in this manner is a reasonable approach to ensuring that transactions receive or pay the PJM market value of the transaction based on expected flows, but this method does not address loop flow issues.

Loop flows remain a significant concern for the efficiency of the PJM market. Loop flows can have negative impacts on the efficiency of markets with explicit locational pricing, including impacts on locational prices, on FTR revenue adequacy and on system operations, and can be evidence of attempts to game the markets.

The MMU recommends that PJM implement a validation method for submitted transactions that would prohibit market participants from breaking transactions into smaller segments to defeat the interface pricing rule and receive higher prices (for imports) or lower prices (for exports) from PJM resulting from the inability to identify the true source or sink of the transaction. If all of the Northeast ISOs and RTOs implemented validation to prohibit the breaking of transactions into smaller segments, the level of Lake Erie loop flow would be reduced.

The MMU also recommends that PJM implement a validation method for submitted transactions that would require market participants to submit transactions on paths that reflect the expected actual power flow in order to reduce unscheduled loop flows.

Table 9-23 shows the net scheduled and actual PJM flows by interface and interface pricing point. This table shows the interface pricing points that were assigned to energy transactions that had paths at each of PJM's interfaces. For example, Table 9-23 shows that in the first three months of 2021, the majority of imports to the PJM energy market for which a market participant specified Ameren-Illinois (AMIL) as the interface with PJM based on the scheduled transmission path, had a generation control area mapped to the SOUTHIMP Interface, and thus actual flows were assigned the SOUTHIMP interface pricing point (16 GWh). The majority of exports from the PJM energy market for which a market participant specified AMIL as the interface with PJM based on the scheduled transmission path had a load control area for which the actual flows would leave the PJM energy market at the MISO Interface, and were assigned the MISO interface pricing point (-140 GWh).

Table 9-23 Net scheduled and actual flows by interface and interface pricing point (GWh): January through March, 2021

Interface	Interface Pricing Point	Actual	Net Scheduled	Difference (GWh)	Interface	Interface Pricing Point	Actual	Net Scheduled	Difference (GWh)
ALTE		(688)	(762)	74	LGEE		456	(149)	604
	IMO	0	40	(40)		SOUTHEXP	(2,239)	(242)	(1,996)
	MISO	(688)	(798)	110		SOUTHIMP	2,694	93	2,601
	SOUTHEXP	0	(3)	3	LIND		(629)	(629)	0
ALTW		(718)	(82)	(635)		LINDENVFT	(629)	(629)	0
	IMO	0	4	(4)	MEC		(1,746)	(1,275)	(471)
	MISO	(718)	(86)	(632)		MISO	(1,746)	(1,265)	(480)
AMIL		(1,479)	(158)	(1,321)		SOUTHEXP	0	(9)	9
	MISO	(1,479)	(140)	(1,339)	MECS		885	(505)	1,390
	SOUTHEXP	0	(34)	34		IMO	0	321	(321)
	SOUTHIMP	0	16	(16)		MISO	885	(813)	1,698
CIN		(1,628)	(2,385)	757		SOUTHEXP	0	(12)	12
	IMO	0	12	(12)		SOUTHIMP	0	0	(0)
	MISO	(1,628)	(2,275)	648	NEPT		(524)	(524)	0
	SOUTHEXP	0	(123)	123		NEPTUNE	(524)	(524)	0
	SOUTHIMP	0	3	(3)	NIPS		(3,097)	(339)	(2,758)
CPLE		(174)	(52)	(121)		IMO	0	0	(0)
	SOUTHEXP	(1,012)	(276)	(736)		MISO	(3,097)	(339)	(2,757)
	SOUTHIMP	839	223	615	NYIS		(1,504)	(1,539)	34
CPLW		(126)	1	(127)		IMO	0	17	(17)
	SOUTHEXP	(158)	0	(158)		NYIS	(1,504)	(1,556)	51
	SOUTHIMP	32	1	31	TVA		967	(6)	973
CWLP		(116)	0	(116)		MISO	0	(0)	0
	MISO	(116)	0	(116)		SOUTHEXP	(1,088)	(234)	(855)
DUK		291	346	(55)		SOUTHIMP	2,055	228	1,828
	SOUTHEXP	(289)	(211)	(77)	WEC		1,750	(175)	1,925
	SOUTHIMP	580	557	22		MISO	1,750	(153)	1,903
HUDD		(718)	(718)	0		SOUTHEXP	0	(22)	22
	HUDSONTP	(718)	(718)	0		SOUTHIMP	0	0	(0)
IPL		(443)	(290)	(154)	Grand Total		(9,240.8)	(9,240.5)	(0.3)
	IMO	0	27	(27)					
	MISO	(443)	(249)	(194)					
	SOUTHEXP	0	(67)	67					

Table 9-24 shows the net scheduled and actual PJM flows by interface pricing point and interface. The grouping is reversed from Table 9-23. Table 9-24 shows the interfaces where transactions were scheduled which received the individual interface pricing points. For example, Table 9-24 shows that in the first three months of 2021, the majority of imports to the PJM energy market for which a market participant specified a generation control area for which it was assigned the IMO interface pricing point, had a path that entered the PJM energy market at the MECS Interface (321 GWh).

Table 9-24 Net scheduled and actual flows by interface pricing point and interface (GWh): January through March, 2021

Interface Pricing Point	Interface	Actual	Net Scheduled	Difference (GWh)	Interface Pricing Point	Interface	Actual	Net Scheduled	Difference (GWh)
HUDSONTP		(718)	(718)	0	NYIS		(1,504)	(1,556)	51
	HUDS	(718)	(718)	0		NYIS	(1,504)	(1,556)	51
IMO		0	419	(419)	SOUTHXP		(4,786)	(1,235)	(3,551)
	ALTE	0	40	(40)		ALTE	0	(3)	3
	ALTW	0	4	(4)		AMIL	0	(34)	34
	CIN	0	12	(12)		CIN	0	(123)	123
	IPL	0	27	(27)		CPLW	(1,012)	(276)	(736)
	MECS	0	321	(321)		CPLW	(158)	0	(158)
	NIPS	0	0	(0)		DUK	(289)	(211)	(77)
	NYIS	0	17	(17)		IPL	0	(67)	67
LINDENVFT		(629)	(629)	0	LGEE		(2,239)	(242)	(1,996)
	LIND	(629)	(629)	0		MEC	0	(9)	9
MISO		(7,279)	(6,120)	(1,160)	MECS		0	(12)	12
	ALTE	(688)	(798)	110		TVA	(1,088)	(234)	(855)
	ALTW	(718)	(86)	(632)		WEC	0	(22)	22
	AMIL	(1,479)	(140)	(1,339)	SOUTHIMP		6,200	1,121	5,079
	CIN	(1,628)	(2,275)	648		AMIL	0	16	(16)
	CWLP	(116)	0	(116)		CIN	0	3	(3)
	IPL	(443)	(249)	(194)		CPLW	839	223	615
	MEC	(1,746)	(1,265)	(480)		CPLW	32	1	31
	MECS	885	(813)	1,698		DUK	580	557	22
	NIPS	(3,097)	(339)	(2,757)		LGEE	2,694	93	2,601
	TVA	0	(0)	0		MECS	0	0	(0)
	WEC	1,750	(153)	1,903		TVA	2,055	228	1,828
NEPTUNE		(524)	(524)	0		WEC	0	0	(0)
	NEPT	(524)	(524)	0	Grand Total		(9,240.8)	(9,240.5)	(0.3)

Data Required for Full Loop Flow Analysis

Loop flows are defined as the difference between actual and scheduled power flows at one or more specific interfaces. The differences between actual and scheduled power flows can be the result of a number of underlying causes. To adequately investigate the causes of loop flows, complete data are required.

Loop flows exist because electricity flows on the path of least resistance regardless of the path specified by contractual agreement or regulatory prescription. Loop flows can arise from transactions scheduled into, out of or around a balancing authority on contract paths that do not correspond to the actual physical paths on which energy flows. Outside of LMP-based energy markets, energy is scheduled and paid for based on contract path, without regard to the path of the actual energy flows. Loop flows can also result from actions within balancing authorities.

Loop flows are a significant concern. Loop flows can have negative impacts on the efficiency of markets with explicit locational pricing, including impacts on locational prices, on FTR revenue adequacy and on system operations, and can be evidence of attempts to game such markets. Loop flows also have poorly understood impacts on nonmarket areas. In general, the detailed sources of the identified differences between scheduled and actual flows remain unclear as a result of incomplete or inadequate access to the required data.

A complete analysis of loop flow could provide additional insight that could lead to enhanced overall market efficiency and clarify the interactions among market and nonmarket areas. A complete analysis of loop flow would improve the overall transparency of electricity transactions. There are areas with transparent markets, and there are areas with less transparent markets (nonmarket areas), but these areas together comprise a market, and overall market efficiency would benefit from the increased transparency that would derive from a better understanding of loop flows.

For a complete loop flow analysis, several types of data are required from all balancing authorities in the Eastern Interconnection. The Commission required access to NERC Tag data. In addition to the Tag data, actual tie line data,

dynamic schedule and pseudo-tie data are required in order to analyze the differences between actual and scheduled transactions. ACE data, market flow impact data and generation and load data are required in order to understand the sources, within each balancing authority, of loop flows that do not result from differences between actual and scheduled transactions.²⁵

NERC Tag Data

An analysis of loop flow requires knowledge of the scheduled path of energy transactions. NERC Tag data include the scheduled path and energy profile of the transactions, including the Generation Control Area (GCA), the intermediate Control Areas, the Load Control Area (LCA) and the energy profile of all transactions. Complete tag data include the identity of the specific market participants. FERC Order No. 771 required access to NERC Tag data for the Commission, regional transmission organizations, independent system operators and market monitoring units.²⁶

Actual Tie Line Flow Data

An analysis of loop flow requires knowledge of the actual path of energy transactions. Currently, a very limited set of tie line data is made available via the NERC IDC and the Central Repository for Curtailments (CRC) website. The available tie line data, and the data within the IDC, are presented as information on a screen, which does not permit analysis of the underlying data.

Dynamic Schedule and Pseudo Tie Data

Dynamic schedule and pseudo ties represent another type of interchange transaction between balancing authorities. While dynamic schedules are required to be tagged, the tagged profile is only an estimate of what energy is expected to flow. Dynamic schedules are implemented within each balancing authority's Energy Management System (EMS), with the current values shared over Inter-Control Center Protocol (ICCP) links. By definition, the dynamic schedule scheduled and actual values will always be identical from a balancing authority standpoint, and the tagged profile should be removed

²⁵ It is requested that all data be made available in downloadable format in order to make analysis possible. A data viewing tool alone is not adequate.

²⁶ 141 FERC ¶ 61,235 (2012).

from the calculation of loop flows to eliminate double counting of the energy profile. Dynamic schedule data from all balancing authorities are required in order to account for all scheduled and actual flows.

Pseudo-ties are similar to dynamic schedules in that they represent a transaction between balancing authorities and are handled within the EMS systems and data are shared over the ICCP. Pseudo ties differ from dynamic schedules in how the generating resource is modeled within the balancing authorities' ACE equations. Dynamic schedules are modeled as resources located in one area serving load in another, while pseudo ties are modeled as resources in one area moved to another area. Unlike dynamic schedules, pseudo tie transactions are not required to be tagged. Pseudo tie data from all balancing authorities are required in order to account for all scheduled and actual flows.

Area Control Error (ACE) Data

Area control error (ACE) data provides information about how well each balancing authority is matching their generation with their load. This information, combined with the scheduled and actual interchange values will show whether an individual balancing authority is pushing on or leaning on the interconnection, contributing to loop flows.

NERC makes real-time ACE graphs available on their Reliability Coordinator Information System (RCIS) website. This information is presented only in graphical form, and the underlying data is not available for analysis.

Market Flow Impact Data

In addition to interchange transactions, internal dispatch can also affect flows on balancing authorities' tie lines. The impact of internal dispatch on tie lines is called market flow. Market flow data are imported in the IDC, but there is only limited historical data, as only market flow data related to TLR levels 3 or higher are required to be made available via a Congestion Management Report (CMR). The remaining data are deleted.

There is currently a project in development through the NERC Operating Reliability Subcommittee (ORS) called the Market Flow Impact Tool. The purpose of this tool is to make visible the impacts of dispatch on loop flows. The MMU supports the development of this tool, but, equally important, requests that FERC and NERC ensure that the underlying data are provided to market monitors and other approved entities.

Generation and Load Data

Generation data (both real-time scheduled generation and actual output) and load data would permit analysis of the extent to which balancing authorities are meeting their commitments to serve load. If a balancing authority is not meeting its load commitment with adequate generation, the result is unscheduled flows across the interconnections to establish power balance.

Market areas are transparent in providing real-time load while nonmarket areas are not. For example, PJM posts real-time load via its eDATA application. Most nonmarket balancing authorities provide only the expected peak load on their individual websites. Data on generation are not made publicly available, as this is considered market sensitive information.

The MMU recommends, that in order to permit a complete analysis of loop flow, FERC and NERC ensure that the identified data are made available to market monitors as well as other industry entities determined appropriate by FERC.

PJM and MISO Interface Prices

Both the PJM/MISO and MISO/PJM interface pricing points represent the value of power at the relevant border, as determined in each market. In both cases, the interface price is the price at which transactions are settled. For example, a transaction into PJM from MISO would receive the PJM/MISO interface price upon entering PJM, while a transaction into MISO from PJM would receive the MISO/PJM interface price. PJM and MISO use network models to determine these prices and to attempt to ensure that the prices are consistent with the underlying electrical flows.

Under the PJM/MISO Joint Operating Agreement, the two RTOs mutually determine a set of transmission facilities on which both RTOs have an impact, and therefore jointly operate to those constraints. These jointly controlled facilities are M2M (Market to Market) flowgates. When a M2M constraint binds, PJM’s LMP calculations at the buses that make up PJM’s MISO interface pricing point are based on the PJM model’s distribution factors of the selected buses to the binding M2M constraint and PJM’s shadow price of the binding M2M constraint. MISO’s LMP calculations at the buses that make up MISO’s PJM interface pricing point are based on the MISO model’s distribution factors of the selected buses to the binding M2M constraint and MISO’s shadow price of the binding M2M constraint.

Prior to June 1, 2014, the PJM interface definition for MISO consisted of nine buses located near the middle of the MISO system and not at the border between the RTOs. The interface definitions led to questions about the level of congestion included in interchange pricing.²⁷

PJM modified the definition of the PJM/MISO interface price effective June 1, 2014. PJM’s new MISO interface pricing point includes 10 equally weighted buses that are close to the PJM/MISO border. The 10 buses were selected based on PJM’s analysis that showed that over 80 percent of the hourly tie line flows between PJM and MISO occurred on 10 ties composed of MISO and PJM monitored facilities. On June 1, 2017, MISO modified their MISO/PJM interface definition to match PJM’s PJM/MISO interface definition.

Real-Time and Day-Ahead PJM/MISO Interface Prices

In the first three months of 2021, the direction of flow was consistent with price differentials in 60.2 percent of the hours. Table 9-25 shows the number of hours and average hourly price differences between the PJM/MISO Interface and the MISO/PJM Interface based on LMP differences and flow direction. Figure 9-5 shows the underlying variability in prices calculated on a daily hourly average basis. There are a number of relevant measures of variability, including the number of times the price differential fluctuates between

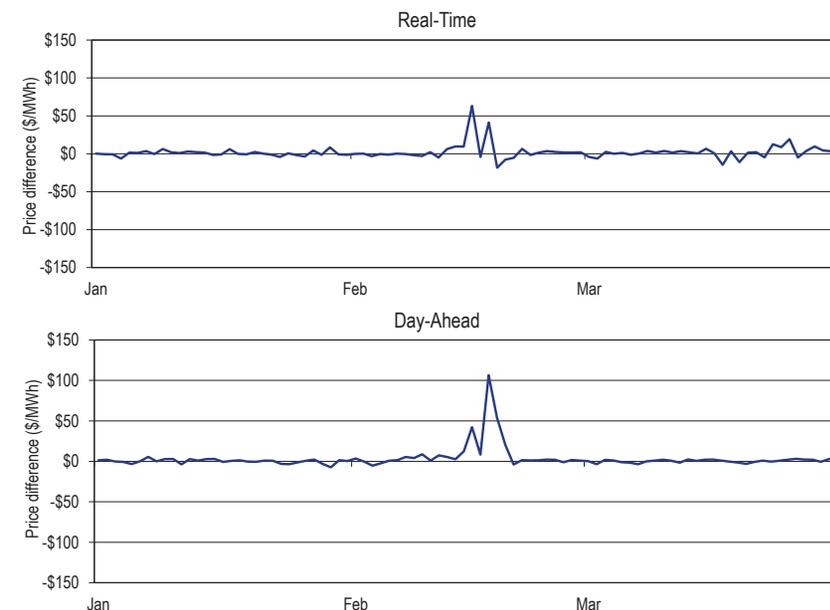
²⁷ See "LMP Aggregate Definitions," (March 10, 2021) <<http://www.pjm.com/~media/markets-ops/energy/lmp-model-info/lmp-aggregate-definitions.ashx>>. PJM periodically updates these definitions on its website. See <<http://www.pjm.com>>.

positive and negative, the standard deviation of individual prices and of price differences and the absolute value of the price differences (Table 9-29).

Table 9-25 PJM and MISO flow based hours and price differences: January through March, 2021

LMP Difference	Flow Direction	Number of Hours	Average Hourly Price Difference
MISO/PJM LMP > PJM/MISO LMP	Total Hours	1,299	\$8.38
	Consistent Flow (PJM to MISO)	1,299	\$8.38
	Inconsistent Flow (MISO to PJM)	0	\$0.00
	No Flow	0	\$0.00
PJM/MISO LMP > MISO/PJM LMP	Total Hours	860	\$7.97
	Consistent Flow (MISO to PJM)	0	\$0.00
	Inconsistent Flow (PJM to MISO)	860	\$7.97
	No Flow	0	\$0.00

Figure 9-5 Price differences (MISO/PJM Interface minus PJM/MISO Interface): January through March, 2021



Distribution and Prices of Hourly Flows at the PJM/MISO Interface

In the first three months of 2021, the direction of hourly energy flows was consistent with PJM and MISO interface price differentials in 1,299 hours (60.2 percent of all hours), and was inconsistent with price differentials in 860 hours (39.8 percent of all hours). Table 9-26 shows the distribution of hourly energy flows between PJM and MISO based on the price differences between the PJM/MISO and MISO/PJM prices. Of the 860 hours where flows were in a direction inconsistent with price differences, 653 of those hours (75.9 percent) had a price difference greater than or equal to \$1.00 and 273 of those hours (31.7 percent) had a price difference greater than or equal to \$5.00. The largest price difference with such flows was \$469.04. Of the 1,299 hours where flows were consistent with price differences, 1,033 of those hours (79.5 percent) had a price difference greater than or equal to \$1.00 and 340 of all such hours (26.2 percent) had a price difference greater than or equal to \$5.00. The largest price difference with such flows was \$450.45.

Table 9-26 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and MISO: January through March, 2021

Price Difference Range (Greater Than or Equal To)	Inconsistent Hours	Percent of Inconsistent Hours	Consistent Hours	Percent of Consistent Hours
\$0.00	860	100.0%	1,299	100.0%
\$1.00	653	75.9%	1,033	79.5%
\$5.00	273	31.7%	340	26.2%
\$10.00	137	15.9%	188	14.5%
\$15.00	95	11.0%	140	10.8%
\$20.00	72	8.4%	110	8.5%
\$25.00	54	6.3%	91	7.0%
\$50.00	23	2.7%	41	3.2%
\$75.00	9	1.0%	26	2.0%
\$100.00	6	0.7%	15	1.2%
\$200.00	3	0.3%	3	0.2%
\$300.00	2	0.2%	2	0.2%
\$400.00	1	0.1%	1	0.1%
\$500.00	0	0.0%	0	0.0%

PJM and NYISO Interface Prices

If interface prices were defined in a comparable manner by PJM and the NYISO, if identical rules governed external transactions in PJM and the NYISO, if time lags were not built into the rules governing such transactions and if no risks were associated with such transactions, then prices at the interfaces would be expected to be very close and the level of transactions would be expected to be related to any price differentials. The fact that none of these conditions exists is important in explaining the observed relationship between interface prices and inter-RTO/ISO power flows, and those price differentials.²⁸

PJM and NYISO each calculate an interface LMP using network models including distribution factor impacts. Prior to May 1, 2017, PJM used two buses within NYISO to calculate the PJM/NYIS interface pricing point LMP. The NYISO uses proxy buses to calculate interface prices with neighboring balancing authorities. A proxy bus is a single bus, located outside the NYISO footprint, which represents generation and load in a neighboring balancing authority area. The NYISO models imports from PJM as generation at the Keystone proxy bus, delivered to the NYISO reference bus with the assumption that 32 percent of the flow will enter the NYISO across the free flowing A/C ties, 32 percent will enter the NYISO across the Ramapo PARs, 21 percent will enter the NYISO across the ABC PARs and 15 percent will enter the NYISO across the J/K PARs. The NYISO models exports to PJM as being delivered to load at the Keystone proxy bus, sourced from the NYISO reference bus with the assumption that 32 percent of the flow will enter PJM across the free flowing A/C ties, 32 percent will enter PJM across the Ramapo PARs, 21 percent will enter PJM across the ABC PARs and 15 percent will enter PJM across the J/K PARs.

The PJM/NYIS interface definition using two buses was created to include the impact of the ConEd wheeling agreement. The ConEd wheeling agreement ended on May 1, 2017. The end of the wheeling agreement meant that the expected actual power flows would change and therefore the definition of the interface price needed to change. Effective May 1, 2017, PJM replaced the old PJM/NYIS interface price definition. The new PJM/NYIS interface

²⁸ See the 2012 State of the Market Report for PJM, Volume II, Section 8, "Interchange Transactions," for a more detailed discussion.

price is based on four buses within NYISO. The four buses were chosen based on a power flow analysis of transfers between PJM and the NYISO and the resultant distribution of flows across the free flowing A/C ties.

Real-Time and Day-Ahead PJM/NYISO Interface Prices

In the first three months of 2021, the relationship between prices at the PJM/NYIS Interface and at the NYISO/PJM proxy bus and the relationship between interface price differentials and power flows continued to be affected by differences in institutional and operating practices between PJM and the NYISO. The direction of flow was consistent with price differentials in 52.4 percent of the hours in the first three months of 2021. Table 9-27 shows the number of hours and average hourly price differences between the PJM/NYIS Interface and the NYIS/PJM proxy bus based on LMP differences and flow direction. Figure 9-6 shows the underlying variability in prices calculated on a daily hourly average basis. There are a number of relevant measures of variability, including the number of times the price differential fluctuates between positive and negative, the standard deviation of individual prices and of price differences and the absolute value of the price differences (Table 9-29).

Figure 9-6 Price differences (NY/PJM proxy - PJM/NYIS Interface): January through March, 2021



Table 9-27 PJM and NYISO flow based hours and price differences: January through March, 2021²⁹

LMP Difference	Flow Direction	Number of Hours	Average Hourly Price Difference
NYIS/PJM proxy bus LBMP > PJM/NYIS LMP	Total Hours	994	\$11.22
	Consistent Flow (PJM to NYIS)	930	\$11.59
	Inconsistent Flow (NYIS to PJM)	64	\$5.92
	No Flow	0	\$0.00
PJM/NYIS LMP > NYIS/PJM proxy bus LBMP	Total Hours	1,165	\$18.25
	Consistent Flow (NYIS to PJM)	202	\$11.34
	Inconsistent Flow (PJM to NYIS)	963	\$19.70
	No Flow	0	\$0.00

²⁹ The NYISO Locational Based Marginal Price (LBMP) is the equivalent term to PJM's Locational Marginal Price (LMP).

Distribution and Prices of Hourly Flows at the PJM/NYISO Interface

In the first three months of 2021, the direction of hourly energy flows was consistent with PJM/NYISO and NYISO/PJM price differences in 1,132 hours (52.4 percent of all hours), and was inconsistent with price differences in 1,027 hours (47.6 percent of all hours). Table 9-28 shows the distribution of hourly energy flows between PJM and NYISO based on the price differences between the PJM/NYISO and NYISO/PJM prices. Of the 1,027 hours where flows were in a direction inconsistent with price differences, 909 of those hours (88.5 percent) had a price difference greater than or equal to \$1.00 and 565 of all those hours (55.0 percent) had a price difference greater than or equal to \$5.00. The largest price difference with such flows was \$379.02. Of the 1,132 hours where flows were consistent with price differences, 1,004 of those hours (88.7 percent) had a price difference greater than or equal to \$1.00 and 617 of all such hours (54.5 percent) had a price difference greater than or equal to \$5.00. The largest price difference with such flows was \$521.78.

Table 9-28 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and NYISO: January through March, 2021

Price Difference Range (Greater Than or Equal To)	Inconsistent Hours	Percent of Inconsistent Hours	Consistent Hours	Percent of Consistent Hours
\$0.00	1,027	100.0%	1,132	100.0%
\$1.00	909	88.5%	1,004	88.7%
\$5.00	565	55.0%	617	54.5%
\$10.00	336	32.7%	331	29.2%
\$15.00	253	24.6%	208	18.4%
\$20.00	208	20.3%	142	12.5%
\$25.00	173	16.8%	112	9.9%
\$50.00	92	9.0%	36	3.2%
\$75.00	55	5.4%	19	1.7%
\$100.00	41	4.0%	11	1.0%
\$200.00	16	1.6%	2	0.2%
\$300.00	3	0.3%	1	0.1%
\$400.00	0	0.0%	1	0.1%
\$500.00	0	0.0%	1	0.1%

Summary of Interface Prices between PJM and Organized Markets

Some measures of the real-time and day-ahead PJM interface pricing with MISO and with the NYISO are summarized and compared in Table 9-29, including average prices and measures of variability.

Table 9-29 PJM, NYISO and MISO border price averages: January through March, 2021³⁰

Description	Real-Time		Day-Ahead	
	NYISO	MISO	NYISO	MISO
PJM Price at ISO Border	\$34.96	\$28.08	\$31.67	\$29.48
ISO Price at PJM Border	\$30.21	\$29.95	\$32.07	\$32.81
Average Interval Price				
Difference at Border (PJM-ISO)	\$4.76	(\$1.87)	(\$0.40)	(\$3.33)
Average Absolute Value of Interval Difference at Border	\$68.74	\$50.69	\$6.46	\$15.60
Sign Changes per Day	40.1	45.3	3.1	2.8
Standard Deviation				
PJM Price at ISO Border	\$68.95	\$47.52	\$17.62	\$22.36
ISO Price at PJM Border	\$34.24	\$40.47	\$18.96	\$35.26
Difference at Border (PJM-ISO)	\$70.82	\$51.68	\$8.07	\$16.30

Neptune Underwater Transmission Line to Long Island, New York

The Neptune Line is a 65 mile direct current (DC) merchant 230 kV transmission line, with a capacity of 660 MW, providing a direct connection between PJM (Sayreville, New Jersey), and NYISO (Nassau County on Long Island). Schedule 14 of the PJM Open Access Transmission Tariff provides that power flows will only be from PJM to New York. The flows were consistent with price differentials in 53.8 percent of the hours in the first three months of 2021. Table 9-30 shows the number of hours and average hourly price differences between the PJM/NEPT Interface and the NYIS/Neptune bus based on LMP differences and flow direction.

³⁰ Effective April 1, 2018, PJM implemented 5 minute LMP settlements in the real-time energy market. The sign changes per day represented in this table reflect the number of intervals where the sign changed per day. For the real-time energy market, there are 288 five minute intervals. For the day-ahead market there are 24 hourly intervals.

Table 9-30 PJM and NYISO flow based hours and price differences (Neptune): January through March, 2021

LMP Difference	Flow Direction	Number of Hours	Average Hourly Price Difference
NYIS/Neptune Bus LBMP > PJM/NEPT LMP	Total Hours	1,848	\$33.58
	Consistent Flow (PJM to NYIS)	1,162	\$33.21
	Inconsistent Flow (NYIS to PJM)	0	\$0.00
	No Flow	686	\$34.21
PJM/NEPT LMP > NYIS/Neptune Bus LBMP	Total Hours	311	\$11.21
	Consistent Flow (NYIS to PJM)	0	\$0.00
	Inconsistent Flow (PJM to NYIS)	278	\$12.05
	No Flow	33	\$4.12

To move power from PJM to NYISO using the Neptune Line, two PJM transmission service reservations are required. A transmission service reservation is required from the PJM Transmission System to the Neptune HVDC Line (“Out Service”) and another transmission service reservation is required on the Neptune HVDC Line (“Neptune Service”).³¹ The PJM Out Service is covered by normal PJM OASIS business operations.³² The Neptune Service falls under the provisions for controllable merchant facilities, Schedule 14 of the PJM Tariff. The Neptune Service is also acquired on the PJM OASIS.

Neptune Service is owned by a primary rights holder, and any nonfirm service that is not used (as defined by a schedule on a NERC Tag) may be released either voluntarily by the primary rights holder or by default by PJM. The primary rights holder may elect to voluntarily release monthly, weekly, daily or hourly firm or nonfirm service. Voluntarily releasing the service allows for the primary rights holder to specify a rate to be charged for the released service. If the primary rights holder does not elect to voluntarily release nonfirm service, and does not use the service, the available transmission will be released by default at 12:00, one business day before the start of service. On March 31, 2021, the rate for the nonfirm service released by default was \$10.00 per MWh. The primary rights holder remains obligated to pay for the released service unless a second transmission customer acquires the released service.

³¹ See OASIS “PJM Business Practices for Neptune Transmission Service,” (August 21, 2015) <<http://www.pjm.com/~media/etools/oasis/merch-trans-facilities/neptune-oasis-Business-practices-doc-clean.ashx>>.

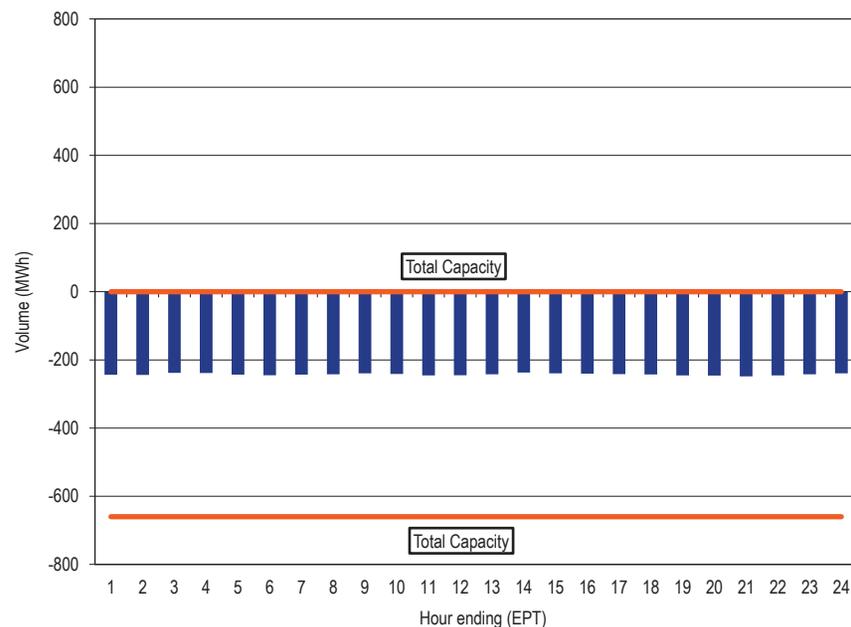
³² See OASIS “Regional Transmission and Energy Scheduling Practices,” Rev. 8 (June 23, 2019) <<http://www.pjm.com/~media/etools/oasis/regional-practices-clean-pdf.ashx>>.

Table 9-31 shows the percent of scheduled interchange across the Neptune Line by the primary rights holder since commercial operations began in July 2007. Table 9-31 shows that in the first three months of 2021, the primary rights holder was responsible for 100 percent of the scheduled interchange across the Neptune Line in all months. Figure 9-7 shows the hourly average flow across the Neptune Line for the first three months of 2021.

Table 9-31 Percent of scheduled interchange across the Neptune Line by primary rights holder: July 2007 through March 2021

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
February	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
March	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
April	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	99.99%	100.00%	100.00%	100.00%	100.00%	100.00%	
May	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
June	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
July	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
August	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
September	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
October	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
November	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	
December	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	

Figure 9-7 Neptune hourly average flow: January through March, 2021



Linden Variable Frequency Transformer (VFT) facility

The Linden VFT facility is a controllable AC merchant transmission facility, with a capacity of 315 MW, providing a direct connection between PJM (Linden, New Jersey) and NYISO (Staten Island, New York). The flows were consistent with price differentials in 75.8 percent of the hours in the first three months of 2021. Table 9-32 shows the number of hours and average hourly price differences between the PJM/LIND Interface and the NYIS/Linden Bus based on LMP differences and flow direction.

Table 9-32 PJM and NYISO flow based hours and price differences (Linden): January through March, 2021

LMP Difference	Flow Direction	Number of Hours	Average Hourly Price Difference
	Total Hours	1,636	\$20.09
NYIS/Linden Bus LBMP > PJM/LIND LMP	Consistent Flow (PJM to NYIS)	1,636	\$20.09
	Inconsistent Flow (NYIS to PJM)	0	\$0.00
	No Flow	0	\$0.00
PJM/LIND LMP > NYIS/Linden Bus LBMP	Total Hours	523	\$15.17
	Consistent Flow (NYIS to PJM)	0	\$0.00
	Inconsistent Flow (PJM to NYIS)	523	\$15.17
	No Flow	0	\$0.00

To move power from PJM to NYISO on the Linden VFT Line, two PJM transmission service reservations are required. A transmission service reservation is required from the PJM Transmission System to the Linden VFT (“Out Service”) and another transmission service reservation is required on the Linden VFT (“Linden VFT Service”).³³ The PJM Out Service is covered by normal PJM OASIS business operations.³⁴ The Linden VFT Service falls under the provisions for controllable merchant facilities, Schedule 16 and Schedule 16-A of the PJM Tariff. The Linden VFT Service is also acquired on the PJM OASIS.

Linden VFT Service is owned by a primary rights holder, and any nonfirm service that is not used (as defined by a schedule on a NERC Tag) may be released either voluntarily by the primary rights holder or by default by PJM. The primary rights holder may elect to voluntarily release monthly, weekly, daily or hourly firm or nonfirm service. Voluntarily releasing the service allows for the primary rights holder to specify a rate to be charged for the released service. If the primary rights holder elects to not voluntarily release nonfirm service, and does not use the service, the available transmission will be released by default at 12:00, one business day before the start of service. On March 31, 2021, the rate for the nonfirm service released by default was \$6.00 per MWh. The primary rights holder remains obligated to pay for the released service unless a second transmission customer acquires the released service.

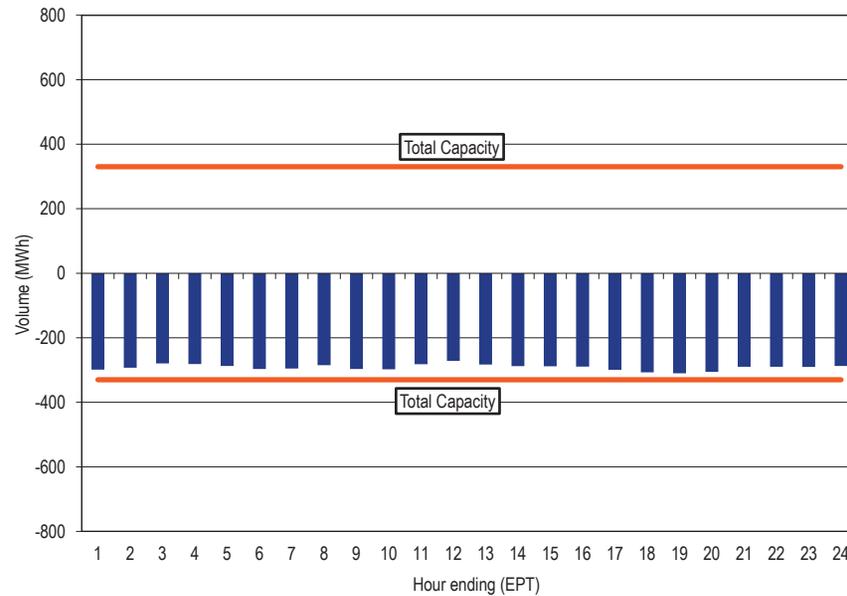
Table 9-33 shows the percent of scheduled interchange across the Linden VFT Line by the primary rights holder since commercial operations began in November, 2009. Table 9-33 shows that in the first three months of 2021, the primary rights holder was responsible for 100 percent of the scheduled interchange across the Linden VFT Line in all months. Figure 9-8 shows the hourly average flow across the Linden VFT Line for the first three months of 2021.

Table 9-33 Percent of scheduled interchange across the Linden VFT Line by primary rights holder: November 2009 through March 2021

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	70.53%	100.00%	100.00%	100.00%	100.00%	100.00%
February	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	94.95%	100.00%	100.00%	100.00%	100.00%	100.00%
March	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	96.46%	100.00%	100.00%	100.00%	100.00%	100.00%
April	NA	99.97%	100.00%	100.00%	100.00%	99.98%	100.00%	49.32%	100.00%	100.00%	100.00%	100.00%	100.00%
May	NA	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
June	NA	100.00%	100.00%	100.00%	100.00%	27.27%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
July	NA	100.00%	100.00%	100.00%	100.00%	29.56%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
August	NA	100.00%	100.00%	100.00%	100.00%	82.46%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
September	NA	100.00%	100.00%	100.00%	100.00%	81.68%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
October	NA	100.00%	100.00%	100.00%	100.00%	100.00%	35.05%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
November	100.00%	100.00%	100.00%	100.00%	99.86%	100.00%	61.45%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
December	100.00%	100.00%	100.00%	98.22%	100.00%	100.00%	84.57%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

³³ See OASIS “PJM Business Practices for Linden VFT Transmission Service,” (June 1, 2011) <<http://www.pjm.com/~media/etools/oasis/merch-trans-facilities/linden-vft-oasis-Business-practices-doc-clean.ashx>>.

³⁴ See OASIS “Regional Transmission and Energy Scheduling Practices,” Rev. 8 (June 23, 2019) <<http://www.pjm.com/~media/etools/oasis/regional-practices-clean-doc.ashx>>.

Figure 9-8 Linden hourly average flow: January through March, 2021³⁵

Hudson Direct Current (DC) Merchant Transmission Line

The Hudson direct current (DC) Line is a bidirectional merchant 230 kV transmission line, with a capacity of 673 MW, providing a direct connection between PJM (Public Service Electric and Gas Company's (PSE&G) Bergen 230 kV Switching Station located in Ridgfield, New Jersey) and NYISO (Consolidated Edison's (Con Ed) W. 49th Street 345 kV Substation in New York City). The connection is a submarine cable system. While the Hudson DC Line is a bidirectional line, power flows are only from PJM to New York because the Hudson Transmission Partners, LLC had only requested withdrawal rights (320 MW of firm withdrawal rights, and 353 MW of nonfirm withdrawal rights). The flows were consistent with price differentials in 62.3 percent of the hours in the first three months of 2021. Table 9-34 shows the number of

³⁵ The Linden VFT Line is a bidirectional facility. The "Total Capacity" lines represent the maximum amount of interchange possible in either direction. These lines were included to maintain a consistent scale, for comparison purposes, with the Neptune DC Tie Line.

hours and average hourly price differences between the PJM/HUDS Interface and the NYIS/Hudson bus based on LMP differences and flow direction.

Table 9-34 PJM and NYISO flow based hours and price differences (Hudson): January through March, 2021

LMP Difference	Flow Direction	Number of Hours	Average Hourly Price Difference
NYIS/Hudson Bus LBMP > PJM/HUDS LMP	Total Hours	1,384	\$15.22
	Consistent Flow (PJM to NYIS)	1,345	\$15.51
	Inconsistent Flow (NYIS to PJM)	0	\$0.00
	No Flow	39	\$5.21
PJM/HUDS LMP > NYIS/Hudson Bus LBMP	Total Hours	775	\$26.18
	Consistent Flow (NYIS to PJM)	0	\$0.00
	Inconsistent Flow (PJM to NYIS)	767	\$26.39
	No Flow	8	\$6.44

To move power from PJM to NYISO on the Hudson Line, two PJM transmission service reservations are required. A transmission service reservation is required from the PJM Transmission System to the Hudson Line ("Out Service") and another transmission service reservation is required on the Hudson Line ("Hudson Service").³⁶ The PJM Out Service is covered by normal PJM OASIS business operations.³⁷ The Hudson Service falls under the provisions for controllable merchant facilities, Schedule 17 of the PJM Tariff. The Hudson Service is also acquired on the PJM OASIS.

Hudson Service is owned by a primary rights holder, and any nonfirm service that is not used (as defined by scheduled on a NERC Tag) may be released either voluntarily by the primary rights holder or by default by PJM. The primary rights holder may elect to voluntarily release monthly, weekly, daily or hourly firm or nonfirm service. Voluntarily releasing the service allows for the primary rights holder to specify a rate to be charged for the released service. If the primary rights holder elects to not voluntarily release nonfirm service, and does not use the service, the available transmission will be released by default at 12:00, one business day before the start of service. On

³⁶ See OASIS "PJM Business Practices for Hudson Transmission Service," <<http://www.pjm.com/~media/etools/oasis/merch-trans-facilities/http-Business-practices.ashx>>.

³⁷ See OASIS "Regional Transmission and Energy Scheduling Practices," Rev. 8 (June 23, 2019) <<http://www.pjm.com/~media/etools/oasis/regional-practices-clean-doc.ashx>>.

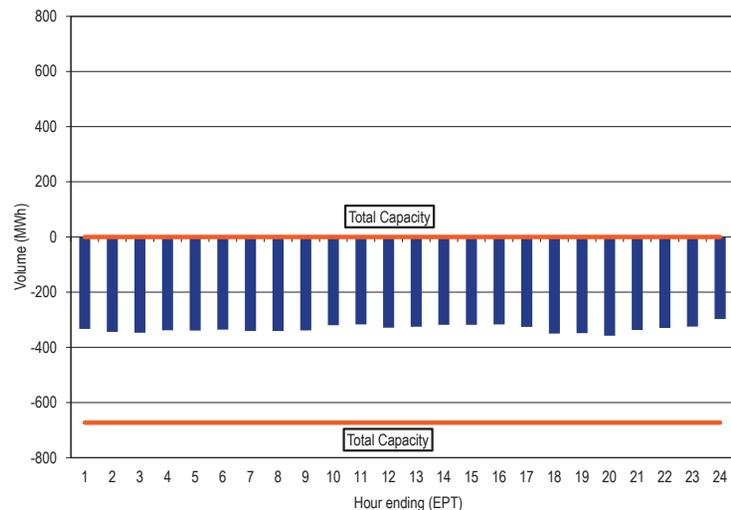
March 31, 2021, the rate for the nonfirm service released by default was \$10.00 per MWh. The primary rights holder remains obligated to pay for the released service unless a second transmission customer acquires the released service.

Table 9-35 shows the percent of scheduled interchange across the Hudson Line by the primary rights holder since commercial operations began in May, 2013. Table 9-35 shows that in the first three months of 2021, the primary rights holder was responsible for less than 100 percent of the scheduled interchange across the Hudson Line in all months. Figure 9-9 shows the hourly average flow across the Hudson Line for the first three months of 2021.

Table 9-35 Percent of scheduled interchange across the Hudson Line by primary rights holder: May 2013 through March 2021³⁸

	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	NA	51.22%	16.27%	100.00%	NA	24.44%	52.21%	29.70%	37.64%
February	NA	49.00%	14.67%	NA	NA	23.25%	77.12%	23.61%	47.37%
March	NA	40.40%	71.88%	NA	NA	9.55%	72.42%	87.24%	53.27%
April	NA	100.00%	100.00%	NA	NA	15.13%	100.00%	10.02%	
May	100.00%	26.87%	100.00%	100.00%	NA	92.18%	100.00%	20.53%	
June	100.00%	5.89%	59.72%	100.00%	NA	44.89%	44.98%	38.26%	
July	100.00%	18.51%	84.34%	NA	NA	16.26%	36.43%	27.56%	
August	100.00%	75.17%	65.48%	NA	NA	19.24%	43.10%	35.64%	
September	100.00%	75.31%	78.73%	NA	NA	22.90%	43.42%	30.75%	
October	100.00%	99.71%	18.65%	100.00%	NA	22.67%	33.60%	52.58%	
November	85.57%	99.60%	24.67%	100.00%	80.12%	50.44%	44.36%	38.60%	
December	28.32%	1.68%	100.00%	NA	21.93%	29.38%	41.78%	38.82%	

Figure 9-9 Hudson hourly average flow: January through March, 2021



³⁸ The designation of "NA" means there was no flow on the Hudson Line during those months.

Interchange Activity During High Load Hours

The PJM metered system peak load during the first three months of 2021 was 114,457 MW in the HE 0900 on January 29, 2021. PJM was a net scheduled exporter of energy in all hours on January 29, 2021, with average hourly scheduled exports of 1,747 MW. During HE 0900 on January 29, 2021, PJM had net scheduled exports of 3,324 MW and net metered actual exports of 3,279 MW. Net transaction exports during this time were inconsistent with the price differences between PJM and MISO. Net transaction exports were also inconsistent with price differences between PJM and the NYISO interfaces (NYIS, Neptune, and Hudson) but consistent with price differences between PJM and the Linden interface. During January 2021, PJM was a net scheduled exporter of energy in all hours. During January 2021, the average hourly scheduled interchange was -3,068 MW (representing 3.3 percent of the average hourly load of 93,150 MW in January 2021).

Operating Agreements with Bordering Areas

To improve reliability and reduce potential seams issues, PJM and its neighbors have developed operating agreements, including: operating agreements with MISO and the NYISO; a reliability agreement with TVA; an operating agreement with Duke Energy Progress, Inc.; a reliability coordination agreement with VACAR South; a balancing authority operations agreement with the Wisconsin Electric Power Company (WEC); and a Northeastern planning coordination protocol with NYISO and ISO New England.

Table 9-36 shows a summary of the elements included in each of the operating agreements PJM has with its bordering areas.

Table 9-36 Summary of elements included in operating agreements with bordering areas

Agreement:	PJM-MISO	PJM-NYISO	PJM-TVA	PJM-DEP	PJM-VACAR	PJM-WEP	Northeastern Protocol
Data Exchange							
Real-Time Data	YES	YES	YES	YES	YES	YES	NO
Projected Data	YES	YES	YES	YES	NO	NO	NO
SCADA Data	YES	YES	YES	YES	NO	NO	NO
EMS Models	YES	YES	YES	YES	NO	NO	YES
Operations Planning Data	YES	YES	YES	YES	NO	NO	YES
Available Flowgate Capability Data	YES	YES	YES	YES	NO	NO	YES
Near-Term System Coordination							
Operating Limit Violation Assistance	YES	YES	YES	YES	YES	NO	NO
Over/Under Voltage Assistance	YES	YES	YES	YES	YES	NO	NO
Emergency Energy Assistance	YES	YES	NO	YES	YES	NO	NO
Outage Coordination	YES	YES	YES	YES	YES	NO	NO
Long-Term System Coordination	YES	YES	YES	YES	NO	NO	YES
Congestion Management Process							
ATC Coordination	YES	YES	YES	YES	NO	NO	NO
Market Flow Calculations	YES	YES	YES	NO	NO	NO	NO
Firm Flow Entitlements	YES	YES	YES	NO	NO	NO	NO
Market to Market Redispatch	YES - Redispatch	YES - Redispatch	NO	NO	NO	NO	NO
Joint Checkout Procedures	YES	YES	YES	YES	NO	YES	NO

PJM-MISO = MISO/PJM Joint Operating Agreement

PJM-NYISO = New York ISO/PJM Joint Operating Agreement

PJM-TVA = Joint Reliability Coordination Agreement Between PJM - Tennessee Valley Authority (TVA)

PJM-DEP = Duke Energy Progress (DEP) - PJM Joint Operating Agreement

PJM-VACAR = PJM-VACAR South Reliability Coordination Agreement

PJM-WEP = Balancing Authority Operations Coordination Agreement Between Wisconsin Electric Power Company and PJM Interconnection, LLC

Northeastern Protocol = Northeastern ISO-Regional Transmission Organization Planning Coordination Protocol

PJM and MISO Joint Operating Agreement³⁹

The Joint Operating Agreement between MISO and PJM Interconnection, L.L.C. was executed on December 31, 2003. The PJM/MISO JOA includes provisions for market based congestion management that, for designated flowgates within MISO and PJM, allow for redispatch of units within the PJM and MISO regions to jointly manage congestion on these flowgates and to assign the costs of congestion management appropriately. In 2012, MISO and PJM initiated a joint stakeholder process to address issues associated with the operation of the markets at the seam.⁴⁰

Under the market to market rules, the organizations coordinate pricing at their borders. PJM and MISO each calculate an interface LMP using network models including distribution factor impacts. PJM uses 10 buses along the PJM/MISO border to calculate the PJM/MISO interface pricing point LMP. Prior to June 1, 2017, MISO used all of the PJM generator buses in its model of the PJM system in its calculation of the MISO/PJM interface pricing point.⁴¹ On June 1, 2017, MISO modified their MISO/PJM interface definition to match PJM's PJM/MISO interface definition.⁴²

An operating entity is an entity that operates and controls a portion of the bulk transmission system with the goal of ensuring reliable energy interchange between generators, loads and other operating entities.⁴³ Coordinated flowgates are identified to determine which flowgates an operating entity affects significantly. This set of flowgates may then be used in the congestion management process. An operating entity will conduct sensitivity studies to determine which flowgates are significantly affected by the flows of the operating entity's control zones (historic control areas that existed in the IDC). An operating entity identifies these flowgates by performing five studies to determine which flowgates the operating entity will monitor and help control. These studies include generation to load distribution factor studies, transfer

³⁹ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C." (December 11, 2008) <<http://www.pjm.com/directory/merged-tariffs/miso-joa.pdf>>.

⁴⁰ See "PJM/MISO Joint and Common Market Initiative," <<http://www.pjm.com/committees-and-groups/stakeholder-meetings/pjm-miso-joint-common.aspx>>.

⁴¹ See the 2012 State of the Market Report for PJM, Volume II, Section 8, "Interchange Transactions," for a more detailed discussion.

⁴² See "Joint and Common Market: MISO-PJM Interface Pricing Update," (November 15, 2016) <<http://www.pjm.com/~media/committees-groups/stakeholder-meetings/pjm-miso-joint-common/20161115/20161115-item-03a-interface-pricing-post-implementation.ashx>>.

⁴³ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C." (December 11, 2008) <<http://www.pjm.com/directory/merged-tariffs/miso-joa.pdf>>.

distribution factor analysis and an external asynchronous resource study. An operating entity may also specify additional flowgates that have not passed any of the five studies to be coordinated flowgates where the operating entity expects to use the TLR process to manage congestion.⁴⁴ A reciprocal coordinated flowgate (RCF) is a CF that is monitored and controlled by PJM or MISO, on which both have significant impacts. Only RCFs are subject to the market to market congestion management process.

As of January 1, 2021, PJM had 143 flowgates eligible for M2M (Market to Market) coordination. In the first three months of 2021, PJM added 16 flowgates, resulting in 159 flowgates eligible for M2M coordination as of March 31, 2021. As of January 1, 2021, MISO had 147 flowgates eligible for M2M coordination. In the first three months of 2021, MISO added 14 flowgates and deleted 28 flowgates, resulting in 133 flowgates eligible for M2M coordination as of March 31, 2021.

The firm flow entitlement (FFE) represents the amount of historic 2004 flow that each RTO had created on each RCF used in the market to market settlement process. The FFE establishes the amount of market flow that each RTO is permitted to create on the RCF before incurring redispatch costs during the market to market process. If the nonmonitoring RTO's real-time market flow is greater than their FFE plus the approved MW adjustment from day-ahead coordination, then the nonmonitoring RTO will pay the monitoring RTO based on the difference between their market flow and their FFE. If the nonmonitoring RTO's real-time market flow is less than their FFE plus the approved MW adjustment from day-ahead coordination, then the monitoring RTO will pay the nonmonitoring RTO for congestion relief provided by the nonmonitoring RTO based on the difference between the nonmonitoring RTO's market flow and their FFE.

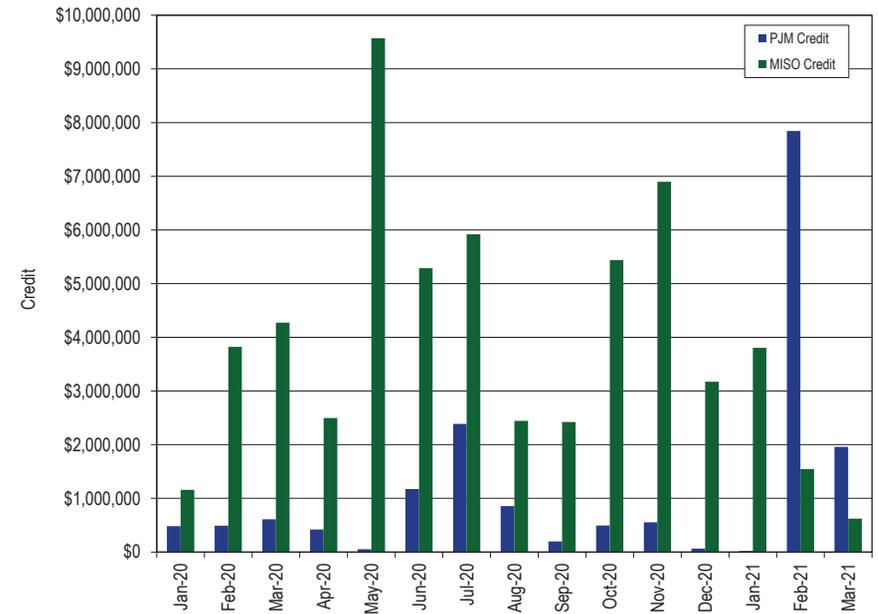
April 1, 2004, known as the freeze date, is used to determine the firm rights on flowgates based on historic premarket firm flows as of that date. In the past 16 years, topology and market changes have occurred, making the 2004 flows irrelevant in 2020. The RTOs and stakeholders recognize that a modification

⁴⁴ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C." (December 11, 2008) <<http://www.pjm.com/directory/merged-tariffs/miso-joa.pdf>>.

to the freeze date is necessary.⁴⁵ PJM and MISO stakeholders have spent several years on the freeze date issues. Discussions regarding the Firm Flow Limit (FFL) solutions between market and nonmarket areas are also ongoing. No resolution to these issues appears imminent. The final resolution to the freeze date alternative should account for the investments made by each RTO in the transmission system. The MMU recommends modifications to the FFE calculation to ensure that FFE calculations reflect the current capability of the transmission system as it evolves. The MMU recommends that the Commission set a deadline for PJM and MISO to resolve the FFE freeze date and related issues.

In the first three months of 2021, market to market operations resulted in MISO and PJM redispatching units to control congestion on M2M flowgates and the exchange of payments for this redispatch. Figure 9-10 shows credits for coordinated congestion management between PJM and MISO.

Figure 9-10 PJM/MISO credits for coordinated congestion management: January 2020 through March 2021⁴⁶



⁴⁵ See "Freeze Date Alternatives," (May 21, 2019) <<https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/pjm-miso-joint-common/20190521/20190521-item-01-freeze-date-update.ashx>>.

⁴⁶ The totals represented in this figure represent the settlements as of the time of this report and may not include adjustments or resettlements.

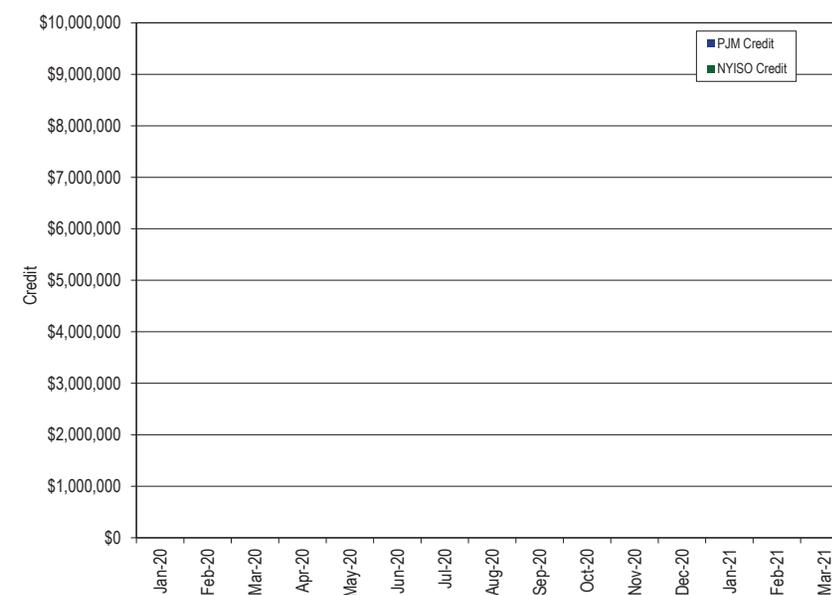
PJM and New York Independent System Operator Joint Operating Agreement (JOA)⁴⁷

The Joint Operating Agreement between NYISO and PJM Interconnection, L.L.C. became effective on January 15, 2013. Under the market to market rules, the organizations coordinate pricing at their borders.

On June 28, 2019, NYISO and PJM submitted revisions to the NYISO-PJM Joint Operating Agreement (JOA). The revisions would address RTO concerns identified in their joint request for limited waiver of the JOA to authorize redispatch of generation in PJM. The intent of the redispatch would be to mitigate post-contingency overloads of transmission equipment on the New York side of the East Towanda-Hillside 230 kV Transmission Line. The agreement allows for the RTOs to control for this contingency without the exchange of payments for redispatch.⁴⁸

In the first three months of 2021, market to market operations did not result in NYISO and PJM redispatching units to control congestion on M2M flowgates. Therefore, there was no exchange of payments for redispatch in the first three months of 2021. Figure 9-11 shows credits for coordinated congestion management between PJM and NYISO.

Figure 9-11 PJM/NYISO credits for coordinated congestion management (flowgates): January 2020 through March 2021⁴⁹



The M2M coordination process focuses on real-time market coordination to manage transmission limitations that occur on M2M flowgates in a cost effective manner. Coordination between NYISO and PJM includes not only joint redispatch, but also incorporates coordinated operation of the PARs that are located at the PJM/NYIS border. This real-time coordination results in an efficient economic dispatch solution across both markets to manage the real-time transmission constraints that impact both markets, focusing on the actual flows in real time to manage constraints.⁵⁰ For each M2M flowgate, a PAR settlement will occur for each interval during coordinated operations. The PAR settlements are determined based on whether the measured real-time flow on each of the PARs is greater than or less than the calculated target value. If the actual flow is greater than the target flow, NYISO will make

⁴⁷ See "New York Independent System Operator, Inc., Joint Operating Agreement with PJM Interconnection, L.L.C.," (September 16, 2019) <<http://www.pjm.com/~media/documents/agreements/nyiso-joa.ashx>>.

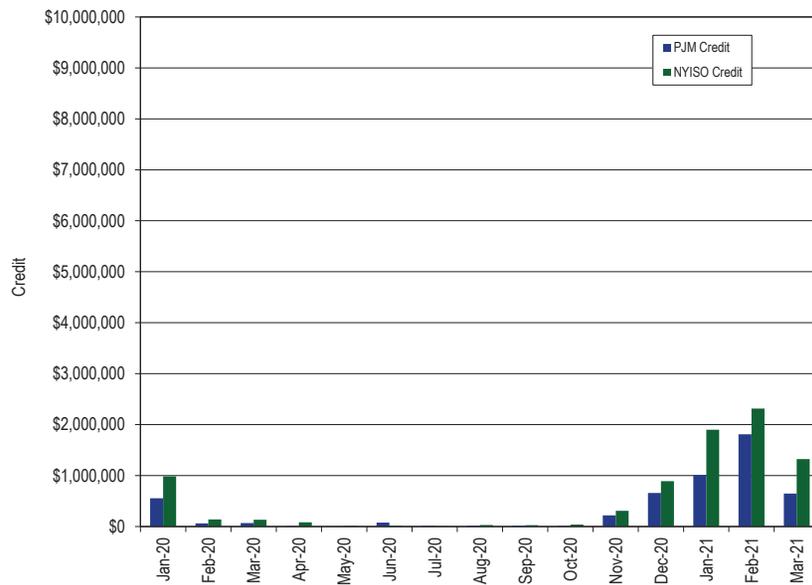
⁴⁸ See NYISO Filing, FERC Docket No. ER19-2282-000 (June 28, 2019).

⁴⁹ The totals represented in this figure represent the settlements as of the time of this report and may not include adjustments or resettlements.

⁵⁰ See "New York Independent System Operator, Inc., Joint Operating Agreement with PJM Interconnection, L.L.C.," (September 16, 2019) <<http://www.pjm.com/~media/documents/agreements/nyiso-joa.ashx>>.

a payment to PJM. This payment is calculated as the product of the M2M flowgate shadow price, the PAR shift factor and the difference between the actual and target PAR flow. If the actual flow is less than the target flow, PJM will make a payment to NYISO. This payment is calculated as the product of the M2M flowgate shadow price, the PAR shift factor and the difference between the target and actual PAR flow. Effective May 1, 2017, coincident with the termination of the ConEd wheel, PJM and NYISO began M2M coordination at all of the PARs along the PJM/NYISO seam. Prior to May 1, 2017, only the Ramapo PARs were included in the M2M process. In the first three months of 2021, market to market operations resulted in NYISO and PJM adjusting PARs to control congestion and the exchange of payments for this coordination. Figure 9-12 shows the PAR credits for coordinated congestion management between PJM and NYISO.

Figure 9-12 PJM/NYISO credits for coordinated congestion management (PARs): January 2020 through March 2021⁵¹



⁵¹ The totals represented in this figure represent the settlements as of the time of this report and may not include adjustments or resettlements.

PJM and TVA Joint Reliability Coordination Agreement (JRCA)⁵²

The joint reliability coordination agreement (JRCA) executed on April 22, 2005, provides for the exchange of information and the implementation of reliability and efficiency protocols between TVA and PJM. The agreement also provides for the management of congestion and arrangements for both near-term and long-term system coordination. Under the JRCA, PJM and TVA honor constraints on the other's flowgates in their Available Transmission Capability (ATC) calculations. Market flows are calculated on reciprocal flowgates. When a constraint occurs on a reciprocal flowgate within TVA, PJM has the option to redispatch generation to reduce market flow, and therefore alleviate the constraint. Unlike the M2M procedure between MISO and PJM, this redispatch does not result in M2M payments. However, electing to redispatch generation within PJM can avoid potential market disruption by curtailing transactions under the Transmission Line Loading Relief (TLR) procedure to achieve the same relief. The agreement remained in effect in the first three months of 2021.

PJM and Duke Energy Progress, Inc. Joint Operating Agreement⁵³

On September 9, 2005, FERC approved a JOA between PJM and Progress Energy Carolinas, Inc. (PEC), with an effective date of July 30, 2005. As part of this agreement, both parties agreed to develop a formal congestion management protocol (CMP). On February 2, 2010, PJM and PEC filed a revision to include a CMP under Article 14 of the JOA.⁵⁴ On January 20, 2011, the Commission conditionally accepted the compliance filing. On July 2, 2012, Duke Energy and Progress Energy Inc. completed a merger. At that time, Progress Energy Carolinas Inc., now a subsidiary of Duke Energy, changed its name to Duke Energy Progress (DEP).

⁵² See "Joint Reliability Coordination Agreement Among and Between PJM Interconnection, L.L.C., and Tennessee Valley Authority," (October 15, 2014) <<http://www.pjm.com/~media/documents/agreements/joint-reliability-coordination-agreement-miso-pjm-tva.ashx>>.

⁵³ See "Amended and Restated Joint Operating Agreement Among and Between PJM Interconnection, L.L.C., and Duke Energy Progress Inc.," (July 22, 2019) <<http://www.pjm.com/directory/merged-tariffs/progress-joa.pdf>>.

⁵⁴ See *PJM Interconnection, L.L.C. and Progress Energy Carolinas, Inc.* Docket No. ER10-713-000 (February 2, 2010).

On May 20, 2019, PJM and DEP submitted revisions to the JOA to delete Article 14.⁵⁵ PJM and DEP requested an effective date of July 22, 2019, for the filed revisions. On July 2, 2019, the Commission issued a letter order accepted the revisions to the JOA to delete the congestion management agreement effective July 22, 2019.⁵⁶

PJM and VACAR South Reliability Coordination Agreement⁵⁷

On May 23, 2007, PJM and VACAR South (comprised of Duke Energy Carolinas, LLC (DUK), DEP, South Carolina Public Service Authority (SCPSA), Southeast Power Administration (SEPA), South Carolina Energy and Gas Company (SCE&G) and Yadkin Inc. (a part of Alcoa)) entered into a reliability coordination agreement which provides for system and outage coordination, emergency procedures and the exchange of data. The parties meet on a yearly basis. The agreement remained in effect in the first three months of 2021.

VACAR Reserve Sharing Agreement

The VACAR Reserve Sharing Agreement (VRSA) is a combination of agreements among the entities in the VACAR Subregion including Dominion.⁵⁸ VACAR is a subregion of the SERC Reliability Corporation (SERC) region. The agreement remained in effect in the first three months of 2021. The agreement requires that each entity maintain primary reserves to meet the VACAR contingency reserve commitment (VACAR reserves) and deploy such reserves in the case of an emergency (e.g. loss of a unit in VACAR).⁵⁹ Dominion is the only party to the VRSA that is also a transmission owner and a generation owner in PJM. The VRSA is not a public agreement. PJM is not a party to the VRSA. However, as the reliability coordinator for Dominion Virginia Power, PJM is responsible for scheduling Dominion's required reserves in the SERC region as described in the PJM manuals.⁶⁰

⁵⁵ See *PJM Interconnection, LLC*, Docket No. ER19-1905-000 (May 20, 2019).

⁵⁶ FERC Docket No. ER19-1905-000 (July 2, 2019).

⁵⁷ See "PJM-VACAR South RC Agreement," (November 7, 2014) <<http://www.pjm.com/~media/documents/agreements/executed-pjm-vacar-rc-agreement.ashx>>.

⁵⁸ VRSA entities: Dominion, Duke Energy Progress, Duke Energy Carolinas, South Carolina Electric & Gas Company, South Carolina Public Service Authority and Cube Hydro Carolinas.

⁵⁹ See SERC Regional Criteria, Contingency Reserve Policy, NERC Reliability Standard BAL-002 at 10-11.

⁶⁰ See PJM, "Manual 13: Emergency Operations," Rev. 78 (January 27, 2021).

There are issues with the VRSA. The details of the VRSA, including any responsibilities assigned to PJM, are not public. Under PJM's Operating Reserve Demand Curve (ORDC) method of procuring reserves, expected to be implemented on May 1, 2022, it will not be possible for Dominion to meet both the VRSA and the PJM reserve rules.⁶¹

Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company (WEC) and PJM Interconnection, LLC⁶²

The Balancing Authority Operations Coordination Agreement executed on July 20, 2013, provides for the exchange of information between WEC and PJM. The purpose of the data exchange is to allow for the coordination of balancing authority actions to ensure the reliable operation of the systems. The agreement remained in effect in the first three months of 2021.

Northeastern ISO-Regional Transmission Organization Planning Coordination Protocol⁶³

The Northeastern ISO-RTO Planning Coordination Protocol executed on December 8, 2004, provides for the exchange of information among PJM, NYISO and ISO New England. The purpose of the data exchange is to allow for the long-term planning coordination among and between the ISOs and RTOs in the Northeast. The agreement remained in effect in the first three months of 2021.

Interchange Transaction Issues

PJM Transmission Loading Relief Procedures (TLRs)

TLRs are called to control flows on electrical facilities when economic redispatch cannot solve overloads on those facilities. TLRs are called to control

⁶¹ See the *2021 Quarterly State of the Market Report for PJM: January through March*, Section 10: Ancillary Services, "VACAR Reserve Sharing Agreement" for more information on issues identified with the VACAR Reserve Sharing Agreement.

⁶² See "Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company and PJM Interconnection, LLC," (July 20, 2013) <<http://www.pjm.com/~media/documents/agreements/balancing-authority-operations-coordination-agreement.ashx>>.

⁶³ See "Northeastern ISO/RTO Planning Coordination Protocol," (December 8, 2004) <<http://www.pjm.com/~media/documents/agreements/northeastern-iso-rto-planning-coordination-protocol.ashx>>.

flows related to external balancing authorities, as redispatch within an LMP market can generally resolve overloads on internal transmission facilities.

The number of PJM issued TLRs of level 3a or higher was zero in the first three months of 2020 and two in the first three months of 2021.⁶⁴ The number of different flowgates for which PJM declared a TLR 3a or higher was zero in the first three months of 2020, and one in the first three months of 2021. The total MWh of transactions curtailed was zero in the first three months of 2020 and zero in the first three months of 2021.

The number of MISO issued TLRs of level 3a or higher increased from 10 in the first three months of 2020 to 30 in the first three months of 2021. The number of different flowgates for which MISO declared a TLR 3a increased from five in the first three months of 2020 to 12 in the first three months of 2021. The total MWh of transaction curtailments increased by 645.3 percent from 6,082 MWh in the first three months of 2020 to 45,330 MWh in the first three months of 2021.

The number of NYISO issued TLRs of level 3a or higher decreased from two in the first three months of 2020 to one in the first three months of 2021. The number of different flowgates for which NYISO declared a TLR 3a or higher was one in the first three months of 2020, and one in the first three months of 2021. The total MWh of transaction curtailments decreased by 62.1 percent from 1,030 MWh in the first three months of 2020, to 390 MWh in the first three months of 2021.

Table 9-37 PJM, MISO, and NYISO TLR procedures: January through March, 2021⁶⁵

Month	Number of TLRs Level 3 and Higher			Number of Unique Flowgates That Experienced TLRs			Curtailment Volume (MWh)		
	PJM	MISO	NYISO	PJM	MISO	NYISO	PJM	MISO	NYISO
Jan-21	0	7	0	0	3	0	0	1,642	0
Feb-21	2	17	0	1	10	0	0	38,912	0
Mar-21	0	6	1	0	3	1	0	4,776	390
Total	2	30	1	1	12	1	0	45,330	390

⁶⁴ TLR Level 3a is the first level of TLR that results in the curtailment of transactions. See the *2020 State of the Market Report for PJM*, Volume II, Appendix E, "Interchange Transactions," for a more complete discussion of TLR levels.

⁶⁵ The total row in the columns of the number of unique flowgates that experience TLRs are not a sum of the individual months. The total row represents the number of unique flowgates that have experienced TLRs for the year to date.

Table 9-38 Number of TLRs by TLR level by reliability coordinator: January through March, 2021⁶⁶

Year	Reliability Coordinator	3a	3b	4	5a	5b	6	Total
	NYIS	1	0	0	0	0	0	1
	ONT	0	0	0	0	0	0	0
	PJM	0	2	0	0	0	0	2
	SOCO	0	0	0	0	0	0	0
	SWPP	3	2	2	14	8	0	29
	TVA	3	6	0	11	8	0	28
	VACS	1	3	0	0	0	0	4
Total		17	23	2	32	20	0	94

Up To Congestion

The original purpose, in 2000, of up to congestion transactions (UTC) was to allow market participants to submit a maximum congestion charge, up to \$25 per MWh, they were willing to pay on an import, export or wheel through transaction in the day-ahead energy market. This product was offered as a tool for market participants to limit their congestion exposure on scheduled transactions in the real-time energy market.⁶⁷

Up to congestion transactions affect the day-ahead dispatch and unit commitment. Despite that, up to congestion transactions were not required to pay uplift charges from their introduction in 2010 through October 31, 2020. On July 16, 2020, FERC issued an Order directing PJM to revise uplift allocation rules to allocate uplift to one side of up to congestion transactions.⁶⁸ The Order requires PJM to treat an up to congestion transaction, for uplift allocation purposes, as if the up to congestion transaction were equivalent to a DEC at its sink point. On November 1, 2020, PJM began allocating uplift to up to congestion transactions. Up to congestion transactions also negatively affect FTR funding.⁶⁹

⁶⁶ Southern Company Services, Inc. (SOCO) is the reliability coordinator covering a portion of Mississippi, Alabama, Florida and Georgia. Southwest Power Pool (SWPP) is the reliability coordinator for SPP. VACAR-South (VACS) is the reliability coordinator covering a portion of North Carolina and South Carolina.

⁶⁷ See the *2012 State of the Market Report for PJM*, Volume II, Section 8, "Interchange Transactions," for a more detailed discussion.

⁶⁸ 172 FERC ¶ 61,046 (2020).

⁶⁹ See the *2021 Quarterly State of the Market Report for PJM: January through March*, Section 13: FTRs and ARRs, "FTR Forfeitures" for more information on up to congestion transaction impacts on FTRs.

Up to congestion transaction volumes decreased following the allocation of uplift charges on November 1, 2020. The average number of up to congestion bids submitted in the day-ahead energy market decreased by 45.6 percent, from 49,461 bids per day in the first three months of 2020 to 26,918 bids per day in the first three months of 2021. The average cleared volume of up to congestion bids submitted in the day-ahead energy market decreased by 54.8 percent, from 464,019 MWh per day in the first three months of 2020, to 209,921 MWh per day in the first three months of 2021.

Figure 9-13 Monthly up to congestion cleared bids in MWh: January 2005 through March 2021

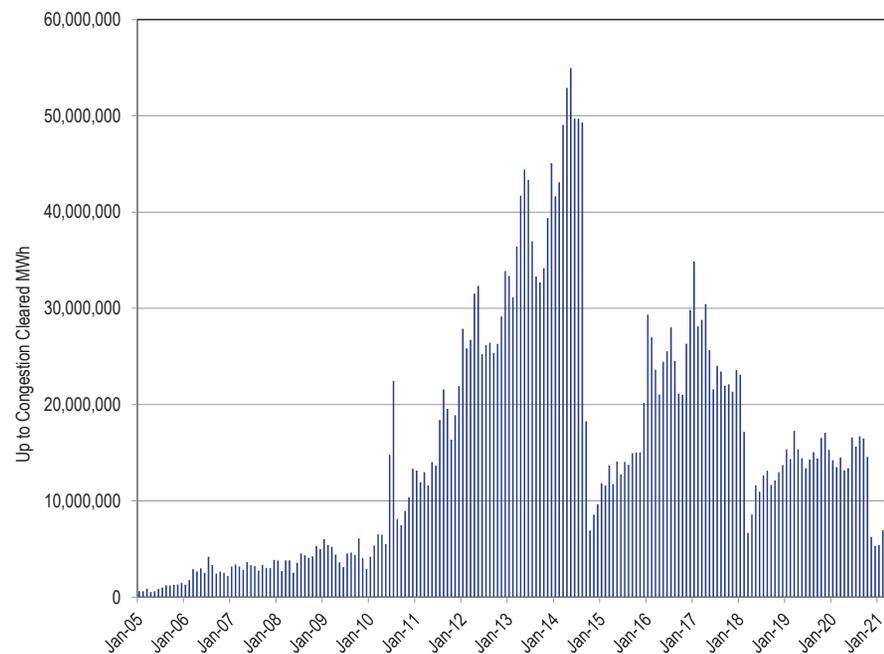


Table 9-39 Monthly volume of cleared and submitted up to congestion bids: January 2020 through March 2021

Month	Bid MW					Bid Volume				
	Import	Export	Wheel	Internal	Total	Import	Export	Wheel	Internal	Total
Jan-20	5,709,294	2,231,205	1,944,774	18,039,136	27,924,410	275,752	162,609	75,183	1,039,001	1,552,545
Feb-20	5,676,276	2,666,146	2,199,490	17,493,382	28,035,292	242,264	146,844	65,051	1,030,601	1,484,760
Mar-20	6,665,180	2,978,585	2,003,110	18,814,938	30,461,812	251,993	161,948	66,569	983,109	1,463,619
Apr-20	6,091,885	2,682,191	1,468,174	16,612,116	26,854,366	254,545	137,594	52,775	893,782	1,338,696
May-20	6,271,609	1,965,274	1,075,904	21,565,323	30,878,110	331,575	137,922	60,794	1,273,857	1,804,148
Jun-20	6,831,949	2,804,284	1,743,982	31,474,224	42,854,440	334,466	159,856	63,796	1,404,345	1,962,463
Jul-20	7,876,157	2,322,606	1,988,024	35,708,931	47,895,717	288,710	109,436	65,635	1,425,030	1,888,811
Aug-20	7,758,436	2,285,138	2,157,739	34,944,219	47,145,532	246,363	101,479	60,503	1,307,254	1,715,599
Sep-20	7,498,635	3,279,523	2,074,365	34,571,326	47,423,850	236,272	113,749	68,013	1,249,116	1,667,150
Oct-20	3,329,528	3,582,220	1,038,616	33,641,971	41,592,335	116,339	118,061	36,445	1,185,280	1,456,125
Nov-20	1,930,357	707,420	554,083	12,050,981	15,242,840	57,036	33,287	13,729	654,986	759,038
Dec-20	1,719,227	1,017,140	131,755	10,500,435	13,368,557	59,542	57,003	8,237	576,292	701,074
Jan-21	2,282,816	1,938,192	276,618	10,688,893	15,186,519	78,521	88,947	15,555	607,025	790,048
Feb-21	2,560,448	1,732,756	251,312	11,403,148	15,947,664	79,571	91,052	12,982	641,265	824,870
Mar-21	2,517,187	947,439	117,398	14,674,083	18,256,107	78,177	50,618	9,589	669,293	807,677
TOTAL	74,718,982	33,140,119	19,025,344	322,183,106	449,067,551	2,931,126	1,670,405	674,856	14,940,236	20,216,623

Month	Cleared MW					Cleared Volume				
	Import	Export	Wheel	Internal	Total	Import	Export	Wheel	Internal	Total
Jan-20	2,898,979	1,255,867	934,870	9,125,163	14,214,879	137,826	96,035	40,542	564,363	838,766
Feb-20	2,612,370	1,482,095	854,591	8,563,657	13,512,713	110,759	87,190	32,242	535,392	765,583
Mar-20	2,858,559	1,898,911	836,553	8,904,119	14,498,142	104,922	101,540	33,173	495,693	735,328
Apr-20	2,865,235	1,604,592	753,404	7,928,948	13,152,179	119,135	85,209	28,416	454,794	687,554
May-20	2,683,033	1,003,073	483,381	9,243,633	13,413,120	145,382	69,535	29,462	590,351	834,730
Jun-20	2,446,275	1,274,509	679,616	12,187,056	16,587,456	153,982	93,233	28,630	734,369	1,010,214
Jul-20	2,327,354	929,229	654,258	11,723,592	15,634,434	122,042	67,440	30,594	692,881	912,957
Aug-20	2,885,456	965,737	602,209	12,270,529	16,723,930	114,008	56,585	26,662	665,354	862,609
Sep-20	2,759,958	1,311,305	545,808	11,870,827	16,487,899	112,007	54,772	24,409	626,387	817,575
Oct-20	1,170,266	1,614,110	333,422	11,454,599	14,572,397	58,869	58,982	17,031	559,349	694,231
Nov-20	473,510	372,486	207,826	5,194,734	6,248,556	25,978	20,300	6,857	363,785	416,920
Dec-20	414,395	595,040	74,661	4,240,307	5,324,402	27,215	36,578	4,791	322,872	391,456
Jan-21	505,184	926,449	85,441	3,896,822	5,413,896	32,026	41,610	4,835	327,824	406,295
Feb-21	665,309	998,094	144,146	5,150,556	6,958,106	38,384	56,952	6,752	362,064	464,152
Mar-21	591,031	618,699	63,162	5,247,981	6,520,873	30,026	36,699	6,398	333,759	406,882
TOTAL	28,156,913	16,850,197	7,253,349	127,002,522	179,262,981	1,332,561	962,660	320,794	7,629,237	10,245,252

In the first three months of 2021, the cleared MW volume of up to congestion transactions was comprised of 9.3 percent imports, 13.5 percent exports, 1.5 percent wheeling transactions and 75.7 percent internal transactions. Less than 0.1 percent of the up to congestion transactions had matching real-time energy market transactions.

Sham Scheduling

Sham scheduling refers to a scheduling method under which a market participant breaks a single transaction, from generation balancing authority (source) to load balancing authority (sink), into multiple segments. Sham scheduling hides the actual source of generation from the load balancing authority. When unable to identify the source of the energy, the load balancing authority cannot see how the power will flow to the load, which can create loop flows and result in inaccurate pricing for transactions.

For example, if the generation balancing authority (source) is NYISO, and the load balancing authority (sink) is PJM, the transaction would be priced, in the PJM energy market, at the PJM/NYIS Interface regardless of the submitted path. However, if a market participant were to break the transaction into multiple segments, one on the NYIS-ONT path, and a second segment on the ONT-MISO-PJM path, the market participant would conceal the true source (NYISO) from PJM, and PJM would price the transaction as if its source were Ontario (the ONT interface price).

Sham scheduling can also be achieved by submitting a transaction that is in the opposite direction of a portion of a larger transaction schedule.

For example, market participants can submit one transaction with multiple segments among balancing authorities and another transaction which offsets all or part of a segment of the first transaction. If a market participant submits two separate transactions, one on the ONT-MISO-PJM path, and a second on the PJM-MISO path, the result of these transactions would be a net scheduled transaction from ONT to MISO, as the MISO-PJM segment of the first transaction is offset by the PJM-MISO transaction. In this example, PJM is not required to raise or lower generation as a result of these transactions, as they would for an import or an export, and there are no associated power flows across PJM. Nonetheless, the market participant is paid the price difference between the PJM/ONT interface pricing point and the PJM/MISO interface pricing point. The market participant would be paid the PJM/ONT interface pricing point for the first transaction (ONT to PJM import) and the market participant would pay the PJM/MISO interface pricing point for the second

transaction (PJM to MISO export). If the PJM/ONT interface price were higher than the PJM/MISO interface price, the market participant would be paid a net profit from the PJM market even though there was no impact on PJM operations.

At the April 10, 2013, PJM Market Implementation Committee (MIC), the MMU presented a problem statement and issue charge to address sham scheduling activities.⁷⁰ The expected deliverables from the stakeholder meetings were revisions to the Tariff and PJM business manuals. The topic was discussed at several MIC meetings. While there was stakeholder agreement that sham scheduling activity was inappropriate, consensus on revised tariff and manual language was not achieved. The topic was closed. The MMU clarified that it would continue to monitor transactions for sham scheduling activities and that the MMU could refer market participants for sham scheduling activities.

The MMU monitors for sham scheduling activities on a daily basis. Following the stakeholder discussions in 2013, the net profits obtained from sham scheduling activities fell by 101.0 percent, from net profits of \$15.5 million in 2014, to a net loss of \$149,893 in 2020. The total number of hours of sham scheduling segments where the MW profile matched exactly across all segments of the path combinations in the same hour fell by 96.6 percent, from 1,898 hours in 2014 to 64 hours in 2020.

The MMU recommends that PJM implement rules to prevent sham scheduling. The MMU recommends that PJM apply after the fact market settlement adjustments to identified sham scheduling segments to ensure that market participants cannot benefit from sham scheduling.

Elimination of Ontario Interface Pricing Point

The PJM/IMO interface pricing point (Ontario) was created to reflect the fact that transactions that originate or sink in the IESO balancing authority create actual energy flows that are split between the MISO and NYISO interface pricing points. PJM created the PJM/IMO interface pricing point to reflect the

⁷⁰ See Market Path/Interface Pricing Point alignment Problem Statement, at: <http://www.monitoringanalytics.com/reports/Presentations/2013/IMM_MIC_Market_Path_Interface_Pricing_Point_Alignment_Problem_Statement_201304010.pdf>.

actual power flows across both the MISO/PJM and NYISO/PJM interfaces. The IMO does not have physical ties with PJM because it is not contiguous.

Prior to June 1, 2015, the PJM/IMO interface pricing point was defined as the LMP at the IESO Bruce bus. The LMP at the Bruce bus includes a congestion and loss component across the MISO and NYISO balancing authorities.

The noncontiguous nature of the PJM/IMO interface pricing point creates opportunities for market participants to engage in sham scheduling activities.⁷¹ For example, a market participant can use two separate transactions to create a flow from Ontario to MISO. In this example, the market participant uses the PJM energy market as a temporary generation and load point by first submitting a wheeling transaction from Ontario, through MISO and into PJM, then by submitting a second transaction from PJM to MISO. These two transactions, combined, create an actual flow along the Ontario/MISO Interface. Through sham scheduling, the market participant receives settlements from PJM when no changes in generation occur. This activity is similar to that observed when PJM had a Southwest and Southeast interface pricing point. During that time, market participants would use the PJM spot market as a temporary load and generation point to wheel transactions through the PJM energy market. This was done to take advantage of the price differences between the interfaces without providing the market benefits of congestion relief.

A new PJM/IMO interface price method was implemented on June 1, 2015. The new method uses a dynamic weighting of the PJM/MISO interface price and the PJM/NYIS interface price, based on the performance of the Michigan-Ontario PARs. When the absolute value of the actual flows on the PARs are greater than or equal to the absolute value of the scheduled flows on the PARs, and the scheduled and actual flows are in the same direction, the PJM/IMO interface price will be equal to the PJM/MISO interface price (i.e. 100 percent weighting on the PJM/MISO Interface). When actual flows on the PARs are in the opposite direction of the scheduled flows on the PARs, the PJM/IMO interface price will be equal to the PJM/NYIS interface price (i.e. 100 percent weighting on the PJM/NYIS Interface). When the absolute value

of the actual flows on the PARs are less than or equal to the absolute value of the scheduled flows on the PARs, and the scheduled and actual flows are in the same direction, the PJM/IMO interface price will be a combination to the PJM/MISO interface price and the PJM/NYIS interface price. In this case the weightings of the PJM/MISO and PJM/NYIS interface prices are determined based on the scheduled and actual flows. For example, in a given interval, the scheduled flow on the Michigan-Ontario PARs is 1,000 MW, and the actual flow is 800 MW. If in that same interval, the PJM/MISO interface price is \$45.00 and the PJM/NYIS interface price \$30.00, the PJM/IMO interface price would be calculated with a weighting of 80 percent of the PJM/MISO interface price ($\$45.00 * 0.8$, or $\$36.00$) and 20 percent of the PJM/NYIS interface price ($\$30.00 * 0.2$, or $\$6.00$), for a PJM/IMO interface price of \$42.00.

The MMU believes that the new PJM/IMO interface price method is a step in the right direction towards pricing energy that sources or sinks in Ontario based on the path of the actual, physical transfer of energy. The MMU remains concerned about the assumption of PAR operations, and will continue to evaluate the impact of PARs on the scheduled and actual flows and the impacts on the PJM/IMO interface price. The MMU remains concerned about the potential for market participants to continue to engage in sham scheduling activities after the new method is implemented.

The MMU recommends that if the PJM/IMO interface price remains and with PJM's new method in place, that PJM implement additional business rules to remove the incentive to engage in sham scheduling activities using the PJM/IMO interface price. Such rules would prohibit the same market participant from scheduling an export transaction from PJM to any balancing authority while at the same time an import transaction is scheduled to PJM that receives the PJM/IMO interface price. PJM should also prohibit the same market participant from scheduling an import transaction to PJM from any balancing authority while at the same time an export transaction is scheduled from PJM that receives the PJM/IMO interface price.

In the first three months of 2021, of the 419 GWh of gross scheduled transactions between PJM and IESO, 402 GWh (95.9 percent) wheeled through

⁷¹ See "Sham Scheduling," Presented at the PJM Market Monitoring Unit Advisory Committee (MMUAC) meeting held on December 6, 2013 <http://www.monitoringanalytics.com/reports/Presentations/2013/JMM_Shams_Scheduling_20131206.pdf>.

MISO (Table 9-24). The MMU recommends that PJM eliminate the PJM/IMO interface pricing point, and assign the transactions that originate or sink in the IESO balancing authority to the PJM/MISO interface pricing point.⁷²

PJM and NYISO Coordinated Interchange Transactions

Coordinated transaction scheduling (CTS) provides the option for market participants to submit intra-hour transactions between the NYISO and PJM that include an interface spread bid on which transactions are evaluated.⁷³ The evaluation is based on the forward-looking prices as determined by PJM's intermediate term security constrained economic dispatch tool (IT SCED) and the NYISO's real-time commitment (RTC) tool. PJM shares its PJM/NYISO interface price IT SCED results with the NYISO. The NYISO compares the PJM/NYISO interface price with its RTC calculated NYISO/PJM interface price. If the PJM and NYISO interface price spread is greater than the market participant's CTS bid, the transaction is approved. If the PJM and NYISO interface price spread is less than the CTS bid, the transaction is denied.

The IT SCED application runs every five minutes and each run produces forecast LMPs for the intervals approximately 30 minutes, 45 minutes, 90 minutes and 135 minutes ahead. Therefore, for each 15 minute interval, the various IT SCED solutions will produce 12 forecasted PJM/NYIS interface prices. To evaluate the accuracy of IT SCED forecasts, the forecasted PJM/NYIS interface price for each 15 minute interval from IT SCED was compared to the actual real-time interface LMP for the first three months of 2021. Table 9-40 shows that over all 12 forecast ranges, IT SCED predicted the real-time PJM/NYIS interface LMP within the range of \$0.00 to \$5.00 in 33.3 percent of the intervals. In those intervals, the average price difference between the IT SCED forecasted LMP and the actual real-time LMP was \$1.48 per MWh. In 13.4 percent of all intervals, the absolute value of the average price difference between the IT SCED forecasted LMP and the actual real-time interface

⁷² On October 1, 2013, a sub-group of PJM's Market Implementation Committee started stakeholder discussions to address this inconsistency in market pricing.

⁷³ PJM and the NYISO implemented CTS on November 4, 2014. 146 FERC ¶ 61,096 (2014).

LMP was greater than \$20.00. The average price differences were \$63.39 when the price difference was greater than \$20.00, and \$152.46 when the price difference was greater than -\$20.00.

Table 9-40 Differences between forecast and actual PJM/NYIS interface prices: January through March, 2021

Range of Price Differences	Percent of All Intervals	Average Price Difference
> \$20	7.7%	\$63.39
\$10 to \$20	6.0%	\$14.23
\$5 to \$10	7.3%	\$7.10
\$0 to \$5	33.3%	\$1.48
\$0 to -\$5	33.0%	\$1.35
-\$5 to -\$10	4.2%	\$7.01
-\$10 to -\$20	2.8%	\$14.31
< -\$20	5.6%	\$152.46

Table 9-41 shows how the accuracy of the IT SCED forecasted LMPs changes as the cases approach real-time. In the final IT SCED results prior to real time, in 67.7 percent of all intervals, the average price difference between the IT SCED forecasted LMP and the actual real-time interface LMP fell within +/- \$5.00 of the actual PJM/NYIS interface real-time LMP, compared to 57.3 percent in the 135 minute ahead IT SCED results.

Table 9-41 Differences between forecast and actual PJM/NYIS interface prices: January through March, 2021

Range of Price Differences	~ 135 Minutes Prior to Real-Time		~ 90 Minutes Prior to Real-Time		~ 45 Minutes Prior to Real-Time		~ 30 Minutes Prior to Real-Time	
	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference
> \$20	12.4%	\$58.93	12.6%	\$57.33	6.3%	\$62.48	6.2%	\$61.79
\$10 to \$20	9.0%	\$14.41	8.8%	\$14.31	5.3%	\$14.33	5.6%	\$14.40
\$5 to \$10	9.4%	\$7.22	9.4%	\$7.22	7.0%	\$7.16	6.6%	\$7.06
\$0 to \$5	29.6%	\$1.71	29.9%	\$1.72	29.5%	\$1.47	29.8%	\$1.46
\$0 to -\$5	27.7%	\$1.49	27.5%	\$1.49	37.8%	\$1.44	38.0%	\$1.43
-\$5 to -\$10	3.7%	\$7.05	3.8%	\$6.94	5.3%	\$6.96	5.1%	\$6.96
-\$10 to -\$20	2.8%	\$14.43	2.6%	\$14.44	2.8%	\$13.87	2.9%	\$13.83
< -\$20	5.4%	\$158.86	5.4%	\$158.28	5.9%	\$150.20	5.8%	\$152.97

In 12.0 percent of the intervals in the 30 minute ahead forecast, the absolute value of the average price difference between the IT SCED forecasted LMP and the actual real-time interface LMP was greater than \$20.00. The average price

difference was \$61.79 when the price difference was greater than \$20.00, and \$152.97 when the price difference was greater than -\$20.00.

Table 9-42 and Table 9-43 show the monthly differences between forecasted and actual PJM/NYIS interface prices. Analysis of the data on a monthly basis shows that there is a decline in the accuracy of the IT SCED forecast during periods of cold and hot weather.

Table 9-42 Monthly Differences between forecast and actual PJM/NYIS interface prices (percent of intervals): January through March, 2021

Interval	Range of Price Differences	Jan	Feb	Mar	YTD Avg
~ 30 Minutes Prior to Real-Time	> \$20	6.4%	11.8%	0.9%	6.2%
	\$10 to \$20	4.5%	10.1%	2.6%	5.6%
	\$5 to \$10	5.6%	9.5%	4.9%	6.6%
	\$0 to \$5	28.0%	27.1%	34.1%	29.8%
	\$0 to -\$5	42.1%	24.2%	46.3%	38.0%
	-\$5 to -\$10	4.0%	5.6%	5.9%	5.1%
	-\$10 to -\$20	2.5%	4.5%	2.0%	2.9%
	< -\$20	7.0%	7.3%	3.3%	5.8%
~ 45 Minutes Prior to Real-Time	> \$20	6.8%	11.8%	0.9%	6.3%
	\$10 to \$20	3.7%	9.8%	2.8%	5.3%
	\$5 to \$10	5.7%	10.3%	5.3%	7.0%
	\$0 to \$5	27.9%	26.4%	34.0%	29.5%
	\$0 to -\$5	42.4%	23.5%	46.1%	37.8%
	-\$5 to -\$10	3.8%	6.1%	6.1%	5.3%
	-\$10 to -\$20	2.6%	4.3%	1.8%	2.8%
	< -\$20	7.1%	7.8%	3.1%	5.9%
~ 90 Minutes Prior to Real-Time	> \$20	14.1%	15.2%	8.6%	12.4%
	\$10 to \$20	8.3%	10.2%	8.0%	8.8%
	\$5 to \$10	7.3%	10.5%	10.7%	9.4%
	\$0 to \$5	25.6%	24.0%	39.5%	29.9%
	\$0 to -\$5	32.5%	22.2%	27.2%	27.5%
	-\$5 to -\$10	3.6%	5.5%	2.6%	3.8%
	-\$10 to -\$20	2.1%	5.1%	1.0%	2.6%
	< -\$20	6.6%	7.4%	2.4%	5.4%
~ 135 Minutes Prior to Real-Time	> \$20	13.8%	15.5%	8.2%	12.4%
	\$10 to \$20	8.4%	10.8%	8.1%	9.0%
	\$5 to \$10	7.4%	10.0%	10.7%	9.4%
	\$0 to \$5	25.0%	23.6%	39.5%	29.6%
	\$0 to -\$5	33.1%	21.9%	27.6%	27.7%
	-\$5 to -\$10	3.3%	5.4%	2.6%	3.7%
	-\$10 to -\$20	2.5%	5.4%	0.9%	2.8%
	< -\$20	6.5%	7.4%	2.5%	5.4%

Table 9-43 Monthly differences between forecast and actual PJM/NYIS interface prices (average price difference): January through March, 2021

Interval	Range of Price Differences	Jan	Feb	Mar	YTD Avg
~ 30 Minutes Prior to Real-Time	> \$20	\$44.95	\$73.81	\$39.78	\$61.79
	\$10 to \$20	\$14.69	\$14.35	\$14.07	\$14.40
	\$5 to \$10	\$7.01	\$7.26	\$6.78	\$7.06
	\$0 to \$5	\$1.33	\$1.80	\$1.33	\$1.46
	\$0 to -\$5	\$1.41	\$1.51	\$1.40	\$1.43
	-\$5 to -\$10	\$6.83	\$7.19	\$6.85	\$6.96
	-\$10 to -\$20	\$13.92	\$13.85	\$13.66	\$13.83
	< -\$20	\$145.03	\$157.03	\$161.81	\$152.97
~ 45 Minutes Prior to Real-Time	> \$20	\$45.33	\$74.95	\$43.12	\$62.48
	\$10 to \$20	\$14.78	\$14.21	\$14.13	\$14.33
	\$5 to \$10	\$7.10	\$7.33	\$6.92	\$7.16
	\$0 to \$5	\$1.39	\$1.73	\$1.36	\$1.47
	\$0 to -\$5	\$1.43	\$1.46	\$1.43	\$1.44
	-\$5 to -\$10	\$6.86	\$7.20	\$6.80	\$6.96
	-\$10 to -\$20	\$14.04	\$13.61	\$14.19	\$13.87
	< -\$20	\$144.06	\$149.23	\$166.30	\$150.20
~ 90 Minutes Prior to Real-Time	> \$20	\$47.82	\$71.96	\$49.65	\$57.33
	\$10 to \$20	\$14.46	\$14.46	\$13.99	\$14.31
	\$5 to \$10	\$7.17	\$7.45	\$7.04	\$7.22
	\$0 to \$5	\$1.73	\$1.79	\$1.68	\$1.72
	\$0 to -\$5	\$1.53	\$1.56	\$1.41	\$1.49
	-\$5 to -\$10	\$6.88	\$7.15	\$6.62	\$6.94
	-\$10 to -\$20	\$14.62	\$14.25	\$14.92	\$14.44
	< -\$20	\$147.42	\$153.79	\$200.12	\$158.28
~ 135 Minutes Prior to Real-Time	> \$20	\$48.55	\$73.92	\$50.91	\$58.93
	\$10 to \$20	\$14.52	\$14.49	\$14.21	\$14.41
	\$5 to \$10	\$7.40	\$7.27	\$7.05	\$7.22
	\$0 to \$5	\$1.71	\$1.73	\$1.69	\$1.71
	\$0 to -\$5	\$1.54	\$1.54	\$1.41	\$1.49
	-\$5 to -\$10	\$6.85	\$7.34	\$6.76	\$7.05
	-\$10 to -\$20	\$14.68	\$14.30	\$14.44	\$14.43
	< -\$20	\$150.33	\$153.71	\$194.79	\$158.86

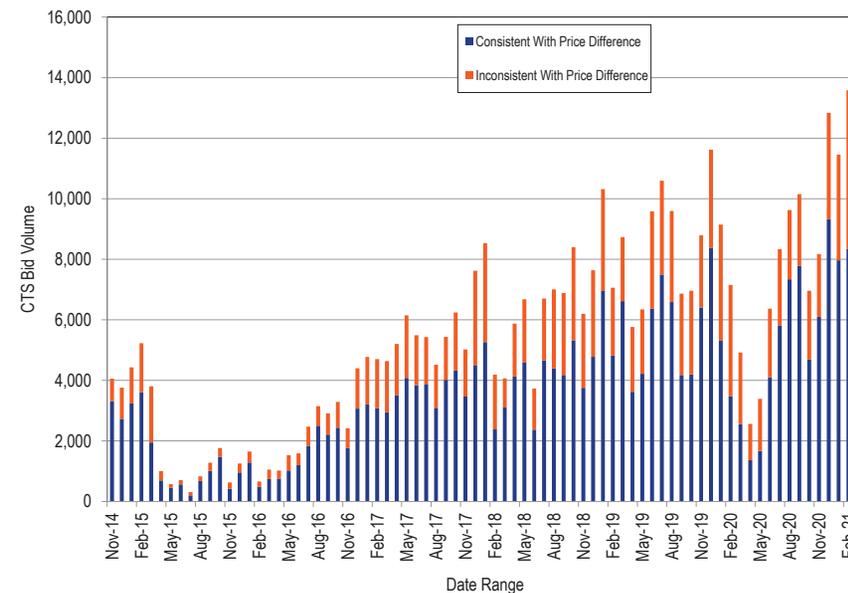
The NYISO uses PJM's IT SCED forecasted LMPs to compare against the NYISO Real-Time Commitment (RTC) results in its evaluation of CTS transactions. The NYISO approves CTS (spread bid) transactions when the offered spread is less than or equal to the spread between the IT SCED forecast PJM/NYIS interface LMP and the NYISO RTC forecast NYIS/PJM interface LMP. The large differences between forecast and actual LMPs in the intervals closest to

real-time could cause CTS transactions to be approved that would contribute to transactions being scheduled counter to real-time economic signals, and contribute to inefficient scheduling across the PJM/NYIS border.

CTS transactions are evaluated based on the spread bid, which limits the amount of price convergence that can occur. As long as balancing operating reserve charges are applied and CTS transactions are optional, the CTS proposal represents a small incremental step toward better interface pricing. The NYISO has a 75 minute bid submission deadline. While market participants have the option to specify bid data on 15 minute intervals, market participants must submit their bids 75 minutes prior to the requested transaction start time. The 75 minute bid submission deadline associated with scheduling energy transactions in the NYISO should be shortened. Reducing this deadline could significantly improve pricing efficiency at the PJM/NYISO border for non-CTS transactions and for CTS transactions as market participants would be able to adjust their bids in response to real-time price signals.

CTS transactions were evaluated for each 15 minute interval. From November 4, 2014, through March 31, 2021, 422,556 15 minute CTS schedules were approved through the CTS process based on the forecast LMPs. When the forecast LMPs for the approved intervals were compared to the hourly integrated real-time LMPs, the direction of the flow in 137,594 (32.6 percent) of the intervals was inconsistent with the differences in real-time PJM/NYISO and NYISO/PJM prices. For example, if a market participant submits a CTS transaction from NYISO to PJM with a spread bid of \$5.00, and NYISO's forecasted PJM interface price was at least \$5.00 lower than PJM's forecasted NYISO interface price, the transaction would be approved. For 32.6 percent of the approved transactions, the actual, real-time price differentials were in the opposite direction of the forecast differential. The actual, real-time price differentials meant that the transactions would have been economic in the opposite direction. For 67.4 percent of the intervals, the forecast price differentials were consistent with real-time PJM/NYISO and NYISO/PJM price differences. Figure 9-14 shows the monthly volume of cleared PJM/NYIS CTS bids. Figure 9-14 also shows the percent of cleared bids that resulted in flows consistent and inconsistent with price differences.

Figure 9-14 Monthly cleared PJM/NYIS CTS bid volume: November 4, 2014 through March 31, 2021



The data reviewed show that IT SCED is not a highly accurate predictor of the real-time PJM/NYIS interface prices. This limits the effectiveness of CTS in improving interface pricing between PJM and NYISO.

Reserving Ramp on the PJM/NYISO Interface

Prior to the implementation of CTS, PJM held ramp space for all transactions submitted between PJM and the NYISO as soon as the NERC Tag was approved. At that time, once transactions were evaluated by the NYISO through their real-time market clearing process, any adjustments made to the submitted transactions would be reflected on the NERC Tags and the PJM ramp was adjusted accordingly.

As part of this process, PJM was often required to make adjustments to transactions on its other interfaces in order to bring total system ramp back to

within its limit. The default ramp limit in PJM is +/- 1,000 MW. For example, the ramp in a given interval is currently -1,000 MW, consisting of 2,000 MW of imports from the NYISO to PJM and 3,000 MW of exports from PJM on its other interfaces. If, through the NYISO real-time market clearing process, the NYISO only approves 1,000 MW of the imports, the other 1,000 MW of import transactions from the NYISO would be curtailed. The ramp in this interval would then be -2,000 MW, consisting of the 1,000 MW of cleared imports from the NYISO to PJM and 3,000 MW of exports from PJM on its other interfaces. PJM would then be required to curtail an additional 1,000 MW of exports at its other interface to bring the limit back to within +/- 1,000. These curtailments were made on a last in first out basis as determined by the timestamp on the NERC Tag.

With the implementation of the CTS product with the NYISO, PJM modified how ramp is handled at the PJM/NYISO Interface. Effective November 4, 2014, PJM no longer holds ramp room for any transactions submitted between PJM and the NYISO at the time of submission. Only after the NYISO completes its real-time market clearing process, and communicates the results to PJM, does PJM perform a ramp evaluation on transactions scheduled with the NYISO. If, in the event the NYISO market clearing process would violate ramp, PJM would make additional adjustments based on a last-in first-out basis as determined by the timestamp on the NERC Tag. This process prevents the transactions scheduled at the PJM/NYISO Interface from holding (or creating) ramp until NYISO has completed its economic evaluation and the transactions are approved through the NYISO market clearing process.

PJM and MISO Coordinated Interchange Transaction Proposal

PJM and MISO proposed the implementation of coordinated interchange transactions, similar to the PJM/NYISO approach, through the Joint and Common Market Initiative. The PJM/MISO coordinated transaction scheduling (CTS) process provides the option for market participants to submit intra-hour transactions between the MISO and PJM that include an interface spread bid on which transactions are evaluated. Similar to the PJM/NYISO approach,

the evaluation is based, in part, on the forward-looking prices as determined by PJM's intermediate term security constrained economic dispatch tool (IT SCED). Unlike the PJM/NYISO CTS process in which the NYISO performs the evaluation, the PJM/MISO CTS process uses a joint clearing process in which both RTOs share forward looking prices. On October 3, 2017, PJM and MISO implemented the CTS process.

The IT SCED application runs every five minutes and each run produces forecast LMPs for the intervals approximately 30 minutes, 45 minutes, 90 minutes and 135 minutes ahead. Therefore, for each 15 minute interval, the various IT SCED solutions will produce 12 forecasted PJM/MISO interface prices. To evaluate the accuracy of IT SCED forecasts, the forecasted PJM/MISO interface price for each 15 minute interval from IT SCED was compared to the actual real-time interface LMP for the first three months of 2021. Table 9-44 shows that over all 12 forecast ranges, IT SCED predicted the real-time PJM/MISO interface LMP within the range of \$0.00 to \$5.00 in 38.7 percent of all intervals. In those intervals, the average price difference between the IT SCED forecasted LMP and the actual real-time LMP was \$1.56. In 8.4 percent of all intervals, the absolute value of the average price difference between the IT SCED forecasted LMP and the actual real-time interface LMP was greater than \$20.00. The average price differences were \$67.50 when the price difference was greater than \$20.00, and \$77.99 when the price difference was greater than -\$20.00.

Table 9-44 Differences between forecast and actual PJM/MISO interface prices: January through March, 2021

Range of Price Differences	Percent of All Intervals	Average Price Difference
> \$20	4.8%	\$67.50
\$10 to \$20	3.9%	\$13.95
\$5 to \$10	6.3%	\$7.03
\$0 to \$5	38.7%	\$1.56
\$0 to -\$5	37.0%	\$1.41
-\$5 to -\$10	3.6%	\$6.93
-\$10 to -\$20	2.2%	\$13.84
< -\$20	3.6%	\$77.99

Table 9-45 shows how the accuracy of the IT SCED forecasted LMPs change as the cases approach real-time. In the final IT SCED results prior to real-time, in 76.2 percent of all intervals, the average price difference between the IT SCED forecasted LMP and the actual real-time interface LMP fell within +/- \$5.00 of the actual PJM/MISO interface real-time LMP, compared to 72.9 percent in the 135 minute ahead IT SCED results.

Table 9-45 Differences between forecast and actual PJM/MISO interface prices: January through March, 2021

Range of Price Differences	~ 135 Minutes Prior to Real-Time		~ 90 Minutes Prior to Real-Time		~ 45 Minutes Prior to Real-Time		~ 30 Minutes Prior to Real-Time	
	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference	Percent of Intervals	Average Price Difference
> \$20	5.6%	\$56.81	5.5%	\$56.37	3.9%	\$67.71	4.0%	\$67.45
\$10 to \$20	4.6%	\$14.22	4.5%	\$14.33	3.9%	\$14.05	3.5%	\$13.69
\$5 to \$10	6.2%	\$7.06	6.2%	\$7.00	5.7%	\$7.04	5.9%	\$6.99
\$0 to \$5	35.5%	\$1.68	35.6%	\$1.67	35.4%	\$1.56	35.9%	\$1.55
\$0 to -\$5	37.4%	\$1.61	37.4%	\$1.58	40.7%	\$1.49	40.3%	\$1.48
-\$5 to -\$10	4.2%	\$7.06	4.1%	\$6.87	4.1%	\$6.78	4.3%	\$6.94
-\$10 to -\$20	2.6%	\$13.74	2.7%	\$13.48	2.3%	\$13.79	2.2%	\$14.03
< -\$20	4.0%	\$78.35	4.0%	\$77.98	4.0%	\$76.26	4.0%	\$75.84

In 8.0 percent of the intervals in the 30 minute ahead forecast, the absolute value of the average price difference between the IT SCED forecasted LMP and the actual real-time interface LMP was greater than \$20.00, the average price differences were \$67.45 when the price difference was greater than \$20.00, and \$75.84 when the price difference was greater than -\$20.00.

Table 9-46 and Table 9-47 show the monthly differences between forecasted and actual PJM/MISO interface prices. Analysis of the data on a monthly basis shows that there is a decline in the accuracy of the IT SCED forecast during periods of cold and hot weather.

Table 9-46 Monthly differences between forecast and actual PJM/MISO interface prices (percent of intervals): January through March, 2021

Interval	Range of Price Differences	Jan	Feb	Mar	YTD Avg
~ 30 Minutes Prior to Real-Time	> \$20	0.9%	9.9%	1.7%	4.0%
	\$10 to \$20	2.4%	4.7%	3.5%	3.5%
	\$5 to \$10	3.8%	6.5%	7.5%	5.9%
	\$0 to \$5	36.9%	32.9%	37.7%	35.9%
	\$0 to -\$5	48.4%	31.5%	40.1%	40.3%
	-\$5 to -\$10	3.6%	5.3%	4.3%	4.3%
	-\$10 to -\$20	2.0%	2.7%	1.8%	2.2%
< -\$20	2.1%	6.6%	3.5%	4.0%	
~ 45 Minutes Prior to Real-Time	> \$20	1.0%	9.6%	1.7%	3.9%
	\$10 to \$20	2.6%	5.4%	3.9%	3.9%
	\$5 to \$10	3.6%	6.6%	7.1%	5.7%
	\$0 to \$5	36.4%	32.2%	37.4%	35.4%
	\$0 to -\$5	49.0%	31.7%	40.5%	40.7%
	-\$5 to -\$10	3.4%	5.0%	4.0%	4.1%
	-\$10 to -\$20	2.0%	3.0%	2.0%	2.3%
< -\$20	2.1%	6.6%	3.4%	4.0%	
~ 90 Minutes Prior to Real-Time	> \$20	2.3%	11.4%	3.5%	5.5%
	\$10 to \$20	3.0%	4.7%	5.9%	4.5%
	\$5 to \$10	3.9%	6.6%	8.2%	6.2%
	\$0 to \$5	37.5%	31.6%	37.2%	35.6%
	\$0 to -\$5	46.5%	30.1%	34.8%	37.4%
	-\$5 to -\$10	3.0%	5.0%	4.3%	4.1%
	-\$10 to -\$20	1.8%	4.0%	2.4%	2.7%
< -\$20	2.0%	6.6%	3.6%	4.0%	
~ 135 Minutes Prior to Real-Time	> \$20	2.2%	11.8%	3.5%	5.6%
	\$10 to \$20	3.0%	4.7%	6.0%	4.6%
	\$5 to \$10	4.0%	6.2%	8.3%	6.2%
	\$0 to \$5	37.5%	31.7%	36.9%	35.5%
	\$0 to -\$5	46.4%	30.0%	35.1%	37.4%
	-\$5 to -\$10	3.1%	5.1%	4.4%	4.2%
	-\$10 to -\$20	1.7%	3.9%	2.2%	2.6%
< -\$20	2.1%	6.6%	3.6%	4.0%	

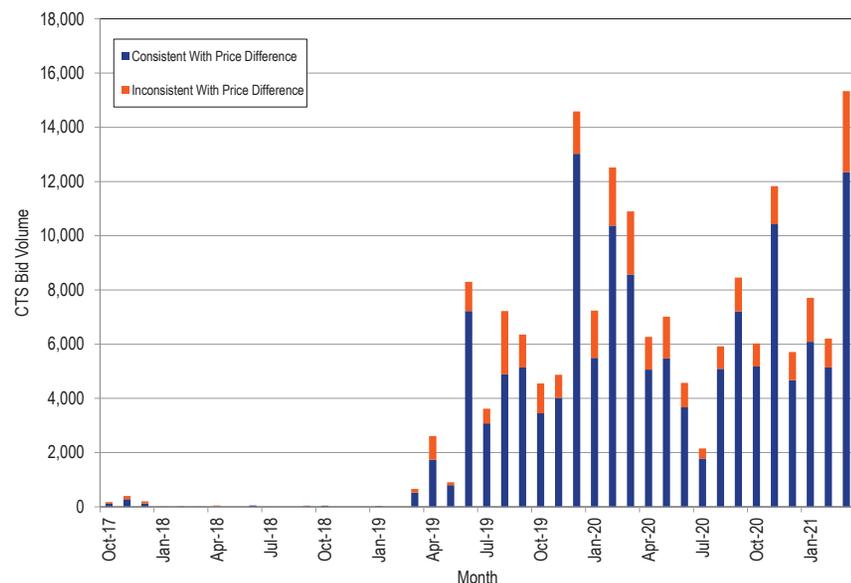
Table 9-47 Monthly differences between forecast and actual PJM/MISO interface prices (average price difference): January through March, 2021

Interval	Range of Price Differences	Jan	Feb	Mar	YTD Avg
~ 30 Minutes Prior to Real-Time	> \$20	\$31.30	\$60.02	\$125.91	\$67.45
	\$10 to \$20	\$13.55	\$13.93	\$13.50	\$13.69
	\$5 to \$10	\$6.84	\$7.06	\$7.02	\$6.99
	\$0 to \$5	\$1.45	\$1.55	\$1.64	\$1.55
	\$0 to -\$5	\$1.36	\$1.48	\$1.62	\$1.48
	-\$5 to -\$10	\$6.88	\$7.05	\$6.88	\$6.94
	-\$10 to -\$20	\$14.15	\$13.83	\$14.19	\$14.03
< -\$20	\$61.67	\$58.63	\$113.80	\$75.84	
~ 45 Minutes Prior to Real-Time	> \$20	\$30.86	\$60.30	\$126.02	\$67.71
	\$10 to \$20	\$14.14	\$14.39	\$13.55	\$14.05
	\$5 to \$10	\$6.86	\$7.21	\$6.99	\$7.04
	\$0 to \$5	\$1.45	\$1.51	\$1.71	\$1.56
	\$0 to -\$5	\$1.38	\$1.44	\$1.66	\$1.49
	-\$5 to -\$10	\$6.78	\$6.72	\$6.85	\$6.78
	-\$10 to -\$20	\$14.11	\$13.59	\$13.73	\$13.79
< -\$20	\$60.66	\$59.71	\$114.46	\$76.26	
~ 90 Minutes Prior to Real-Time	> \$20	\$27.95	\$56.15	\$75.15	\$56.37
	\$10 to \$20	\$14.55	\$14.67	\$13.96	\$14.33
	\$5 to \$10	\$6.97	\$7.13	\$6.93	\$7.00
	\$0 to \$5	\$1.60	\$1.54	\$1.86	\$1.67
	\$0 to -\$5	\$1.48	\$1.53	\$1.77	\$1.58
	-\$5 to -\$10	\$6.84	\$6.98	\$6.78	\$6.87
	-\$10 to -\$20	\$13.97	\$13.59	\$12.92	\$13.48
< -\$20	\$60.91	\$61.47	\$114.68	\$77.98	
~ 135 Minutes Prior to Real-Time	> \$20	\$26.98	\$56.37	\$77.07	\$56.81
	\$10 to \$20	\$14.42	\$14.23	\$14.12	\$14.22
	\$5 to \$10	\$6.93	\$7.18	\$7.05	\$7.06
	\$0 to \$5	\$1.57	\$1.60	\$1.84	\$1.68
	\$0 to -\$5	\$1.51	\$1.54	\$1.81	\$1.61
	-\$5 to -\$10	\$7.07	\$7.11	\$7.00	\$7.06
	-\$10 to -\$20	\$13.81	\$14.02	\$13.25	\$13.74
< -\$20	\$61.55	\$61.65	\$115.73	\$78.35	

CTS transactions were evaluated for each interval. From October 3, 2017, through March 31, 2021, 172,552 CTS schedules were approved through the CTS process based on the forecast LMPs. When the forecast LMPs for the approved intervals were compared to the hourly integrated real-time LMPs, the direction of the flow in 31,399 (18.2 percent) of the intervals was inconsistent with the differences in real-time PJM/MISO and MISO/PJM

prices. For example, if a market participant submits a CTS transaction from MISO to PJM with a spread bid of \$5.00, and MISO’s forecasted PJM interface price was at least \$5.00 lower than PJM’s forecasted MISO interface price, the transaction would be approved. For 18.2 percent of the approved transactions, the actual, real-time price differentials were in the opposite direction of the forecast differential. The actual, real-time price differentials meant that the transactions would have been economic in the opposite direction. For 81.8 percent of the intervals, the forecast price differentials were consistent with real-time PJM/MISO and MISO/PJM price differences. Figure 9-15 shows the monthly volume of cleared PJM/MISO CTS bids. Figure 9-15 also shows the percent of cleared bids that resulted in flows consistent and inconsistent with price differences.

Figure 9-15 Monthly cleared PJM/MISO CTS bid volume: October 3, 2017 through March 31, 2021



The data reviewed show that IT SCED is not a highly accurate predictor of the real-time PJM/MISO interface prices. This limits the effectiveness of CTS in improving interface pricing between PJM and MISO.

Willing to Pay Congestion and Not Willing to Pay Congestion

When reserving nonfirm transmission, market participants have the option to choose whether or not they are willing to pay congestion. When the market participant elects to pay congestion, PJM operators redispatch the system if necessary to allow the energy transaction to continue to flow. The system redispatch often creates price separation across buses on the PJM system. The difference in LMPs between two buses in PJM is the congestion cost (and losses) that the market participant pays in order for their transaction to continue to flow.

The MMU recommended that PJM modify the not willing to pay congestion product to address the issues of uncollected congestion charges. The MMU recommended charging market participants for any congestion incurred while the transaction is loaded, regardless of their election of transmission service, and restricting the use of not willing to pay congestion transactions (as well as all other real-time external energy transactions) to transactions at interfaces.

On April 12, 2011, the PJM Market Implementation Committee (MIC) endorsed the changes recommended by the MMU. The elimination of internal sources and sinks on transmission reservations addressed most of the MMU concerns, as there can no longer be uncollected congestion charges for imports to PJM or exports from PJM. There is still potential exposure to uncollected congestion charges in wheel through transactions, and the MMU will continue to evaluate if additional mitigation measures would be appropriate to address this exposure.

Table 9-48 shows that since the inception of the business rule change on April 12, 2013, there was uncollected congestion in only two months (January 2016 and February 2019). In both months, there was negative uncollected congestion. The negative congestion means that market participants who

used the not willing to pay congestion transmission option for their wheel through transactions had transactions that flowed in the direction opposite to congestion. When market participants use the not willing to pay congestion product, it also means that they are not willing to receive congestion credits, which was the case in both January 2016 and February 2019.

Table 9-48 Monthly uncollected congestion charges: January 2010 through March 2021

Month	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jan	\$148,764	\$3,102	\$0	\$5	\$0	\$0	(\$44)	\$0	\$0	\$0	\$0	\$0
Feb	\$542,575	\$1,567	(\$15)	\$249	\$0	\$0	\$0	\$0	\$0	(\$69,992)	\$0	\$0
Mar	\$287,417	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Apr	\$31,255	\$4,767	(\$68)	(\$3,114)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
May	\$41,025	\$0	(\$27)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Jun	\$169,197	\$1,354	\$78	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Jul	\$827,617	\$1,115	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Aug	\$731,539	\$37	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sep	\$119,162	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Oct	\$257,448	(\$31,443)	(\$6,870)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Nov	\$30,843	(\$795)	(\$4,678)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Dec	\$127,176	(\$659)	(\$209)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total	\$3,314,018	(\$20,955)	(\$11,789)	(\$2,860)	\$0	\$0	(\$44)	\$0	\$0	(\$69,992)	\$0	\$0

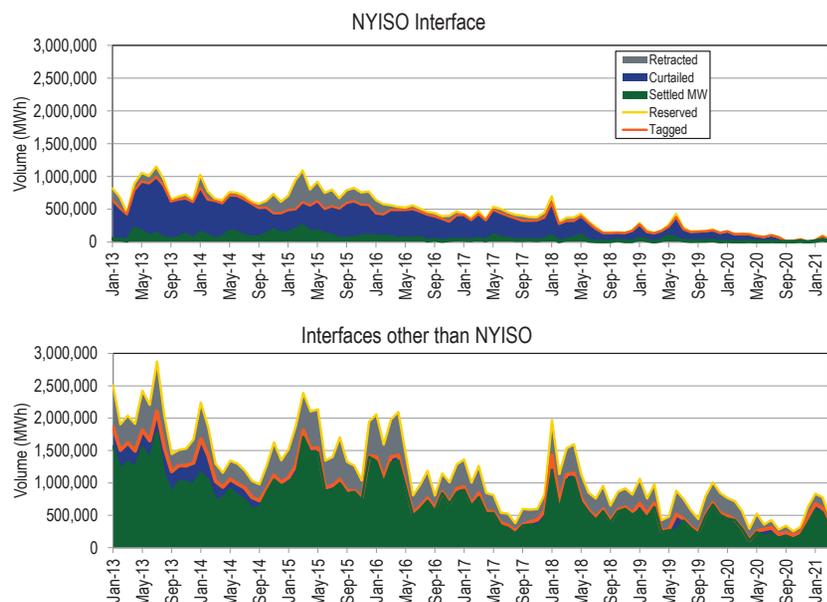
Spot Imports

Figure 9-16 shows the spot import service use for the NYISO Interface, and for all other interfaces, from January 1, 2013 through March 31, 2021. The yellow line shows the total monthly MWh of spot import service reserved and the orange line shows the total monthly MWh of tagged spot import service. The gray shaded area between the yellow and orange lines represents the MWh of retracted spot import service and may represent potential hoarding volumes. This ATC was initially reserved, but not tagged (used). It is possible that in some instances the reserved transmission consisted of the only available ATC which could have been used by another market participant had it not been reserved and not used. The blue shaded area between the orange line and green shaded area represents the MWh of curtailed transactions using spot import service. This area may also represent hoarding opportunities, particularly at the NYISO Interface. In this instance, it is possible that while the market participant reserved and scheduled the transmission, they may have submitted purposely

uneconomic bids in the NYISO market so that their transaction would be curtailed, yet their transmission would not be retracted. The NYISO allows for market participants to modify their bids on an hourly basis, so these market participants can hold their transmission service and evaluate their bids hourly, while withholding the transmission from other market participants that may wish to use it. The green shaded area represents the total settled MWh of spot import service. Figure 9-16 shows that while there are proportionally fewer retracted MWh on the NYISO Interface than on all other interfaces, the NYISO has proportionally more curtailed MWh. This is a result of the NYISO market clearing process.⁷⁴

⁷⁴ See the 2018 State of the Market Report for PJM, Volume II, Section 9, "Interchange Transactions," for a more complete discussion of the history of spot import transmission service.

Figure 9–16 Spot import service use: January 2013 through March 2021



The MMU continues to recommend that PJM permit unlimited spot market imports (as well as all nonfirm point to point willing to pay congestion imports and exports) at all PJM interfaces.

Interchange Optimization

When PJM prices are higher than prices in surrounding balancing authorities, imports will flow into PJM until the prices are approximately equal. This is an appropriate market response to price differentials. Given the nature of interface pricing and the treatment of interface transactions, it is not possible for PJM system operators to reliably predict the quantity or sustainability of such imports. The inability to predict interchange volumes creates additional challenges for PJM dispatch in trying to meet loads, especially on high load days. If all external transactions were submitted as real-time dispatchable transactions during emergency conditions, PJM would be able to include

interchange transactions in its supply stack, and dispatch only enough interchange to meet the demand.

The MMU recommends that the submission deadline for real-time dispatchable transactions be modified from 1800 on the prior day to three hours prior to the requested start time, and that the minimum duration be modified from one hour to 15 minutes.⁷⁵ These changes would give PJM a more flexible product that could be used to meet load based on economic dispatch rather than guessing the sensitivity of the transactions to price changes.

In addition to changing prices, transmission line loading relief procedures (TLRs), market participants' curtailments for economic reasons, and external balancing authority curtailments affect the duration of interchange transactions.

The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that would remove the need for market participants to schedule physical transactions across seams. Such a solution would include an optimized, but limited, joint dispatch approach that uses supply curves and treats seams between balancing authorities as constraints, similar to other constraints within an LMP market.

Interchange Cap During Emergency Conditions

An interchange cap is a limit on the level of interchange permitted for nondispatchable energy using spot import or hourly point to point transmission. An interchange cap is a nonmarket intervention which should be a temporary solution and should be replaced with a market based solution as soon as possible. Since the approval of this process on October 30, 2014, PJM has not yet needed to implement an interchange cap.

The purpose of the interchange cap is to help ensure that actual interchange more closely meets operators' expectations of interchange levels when internal PJM resources, e.g. CTs or demand response, are dispatched to meet the peak load. Once these resources have been called on, PJM must honor their

⁷⁵ The minimum duration for a real-time dispatchable transaction was modified to 15 minutes as per FERC Order No. 764.

minimum operating constraints regardless of whether additional interchange then materializes. Therefore any interchange received in excess of what was expected can have a suppressive effect on energy and reserve pricing and result in increased uplift.

PJM will notify market participants of the possible use of the interchange cap the day before. The interchange cap will be implemented for the forecasted peak and surrounding hours during emergency conditions.

The interchange cap will limit the acceptance of spot import and hourly nonfirm point to point interchange (imports and exports) not submitted as real time with price transactions once net interchange has reached the interchange cap value. Spot imports and hourly nonfirm point to point transactions submitted prior to the implementation of the interchange cap will not be limited. In addition, schedules with firm or network designated transmission service will not be limited either, regardless of whether net interchange is at or above the cap.

The calculation of the interchange cap is based on the operator expectation of interchange at the time the cap is calculated plus an additional margin. The margin is set at 700 MW, which is half of the largest contingency on the system. The additional margin also allows interchange to adjust to the loss of a unit or deviation between actual load and forecasted load. The interchange cap is based on the maximum sustainable interchange from PJM reliability studies.

45 Minute Schedule Duration Rule

PJM limits the change in interchange volumes on 15 minute intervals. These changes are referred to as ramp. The PJM ramp limit is designed to limit the change in the amount of imports or exports in each 15 minute interval to account for the physical characteristics of the generation to respond to changes in the level of imports and exports. The purpose of imposing a ramp limit is to help ensure the reliable operation of the PJM system. The 1,000 MW ramp limit per 15 minute interval was based on the availability of ramping capability by generators in the PJM system. The limit is based

on the assumption that the available generation in the PJM system can only move 1,000 MW over any 15 minute period, although there is no supporting analysis. As an example of how the ramp limit works, if at 0800 the sum of all external transactions were -3,000 MW (negative sign indicates net exporting), the limit for 0815 would be -2,000 MW to -4,000 MW. In other words, the starting or ending of transactions would be limited so that the overall change from the previous 15 minute period would not exceed 1,000 MW in either direction.

In 2008, there was an increase in 15 minute external energy transactions that caused swings in imports and exports submitted in response to intrahour LMP changes. This activity was due to market participants' ability to observe price differences between RTOs in the first third of the hour, and predict the direction of the price difference on an hourly integrated basis. Large quantities of MW would then be scheduled between the RTOs for the last 15 minute interval to capture those hourly integrated price differences with relatively little risk of prices changing. This increase in interchange on 15 minute intervals created operational control issues, and in some cases led to an increase in uplift charges due to calling on resources with minimum run times greater than 15 minutes needed to support the interchange transactions. As a result, a new business rule was proposed and approved that required all transactions to be at least 45 minutes in duration.

On June 22, 2012, FERC issued Order No. 764, which required transmission providers to give transmission customers the option to schedule transmission service at 15 minute intervals to reflect more accurate power production forecasts, load and system conditions.^{76 77} On April 17, 2014, FERC issued its order which found that PJM's 45 minute duration rule was inconsistent with Order No. 764.⁷⁸

⁷⁶ Order No. 764, 139 FERC ¶ 61,246 (2012), *order on reh'g*, Order No. 764-A, 141 FERC ¶ 61231 (2012).

⁷⁷ Order No. 764 at P 51.

⁷⁸ See *Id.* at P 12.

PJM and the MMU issued a statement indicating ongoing concern about market participants' scheduling behavior, and a commitment to address any scheduling behavior that raises operational or market manipulation concerns.⁷⁹

MISO Multi-Value Project Usage Rate (MUR)

MISO defines a multi-value project (MVP) to be a project which, according to MISO, enables the reliable and economic delivery of energy in support of public policy needs, provides multiple types of regional economic value or provides a combination of regional reliability and economic value.⁸⁰ On July 15, 2010, MISO submitted revisions to the MISO Tariff to implement criteria for identifying and allocating the costs of MVPs.⁸¹ On December 16, 2010, the Commission accepted the proposed MVP charge for export and wheel-through transactions, except for transactions that sink in PJM.⁸² The Commission stated that MISO had not shown that their proposal did not constitute a resumption of rate pancaking along the MISO-PJM seam. Following the December 16, 2010, Order, MISO began applying a multi-value usage rate (MUR) to monthly net actual energy withdrawals, export schedules and through schedules with the exception of transactions sinking in PJM. The MUR charge was applied to the relevant transactions in addition to the applicable transmission, ancillary service and network upgrade charges.

On June 7, 2014, the U.S. Court of Appeals for the Seventh Circuit granted a petition for review regarding the Commission's determination in the MVP Order and MVP Rehearing Order.⁸³ The Court ordered the Commission to consider on remand whether, in light of current conditions, what if any limitations on export pricing to PJM by MISO are justified.⁸⁴ The Seventh Circuit highlighted the fact that at the time of the Commission's decision to prohibit rate pancaking on transactions between MISO and PJM, all of MISO's transmission projects were local and provided only local benefits.⁸⁵

79 See joint statement of PJM and the MMU re Interchange Scheduling issued July 29, 2014 <http://www.monitoringanalytics.com/reports/Market_Messages/Messages/PJM_IMM_Statement_on_Interchange_Scheduling_20140729.pdf>.

80 See MISO, MTEP "Multi Value Project Portfolio Analysis," <<https://cdn.misoenergy.org/2011%20MVP%20Portfolio%20Analysis%20Full%20Report117059.pdf>>.

81 See Midwest Independent Transmission Operator Inc. filing, Docket No. ER10-1791-000 (July 15, 2010).

82 133 FERC ¶ 61,221 (2010); *order on reh'g*, 137 FERC ¶ 61,074 (2011).

83 Illinois Commerce Commission, et al. v. FERC, 721 F.3d 764, 778-780 (7th Cir. 2013).

84 *Id.* at 780.

85 *Id.* at 779.

On July 13, 2016, FERC issued an order permitting MISO to collect charges associated with MVPs for all transactions sinking in PJM, effective immediately.⁸⁶ The July 13th Order noted that in light of "the development of large scale wind generation capable of serving both MISO's and its neighbors' energy policy requirements in the western areas of MISO; the reported need of PJM entities to access those resources; and the reported need for MISO to build new transmission facilities to deliver the output of those resources within MISO for export... it is appropriate to allow MISO to assess the MVP usage charge for transmission service used to export to PJM just as MISO assesses the MVP usage charge for transmission service used to export energy to other regions."⁸⁷

The policy rationale for permitting MISO to impose transmission costs on PJM market participants without clear criteria is weak and results in pancaking of rates. The impact is expected to increase.

Table 9-49 shows the projected usage rate to be collected for all wheels through and exports from MISO, including those that sink in PJM, for 2021 through 2040.⁸⁸ As shown in Table 9-4, there were 801.1 GWh of imports from MISO in the first three months of 2021. At the 2021 MUR of \$1.67 per MWh, PJM market participants paid \$1.3 million towards the costs of MISO's multi value projects. It is not clear whether the MUR charge has affected interchange volumes from MISO into PJM.

86 156 FERC ¶ 61,034 (2016).

87 *Id.* at P 55.

88 See MISO, "Schedule 26A Indicative Annual Charges," (August 5, 2020) <<https://cdn.misoenergy.org/Schedule%2026A%20Indicative%20Annual%20Charges106365.xlsx>>.

Table 9-49 MISO projected multi value project usage rate: 2021 through 2040

Year	Total Indicative MVP Usage Rate (\$/MWh)
2021	\$1.67
2022	\$1.65
2023	\$1.64
2024	\$1.77
2025	\$1.75
2026	\$1.73
2027	\$1.72
2028	\$1.70
2029	\$1.69
2030	\$1.67
2031	\$1.65
2032	\$1.64
2033	\$1.62
2034	\$1.61
2035	\$1.59
2036	\$1.58
2037	\$1.56
2038	\$1.55
2039	\$1.53
2040	\$1.52

Ancillary Service Markets

FERC defined six ancillary services in Order No. 888: scheduling, system control and dispatch; reactive supply and voltage control from generation service; regulation and frequency response service; energy imbalance service; operating reserve—synchronized reserve service; and operating reserve—supplemental reserve service.¹ PJM provides scheduling, system control and dispatch, and reactive on a cost basis. PJM provides regulation, energy imbalance, synchronized reserve, and supplemental reserve services through market mechanisms.² Although not defined by FERC as an ancillary service, black start service plays a comparable role. Black start service is provided on the basis of formula rates.

The MMU analyzed measures of market structure, conduct and performance for the PJM Synchronized Reserve Market, the PJM DASR Market, and the PJM Regulation Market in the first three months of 2021.

Table 10-1 The tier 2 synchronized reserve market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Regional Markets	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Mixed

- The tier 2 synchronized reserve market structure was evaluated as not competitive because of high levels of supplier concentration.
- Participant behavior was evaluated as competitive because the market rules require cost-based offers.
- Market performance was evaluated as competitive because the interaction of participant behavior with the market design results in competitive prices.
- Market design was evaluated as mixed. Market power mitigation rules result in competitive outcomes despite high levels of supplier concentration. However, tier 1 reserves are inappropriately compensated when the nonsynchronized reserve market clears with a nonzero price.

¹ 75 FERC ¶ 61,080 (1996).

² Energy imbalance service refers to the real-time energy market.

Table 10-2 The day-ahead scheduling reserve market results were competitive

Market Element	Evaluation	Market Design
Market Structure	Not Competitive	
Participant Behavior	Mixed	
Market Performance	Competitive	Mixed

- The DASR market would have failed a three pivotal supplier test in 18 hours in the first three months of 2021.
- Participant behavior was evaluated as mixed because while most offers were equal to marginal costs, a significant proportion of offers reflected economic withholding.
- Market performance was evaluated as competitive because there were adequate offers in every hour to satisfy the requirement and the clearing prices reflected those offers, although there is concern about offers above the competitive level affecting prices. The day-ahead scheduling reserve market clearing price was above \$0 in 34 hours in the first three months of 2021. In 90.0 percent of hours when the clearing price was above \$0, the clearing price was the offer price of the marginal unit. In the remaining 10.0 percent of hours, the price included lost opportunity cost.
- Market design was evaluated as mixed because the DASR product does not include performance obligations. Offers should be based on opportunity cost only, to ensure competitive outcomes and that market power cannot be exercised.

Table 10-3 The regulation market results were not competitive

Market Element	Evaluation	Market Design
Market Structure	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Not Competitive	Flawed

- The regulation market structure was evaluated as not competitive because the PJM Regulation Market failed the three pivotal supplier (TPS) test in 89.1 percent of the hours in the first three months of 2021.
- Participant behavior in the PJM Regulation Market was evaluated as competitive in the first three months of 2021 because market power

mitigation requires competitive offers when the three pivotal supplier test is failed, although the inclusion of a positive margin raises questions.

- Market performance was evaluated as not competitive, because all units are not paid the same price on an equivalent MW basis.
- Market design was evaluated as flawed. The market design has failed to correctly incorporate a consistent implementation of the marginal benefit factor in optimization, pricing and settlement. The market results continue to include the incorrect definition of opportunity cost. The result is significantly flawed market signals to existing and prospective suppliers of regulation.

Overview

Primary Reserve

PJM's primary reserves are made up of resources, both synchronized and nonsynchronized, that can provide energy within 10 minutes. Primary reserve is PJM's implementation of the NERC 15-minute contingency reserve requirement.³

PJM determines the primary reserve requirement based on the most severe single contingency plus 190 MW in every approved RT SCED case. Every real-time market solution calculates the available tier 1 synchronized reserve. The required synchronized reserve and nonsynchronized reserve are calculated and dispatched in every real-time market solution, and there are associated clearing prices (SRMCP and NSRMCP) assigned every five minutes. Scheduled resources are credited based on a dispatched assignment and a five minute clearing price.

Market Structure

- **Supply.** Primary reserve is satisfied by both synchronized reserve (generation or demand response currently synchronized to the grid and available within 10 minutes), and nonsynchronized reserve (generation

currently off line but available to start and provide energy within 10 minutes).

- **Demand.** The PJM primary reserve requirement is 150 percent of the most severe single contingency plus 190 MW. In the first three months of 2021, the average primary reserve requirement was 2,458.0 MW in both the RTO Zone and the MAD Subzone.

Tier 1 Synchronized Reserve

Synchronized reserve is provided by generators and demand response resources synchronized to the grid and capable of increasing output or decreasing load within 10 minutes in response to a PJM declared synchronized reserve event. Synchronized reserve consists of tier 1 and tier 2 synchronized reserves.

Tier 1 synchronized reserve is the capability of online resources following economic dispatch to ramp up in 10 minutes from their current output in response to a synchronized reserve event. There is no formal market for tier 1 synchronized reserve.

- **Supply.** No offers are made for tier 1 synchronized reserves. The market solution estimates tier 1 synchronized reserve as available 10 minute ramp from the energy dispatch. In the first three months of 2021, there was an average hourly supply of 1,769.8 MW of tier 1 available in the RTO Zone and an average hourly supply of 897.4 MW of tier 1 synchronized reserve available within the MAD Subzone.
- **Demand.** The synchronized reserve requirement is calculated for each real-time dispatch solution as the most severe single contingency plus 190 MW within both the RTO Zone and the MAD Subzone.
- **Tier 1 Synchronized Reserve Event Response.** Tier 1 synchronized reserve is paid when a synchronized reserve event occurs and it responds. When a synchronized reserve event is called, all tier 1 response is paid for increasing its output (or reducing load for demand response) at the rate of \$50 per MWh in addition to LMP.⁴ This is the Synchronized Energy Premium Price.

³ See PJM. "Manual 10: Pre-Scheduling Operations," § 3.1.1 Day-ahead Scheduling (Operating Reserve, Rev. 39 (Nov. 19, 2019)).

⁴ See PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.10 Settlements, Rev. 113 (March 29, 2021).

- **Issues.** The competitive offer for tier 1 synchronized reserves is zero, as there is no incremental cost associated with the ability to ramp up from the current economic dispatch point and the appropriate payment for responding to an event is the synchronized energy premium price of \$50 per MWh. The tariff requires payment of the tier 2 synchronized reserve market clearing price to tier 1 resources whenever the nonsynchronized reserve market clearing price rises above zero. This requirement is unnecessary and inconsistent with efficient markets. This change had a significant impact on the cost of tier 1 synchronized reserves, resulting in a windfall payment of \$89,719,045 to tier 1 resources in 2014, \$34,397,441 in 2015, \$4,948,084 in 2016, \$2,197,514 in 2017, \$4,732,025 in 2018, and \$3,217,178 in 2019. The nonsynchronized reserve market clearing price was above \$0 in 2,015 intervals (1.9 percent of intervals) in 2020 resulting in a payment to tier 1 resources of \$3,319,263. In the first three months of 2021, the nonsynchronized reserve market clearing price was above \$0 in 48 intervals resulting in a net payment of \$1,125,792.

Tier 2 Synchronized Reserve Market

Tier 2 synchronized reserve is part of primary reserve and is comprised of resources that are synchronized to the grid, that may incur costs to be synchronized, and that have an obligation to respond to PJM declared synchronized reserve events. Tier 2 synchronized reserve is penalized for failure to respond to a PJM declared synchronized reserve event. In PJM the required amount of synchronized reserve is defined to be no less than the largest single contingency, and 10 minute primary reserve as no less than 150 percent of the largest single contingency, plus 190 MW. This is stricter than the NERC standard of the greater of 80 percent of the largest single contingency or 900 MW.⁵

When the synchronized reserve requirement cannot be met with tier 1 synchronized reserve, PJM uses the tier 2 synchronized reserve market to satisfy the balance of the requirement. The tier 2 synchronized reserve market includes the PJM RTO Reserve Zone and a subzone, the Mid-Atlantic Dominion Reserve Subzone (MAD).

⁵ NERC (June 2, 2020) <NERC Reliability Standard BAL 002-2 Glossary_of_Terms.pdf>.

Market Structure

- **Supply.** In the first three months of 2021, the supply of daily offered and eligible tier 2 synchronized reserve was 33,842.6 MW in the RTO Zone of which 4,665.5 MW was located in the MAD Subzone.
- **Demand.** The average hourly synchronized reserve requirement was 1,684.6 MW in both the RTO Reserve Zone and the Mid-Atlantic Dominion Reserve Subzone. The hourly average cleared tier 2 synchronized reserve was 243.8 MW in the MAD Subzone and 595.8 MW in the RTO.
- **Market Concentration.** Both the Mid-Atlantic Dominion Subzone Tier 2 Synchronized Reserve Market and the RTO Synchronized Reserve Zone Market were characterized by structural market power in the first three months of 2021.

The average HHI for tier 2 synchronized reserve in the RTO Zone was 5376 which is classified as highly concentrated.

Market Conduct

- **Offers.** There is a must offer requirement for tier 2 synchronized reserve. All nonemergency generation capacity resources are required to submit a daily offer for tier 2 synchronized reserve, unless the unit type is exempt. Tier 2 synchronized reserve offers from generating units are subject to an offer cap of marginal cost plus \$7.50 per MW, plus opportunity cost which is calculated by PJM. PJM automatically enters an offer of \$0 for tier 2 synchronized reserve when an offer is not entered by the owner.

Market Performance

- **Price.** The weighted average price for tier 2 synchronized reserve for all cleared hours in the MAD subzone was \$5.66 per MW in the first three months of 2021. The weighted average price for tier 2 synchronized reserve for all cleared intervals in the RTO Synchronized Reserve Zone was \$5.95 per MW in the first three months of 2021.

Nonsynchronized Reserve Market

Nonsynchronized reserve is part of primary reserve and includes the RTO Reserve Zone and the Mid-Atlantic Dominion Reserve Subzone (MAD). Nonsynchronized reserve is comprised of nonemergency energy resources not currently synchronized to the grid that can provide energy within 10 minutes. Nonsynchronized reserve is available to fill the primary reserve requirement above the synchronized reserve requirement. Generation owners do not submit supply offers for nonsynchronized reserve. PJM defines the demand curve for nonsynchronized reserve and PJM defines the supply curve based on nonemergency generation resources that are available to provide energy and can start in 10 minutes or less (based on offer parameters), and on the resource opportunity costs calculated by PJM.

Market Structure

- **Supply.** In the first three months of 2021, the average supply of eligible and available nonsynchronized reserve was 1,419.2 MW in the RTO Zone.
- **Demand.** Demand for nonsynchronized reserve equals the primary reserve requirement minus the tier 1 synchronized reserve estimate and minus the scheduled tier 2 synchronized reserve.⁶
- **Market Concentration.** The MMU calculates that the three pivotal supplier test would have been failed in 91.2 percent of intervals where the price was above \$0.01 in 2020.

Market Conduct

- **Offers.** Generation owners do not submit supply offers. Nonemergency generation resources that are available to provide energy and can start in 10 minutes or less are considered available for nonsynchronized reserves by the market solution software. PJM calculates the associated offer prices based on PJM calculations of resource specific opportunity costs.

⁶ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 11.2.2 Non-Synchronized Reserve Zones and Levels, Rev. 113 (March 29, 2021). "Because Synchronized Reserve may be utilized to meet the Primary Reserve requirement, there is no explicit requirement for non-synchronized reserves."

Market Performance

- **Price.** The nonsynchronized reserve price is determined by the opportunity cost of the marginal nonsynchronized reserve unit. The nonsynchronized reserve weighted average price for all intervals in the RTO Reserve Zone was \$0.22 in the first three months of 2021.

Secondary Reserve (DASR)

There is no NERC standard for secondary reserve. PJM defines secondary reserve in the day-ahead market as reserves (online or offline available for dispatch) that can be converted to energy in 30 minutes. PJM defines a secondary reserve requirement but is not required to maintain this level of secondary reserve in real time.

PJM maintains a day-ahead, offer-based market for 30 minute day-ahead secondary reserve. The PJM Day-Ahead Scheduling Reserve Market (DASR) has no performance obligations except that a unit which clears the DASR market may not be on an outage in real time.⁷ If DASR units are on an outage in real time or cleared DASR MW are not available, the DASR payment is not made.

Market Structure

- **Supply.** The DASR market is a must offer market. Any resources that do not make an offer have their offer set to \$0.00 per MW. DASR is calculated by the day-ahead market solution as the lesser of the 30 minute energy ramp rate or the economic maximum MW minus the day-ahead dispatch point for all resources that can provide energy within 30 minutes of a request from PJM Dispatch. In the first three months of 2021, the average available hourly DASR was 46,303.2 MW.
- **Demand.** The DASR requirement is the sum of the PJM requirement and the Dominion requirement based on the VACAR reserve sharing agreement. For November 2020 through October 2021, the DASR requirement is 4.78 percent of peak load forecast. The average hourly DASR MW purchased

⁷ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 11.2.7 Day-Ahead Scheduling Reserve Performance, Rev. 113 (March 29, 2021).

in the first three months of 2021 was 4,597.9 MW, a reduction from the 4,911.5 hourly MW in 2020.

- **Concentration.** The three pivotal supplier test would have failed in 11 hours in the first three months of 2021.

Market Conduct

- **Withholding.** Economic withholding remains an issue in the DASR Market. The direct marginal cost of providing DASR is zero. PJM calculates the opportunity cost for each resource. All offers by resource owners greater than zero constitute economic withholding. In the first three months of 2021, 39.4 percent of daily unit offers were above \$0.00 and 16.2 percent of daily unit offers were above \$5.
- **DR.** Demand resources are eligible to participate in the DASR Market. Some demand resources have entered offers for DASR. No demand resources cleared the DASR market in the first three months of 2021.

Market Performance

- **Price.** In the first three months of 2021, the weighted average DASR price for all hours when the DASRMCP was above \$0.00 was \$0.14.

Regulation Market

The PJM Regulation Market is a real-time market. Regulation is provided by generation resources and demand response resources that qualify to follow one of two regulation signals, RegA or RegD. PJM jointly optimizes regulation with synchronized reserve and energy to provide all three products at least cost. The PJM regulation market design includes three clearing price components: capability; performance; and opportunity cost. The RegA signal is designed for energy unlimited resources with physically constrained ramp rates. The RegD signal is designed for energy limited resources with fast ramp rates. In the regulation market RegD MW are converted to effective MW using a marginal rate of technical substitution (MRTS), called a marginal benefit factor (MBF). Correctly implemented, the MBF would be the marginal rate of technical substitution (MRTS) between RegA and RegD, holding the level

of regulation service constant. The current market design is critically flawed as it has not properly implemented the MBF as an MRTS between RegA and RegD resource MW and the MBF has not been consistently applied in the optimization, clearing and settlement of the regulation market.

Market Structure

- **Supply.** In the first three months of 2021, the average hourly offered supply of regulation for nonramp hours was 778.5 performance adjusted MW (762.2 effective MW). This was a decrease of 88.0 performance adjusted MW (a decrease of 64.8 effective MW) from the first three months of 2020. In the first three months of 2021, the average hourly offered supply of regulation for ramp hours was 1,106.5 performance adjusted MW (1,115.1 effective MW). This was a decrease of 173.5 performance adjusted MW (a decrease of 125.5 effective MW) from the first three months of 2020, when the average hourly offered supply of regulation was 933.0 performance adjusted MW (effective MW).
- **Demand.** The hourly regulation demand is 525.0 effective MW for nonramp hours and 800.0 effective MW for ramp hours.
- **Supply and Demand.** The nonramp regulation requirement of 525.0 effective MW was provided by a combination of RegA and RegD resources equal to 497.1 hourly average performance adjusted actual MW in the first three months of 2021. This is an increase of 5.1 performance adjusted actual MW from the first three months of 2020, when the average hourly total regulation cleared performance adjusted actual MW for nonramp hours were 492.0 performance adjusted actual MW. The ramp regulation requirement of 800.0 effective MW was provided by a combination of RegA and RegD resources equal to 712.2 hourly average performance adjusted actual MW in the first three months of 2021. This is a decrease of 9.8 performance adjusted actual MW from the first three months of 2020, where the average hourly regulation cleared MW for ramp hours were 702.5 performance adjusted actual MW.

The ratio of the average hourly offered supply of regulation to average hourly regulation demand (performance adjusted cleared MW) for ramp

hours was 1.55 in the first three months of 2021 (1.33 in the first three months of 2020). The ratio of the average hourly offered supply of regulation to average hourly regulation demand (performance adjusted cleared MW) for nonramp hours was 1.57 in the first three months of 2021 (1.41 in the first three months of 2020).

- **Market Concentration.** In the first three months of 2021, the three pivotal supplier test was failed in 89.1 percent of hours. In the first three months of 2021, the actual MW weighted average HHI of RegA resources was 2528 which is highly concentrated and the weighted average HHI of RegD resources was 1786 which is moderately concentrated. The weighted average HHI of all resources was 1334, which is moderately concentrated.

Market Conduct

- **Offers.** Daily regulation offer prices are submitted for each unit by the unit owner. Owners are required to submit a cost-based offer and may submit a price-based offer. Offers include both a capability offer and a performance offer. Owners must specify which signal type the unit will be following, RegA or RegD.⁸ In the first three months of 2021, there were 164 resources following the RegA signal and 46 resources following the RegD signal.

Market Performance

- **Price and Cost.** The weighted average clearing price for regulation was \$17.18 per MW of regulation in the first three months of 2021, an increase of \$6.19 per MW, or 56.3 percent, from the weighted average clearing price of \$10.00 per MW in the first three months of 2020. The weighted average cost of regulation in the the first three months of 2021 was \$21.01 per MW of regulation, an increase of 51.1 percent, from the weighted average cost of \$13.91 per MW in the first three months of 2020.
- **Prices.** RegD resources continue to be incorrectly compensated relative to RegA resources due to an inconsistent application of the marginal benefit

factor in the optimization, assignment and settlement processes. If the regulation market were functioning efficiently and competitively, RegD and RegA resources would be paid the same price per effective MW.

- **Marginal Benefit Factor.** The marginal benefit factor (MBF) is intended to measure the operational substitutability of RegD resources for RegA resources. The marginal benefit factor is incorrectly defined and applied in the PJM market clearing. The current incorrect and inconsistent implementation of the MBF has resulted in the PJM Regulation Market over procuring RegD relative to RegA in most hours and in an inefficient market signal about the value of RegD in every hour.

Black Start Service

Black start service is required for the reliable restoration of the grid following a blackout. Black start service is the ability of a generating unit to start without an outside electrical supply, or is the demonstrated ability of a generating unit to automatically remain operating at reduced levels when disconnected from the grid (automatic load rejection or ALR).⁹

In the first three months of 2021, total black start charges were \$16.553 million, including \$ 16.5 million in revenue requirement charges and \$0.069 million in uplift charges. Black start revenue requirements consist of fixed black start service costs, variable black start service costs, training costs, fuel storage costs, and an incentive payment. Black start uplift charges are paid to units scheduled in the day-ahead energy market or committed in real time to provide black start service under the ALR option or for black start testing. Black start zonal charges in the first three months of 2021 ranged from \$0.02 per MW-day in the BGE Zone (total charges were \$11,441) to \$4.10 per MW-day in the PE Zone (total charges were \$1,074,321).

The PJM tariff tables including CRF values should have been changed for both black start and the capacity market when the tax laws changed in 2017. As a result, CRF values have overcompensated black start units since the changes to the tax code.

⁸ See the 2019 State of the Market Report for PJM, Vol. II, Appendix F "Ancillary Services Markets."

⁹ OATT Schedule 1 § 1.3BB. There are no ALR units currently providing black start service.

Reactive

Reactive service, reactive supply and voltage control are provided by generation and other sources of reactive power (measured in MVar). Reactive power helps maintain appropriate voltage levels on the transmission system and is essential to the flow of real power (measured in MW). The same equipment provides both MVar and MW. The current rules permit double recovery of some fixed costs.

Reactive capability charges are based on FERC approved filings that permit recovery based on a cost of service approach.¹⁰ Reactive service charges are paid to units that operate in real time outside of their normal range at the direction of PJM for the purpose of providing reactive service. Total reactive charges increased 5.99 percent from \$87.5 million in the first three months of 2020 to \$92.7 million in 2021. Reactive capability charges increased 5.24 percent from \$87.5 million in the first three months of 2020 to \$92.0 million in 2021. Total reactive service charges in the first three months of 2021 ranged from \$0 in the REC and OVEC Zones, to \$12.5 million in the AEP Zone.

Frequency Response

On February 15, 2018, the Commission issued Order No. 842, which modified the pro forma large and small generator interconnection agreements and procedures to require newly interconnecting generating facilities, both synchronous and nonsynchronous, to include equipment for primary frequency response capability as a condition to receive interconnection service.^{11 12}

The PJM Tariff requires that all new generator interconnection customers (Nuclear Regulatory Commission regulated facilities are exempt from this provision) have hardware and/or software that provides frequency responsive real power control with the ability to sense changes in system frequency and autonomously adjust real power output in a direction to correct for frequency deviations. This includes a governor or equivalent controls capable of operating with a maximum five percent droop and a +/- 0.036 deadband.¹³

¹⁰ OATT Schedule 2.

¹¹ See 157 FERC ¶ 61,122 (2016).

¹² See 164 FERC ¶ 61,224 (2018).

¹³ OATT Attachment O § 4.7.2 (Primary Frequency Response).

In addition to resource capability, resource owners must comply by setting control systems to autonomously adjust real power output in a direction to correct for frequency deviations.

The response of generators within PJM to NERC identified frequency events remains under evaluation. A frequency event is declared when the frequency goes outside +/-40 mHz for 60 continuous seconds. The NERC BAL-003-2 requirement for balancing authorities (PJM is a balancing authority) uses a threshold value (L_{10}) equal to -261.1 MW/0.1 Hz and has selected four events between June 1, 2020 and December 31, 2020 as well as two events in January of 2021 to evaluate.

Ancillary Services Costs per MWh of Load

Table 10-4 shows PJM ancillary services costs for the first three months of 1999 through 2021, per MWh of load. The rates are calculated as the total charges for the specified ancillary service divided by the total PJM real-time load in MWh.¹⁴ The scheduling, system control, and dispatch category of costs is comprised of PJM scheduling, PJM system control and PJM dispatch; owner scheduling, owner system control and owner dispatch; other supporting facilities; black start services; direct assignment facilities; and ReliabilityFirst Corporation charges. The cost per MWh of load in Table 10-4 is a different metric than the cost of each ancillary service per MW of that service. The cost per MWh of load includes the effects both of price changes per MW of the ancillary service and changes in total load.

¹⁴ The total prices in this table are a load-weighted, average system price per MWh by category, even if each category is not charged on that basis. These totals are presented for informational purposes and should not be used to calculate the costs of any specific market activity in PJM.

Table 10-4 History of ancillary services costs per MWh of load: January through March, 1999 through 2021^{15 16}

Year (Jan-Mar)	Regulation	Scheduling, Dispatch and System Control	Reactive	Synchronized Reserve	Total
1999	\$0.04	\$0.23	\$0.25	\$0.00	\$0.52
2000	\$0.21	\$0.38	\$0.37	\$0.00	\$0.96
2001	\$0.49	\$0.64	\$0.22	\$0.00	\$1.35
2002	\$0.24	\$0.67	\$0.16	\$0.00	\$1.07
2003	\$0.65	\$1.01	\$0.22	\$0.11	\$1.99
2004	\$0.54	\$1.06	\$0.26	\$0.17	\$2.03
2005	\$0.47	\$0.80	\$0.25	\$0.07	\$1.59
2006	\$0.48	\$0.70	\$0.28	\$0.09	\$1.55
2007	\$0.58	\$0.72	\$0.25	\$0.11	\$1.66
2008	\$0.59	\$0.73	\$0.30	\$0.07	\$1.69
2009	\$0.38	\$0.35	\$0.34	\$0.03	\$1.10
2010	\$0.34	\$0.36	\$0.35	\$0.05	\$1.10
2011	\$0.27	\$0.32	\$0.38	\$0.12	\$1.09
2012	\$0.18	\$0.43	\$0.48	\$0.03	\$1.12
2013	\$0.28	\$0.43	\$0.63	\$0.04	\$1.38
2014	\$0.63	\$0.40	\$0.37	\$0.29	\$1.68
2015	\$0.32	\$0.42	\$0.36	\$0.18	\$1.28
2016	\$0.11	\$0.43	\$0.37	\$0.04	\$0.95
2017	\$0.11	\$0.47	\$0.42	\$0.06	\$1.06
2018	\$0.28	\$0.47	\$0.41	\$0.07	\$1.23
2019	\$0.10	\$0.46	\$0.41	\$0.04	\$1.01
2020	\$0.08	\$0.45	\$0.47	\$0.01	\$1.01
2021	\$0.13	\$0.54	\$0.48	\$0.04	\$1.19

Market Procurement of Real Time Ancillary Services

PJM uses market mechanisms to varying degrees in the procurement of ancillary services, including primary reserves and regulation. Ideally, all ancillary services would be procured taking full account of the interactions with the energy market. When a resource is used for an ancillary service instead of providing energy in real time, the cost of removing the resource, either fully or partially, from the energy market should be weighed against the benefit the ancillary service provides. The degree to which PJM markets account for these interactions depends on the timing of the product clearing and software limitations and the accuracy of unit parameters and offers.

¹⁵ Note: The totals in Table 10-4 account for after the fact billing adjustments made by PJM and may not match totals presented in past reports.

¹⁶ Reactive totals include FERC approved rates for reactive capability.

The synchronized reserve market clearing is more integrated with the energy market clearing than the other ancillary services. Resources categorized as flexible tier 2 reserve, those that can provide reserves by backing down according to their ramp rate, are jointly cleared along with energy in every real-time market solution. Given the joint clearing of energy and flexible tier 2, the synchronized reserve market clearing price should always cover the opportunity cost of providing flexible tier 2. PJM should never need to pay uplift to flexible tier 2. The uplift paid to flexible tier 2 results from issues with the dispatch and pricing software timing. Inflexible tier 2 reserves, provided by resources that require longer notice to take actions to prepare for reserve deployment, are not cleared along with energy in the real-time market solution. Inflexible tier 2 reserves are cleared hourly by the Ancillary Service Optimizer (ASO). The ASO uses forward looking information about the energy market, flexible tier 2, tier 1, and regulation to estimate the costs and benefits of using a resource for inflexible tier 2 synchronized reserves.

Nonsynchronized reserves are cleared with every real-time energy market solution, but its costs are not fully known by the real-time energy market software (RT SCED) because the resources are offline. PJM uses an estimate of the cost of using a resource for nonsynchronized reserve instead of energy from a previously solved IT SCED solution. IT SCED runs every 15 minutes looking ahead at target dispatch times up to two hours in the future. The energy commitment decisions for the offline resources have already been made when the RT SCED clears the nonsynchronized reserve market. RT SCED compares the IT SCED estimated cost of nonsynchronized reserve clearing to the RT SCED determined cost of synchronized reserve clearing in satisfying the primary reserve requirement. Nonsynchronized reserve clearing indirectly interacts with energy clearing through both products' substitutability with synchronized reserves.

Prices for the regulation and reserve markets are set by the pricing calculator (LPC), which is based on the RT SCED solution. The software determining the prices (RT SCED) is partially, but not fully clearing the reserve market. The software determining the prices is not clearing the regulation market.

Recommendations

- The MMU recommends that all data necessary to perform the regulation market three pivotal supplier test be saved by PJM so that the test can be replicated. (Priority: Medium. First reported 2016. Status: Not adopted.)
- The MMU recommends that the total regulation (TReg) signal sent on a fleet wide basis be eliminated and replaced with individual regulation signals for each unit. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the ability to make dual offers (to make offers as both a RegA and a RegD resource in the same market hour) be removed from the regulation market. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the regulation market be modified to incorporate a consistent application of the marginal benefit factor (MBF) throughout the optimization, assignment and settlement process. The MBF should be defined as the Marginal Rate of Technical Substitution (MRTS) between RegA and RegD. (Priority: High. First reported 2012. Status: Not adopted. FERC rejected.¹⁷)
- The MMU recommends that the lost opportunity cost in the ancillary services markets be calculated using the schedule on which the unit was scheduled to run in the energy market. (Priority: High. First reported 2010. Status: Not adopted.¹⁸ FERC rejected.¹⁹)
- The MMU recommends that the lost opportunity cost calculation used in the regulation market be based on the resource's dispatched energy offer schedule, not the lower of its price or cost offer schedule. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.²⁰)
- The MMU recommends that, to prevent gaming, there be a penalty enforced in the regulation market as a reduction in performance score and/or a forfeiture of revenues when resource owners elect to deassign assigned regulation resources within the hour. (Priority: Medium. First reported 2016. Status: Not adopted. FERC rejected.²¹)
- The MMU recommends enhanced documentation of the implementation of the regulation market design. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.²²)
- The MMU recommends that PJM be required to save data elements necessary for verifying the performance of the regulation market. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the \$12.00 margin adder be eliminated from the definition of the cost based regulation offer because it is a markup and not a cost. (Priority: Medium. New recommendation. Status: Not adopted.)
- The MMU recommends that PJM replace the static MidAtlantic/Dominion Reserve Subzone with a reserve zone structure consistent with the actual deliverability of reserves based on current transmission constraints. (Priority: High. First reported 2019. Status: Not adopted.)
- The MMU recommends that the \$7.50 margin be eliminated from the definition of the cost of tier 2 synchronized reserve because it is a markup and not a cost. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that the variable operating and maintenance cost be eliminated from the definition of the cost of tier 2 synchronized reserve and that the calculation of synchronized reserve variable operations and maintenance costs be removed from Manual 15. (Priority: Medium. First reported 2019. Status: Not adopted.)
- The MMU recommends that the components of the cost-based offers for providing regulation and synchronous condensing be defined in Schedule 2 of the Operating Agreement. (Priority: Low. First reported 2019. Status: Not adopted.)
- The MMU recommends that the rule requiring that tier 1 synchronized reserve resources are paid the tier 2 price when the nonsynchronized

¹⁷ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

¹⁸ This recommendation was adopted by PJM for the energy market. Lost opportunity costs in the energy market are calculated using the schedule on which the unit was scheduled to run. In the regulation market, this recommendation has not been adopted, as the LOC continues to be calculated based on the lower of price or cost in the energy market offer.

¹⁹ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

²⁰ *Id.*

²¹ *Id.*

²² *Id.*

reserve price is above zero be eliminated immediately and that, under the current rule, tier 1 synchronized reserve resources not be paid the tier 2 price when they do not respond. (Priority: High. First reported 2013. Status: Not adopted.)

- The MMU recommends that the tier 2 synchronized reserve must offer requirement be enforced on a daily and hourly basis. The MMU recommends that PJM define a set of acceptable reasons why a unit can be made unavailable daily or hourly and require unit owners to select a reason in Markets Gateway whenever making a unit unavailable either daily or hourly or setting the offer MW to 0 MW. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that, for calculating the penalty for a tier 2 resource failing to meet its scheduled obligation during a spinning event, the definition of the IPI be changed from the average number of days between events to the actual number of days since the last event greater than 10 minutes. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that aggregation not be permitted to offset unit specific penalties for failure to respond to a synchronized reserve event. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM eliminate the use of Degree of Generator Performance (DGP) in the synchronized reserve market solution and improve the actual tier 1 estimate. If PJM continues to use DGP, DGP should be documented in PJM's manuals. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that the details of VACAR Reserve Sharing Agreement (VRSA) be made public, including any responsibilities assigned to PJM and including the amount of reserves that Dominion commits to meet its obligations under the VRSA. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends that the VRSA be terminated and, if necessary, replaced by a reserve sharing agreement between PJM and VACAR South,

similar to agreements between PJM and other bordering areas. (Priority: Medium. First reported 2020. Status: Not adopted.)

- The MMU recommends that a reason code be attached to every hour in which PJM market operations adds additional DASR MW. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM modify the DASR market to ensure that all resources cleared incur a real-time performance obligation. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that offers in the DASR market be based on opportunity cost only in order to mitigate market power. (Priority: Low. First reported 2009. Modified, 2018. Status: Not adopted.)
- The MMU recommends that all resources, new and existing, have a requirement to include and maintain equipment for primary frequency response capability as a condition of interconnection service. The PJM capacity and energy markets already compensate resources for frequency response capability and any marginal costs. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that new CRF rates for black start units, incorporating current tax code changes, be implemented immediately. The new CRF rates should apply to all black start units. The black start units should be required to commit to providing black start service for the life of the unit. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends for oil tanks shared with other resources that only a proportionate share of the minimum tank suction level (MTSL) be allocated to black start service. The MMU further recommends that the PJM tariff be updated to clearly state how the MTSL will be calculated for black start units sharing oil tanks. (Priority: Medium. First reported 2017. Status: Not adopted.)
- The MMU recommends that separate cost of service payments for reactive capability be eliminated and the cost of reactive capability be recovered in the capacity market. (Priority: Medium. First reported 2016. Status: Not adopted.)

- The MMU recommends that payments for reactive capability, if continued, be based on the 0.90 power factor that PJM has determined is necessary. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that, if payments for reactive are continued, fleet wide cost of service rates used to compensate resources for reactive capability be eliminated and replaced with compensation based on unit specific costs. (Priority: Low. First reported 2019.²³ Status: Partially adopted.)
- The MMU recommends that Schedule 2 to OATT be revised to state explicitly that only generators that provide reactive capability to the transmission system that PJM operates and has responsibility for are eligible for reactive capability compensation. Specifically, such eligibility should be determined based on whether a generation facility's point of interconnection is on a transmission line that is a Monitored Transmission Facility as defined by PJM and is on a Reportable Transmission Facility as defined by PJM.²⁴ (Priority: Medium. First reported 2020. Status: Not adopted.)

Conclusion

The design of the PJM Regulation Market is significantly flawed.²⁵ The market design does not correctly incorporate the marginal rate of technical substitution (MRTS) in market clearing and settlement. The market design uses the marginal benefit factor (MBF) to incorrectly represent the MRTS and uses a mileage ratio instead of the MBF in settlement. This failure to correctly and consistently incorporate the MRTS into the regulation market design has resulted in both underpayment and overpayment of RegD resources and in the over procurement of RegD resources in all hours. The market results continue to include the incorrect definition of opportunity cost. These issues are the basis for the MMU's conclusion that the regulation market design is flawed.

To address these flaws, the MMU and PJM developed a joint proposal which was approved by the PJM Members Committee on July 27, 2017, and filed with FERC on October 17, 2017.²⁶ The PJM/MMU joint proposal addresses issues with the inconsistent application of the marginal benefit factor throughout the optimization and settlement process in the PJM Regulation Market. FERC rejected the joint proposal on March 30, 2018, as being noncompliant with Order No. 755.²⁷ The MMU and PJM separately filed requests for rehearing, which were denied by order issued March 26, 2020.²⁸

The structure of the tier 2 synchronized reserve market has been evaluated and the MMU has concluded that these markets are not structurally competitive as they are characterized by high levels of supplier concentration and inelastic demand. As a result, these markets are operated with market clearing prices and with offers based on the marginal cost of producing the product plus a margin. As a result of these requirements, the conduct of market participants within these market structures has been consistent with competition, and the market performance results have been competitive. However, the \$7.50 margin is not a cost. The margin is effectively a rule-based form of economic withholding and is therefore not consistent with a competitive outcome. The \$7.50 margin should be eliminated. The variable operating and maintenance component of the synchronized reserve offer should also be eliminated. All variable operating and maintenance costs are incurred to provide energy and to make units available to provide energy. There are no variable operating and maintenance costs associated with providing synchronized reserve.

Participant performance has not been adequate for tier 2 synchronized reserve. Compliance with calls to respond to actual synchronized reserve events remains significantly less than 100 percent. Actual participant performance means that the penalty structure is not an adequate incentive for performance.

The rule that requires payment of the tier 2 synchronized reserve price to tier 1 synchronized reserve resources when the nonsynchronized reserve price is greater than zero, is inefficient and results in a substantial windfall payment

²³ The MMU has discussed this recommendation in state of the market reports since 2016 but Q3, 2019 was the first time it was reported as a formal MMU recommendation.

²⁴ See PJM Transmission Facilities (note that this requires you first log into a PJM Tools account. If you do not, then the link sends you to an Access Request page, <<https://pjm.com/markets-and-operations/ops-analysis/transmission-facilities>>.

²⁵ The current PJM regulation market design that incorporates two signals using two resource types was a result of FERC Order No. 755 and subsequent orders. Order No. 755, 137 FERC ¶ 61,064 at PP 197–200 (2011).

²⁶ 18 CFR § 385.211 (2017)

²⁷ 162 FERC ¶ 61,295.

²⁸ 170 FERC ¶ 61,259.

to the holders of tier 1 synchronized reserve resources. Tier 1 resources have no obligation to perform and pay no penalties if they do not perform, and tier 1 resources do not incur any costs when they are part of the tier 1 estimate in the market solution. Tier 1 resources are already paid for their response if they do respond to a synchronized reserve event. Tier 1 resources require no additional payment. If tier 1 resources wish to be paid as tier 2 resources, the rules provide the opportunity to make competitive offers in the tier 2 market and take on the associated obligations. Overpayment of tier 1 resources based on this rule has added more than \$100 million to the cost of primary reserve since 2014.

The benefits of markets are realized under these approaches to ancillary service markets. Even in the presence of structurally noncompetitive markets, there can be transparent, market clearing prices based on competitive offers that account explicitly and accurately for opportunity cost. This is consistent with the market design goal of ensuring competitive outcomes that provide appropriate incentives without reliance on the exercise of market power and with explicit mechanisms to prevent the exercise of market power.

The MMU concludes that the regulation market results were not competitive, and the market design is significantly flawed. The MMU concludes that the synchronized reserve market results were competitive, although the \$7.50 margin should be removed. The MMU concludes that the DASR market results were competitive, although offers above the competitive level continue to affect prices.

Primary Reserve

NERC Performance Standard BAL-002-3, Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event, requires PJM to carry sufficient contingency reserve to recover from a sudden balancing contingency (usually a loss of generation). The Contingency Event Recovery Period is the time required to return the ACE to zero if it was zero or positive before the event or to its pre-event level if it was negative at the start of the event. NERC standards set the Contingency Event Recovery

Period as 15 minutes and Contingency Reserve Restoration Period as 90 minutes.²⁹ The NERC requirement is 100 percent compliance and status must be reported quarterly. PJM implements this contingency reserve requirement using primary reserves.³⁰ PJM maintains 10 minute reserves (primary reserve) to ensure reliability in the event of disturbances. PJM's primary reserves are made up of resources, both synchronized and nonsynchronized, that can provide energy within 10 minutes. PJM does not have a Contingency Reserve Restoration Period standard.

Market Structure

Demand

PJM requires that 150 percent of the largest single contingency on the system be maintained as primary reserve plus 190 MW. PJM can make temporary adjustments to the primary reserve requirement when grid maintenance or outages change the largest contingency or in cases of hot weather alerts or cold weather alerts.

The primary reserve market requirement is set equal to 150 percent of the largest single contingency for each market solution, ASO, IT SCED, and RT SCED. This is usually the output of the largest generating unit to which PJM adds 190 MW. In cases where temporary switching conditions create the risk that a single fault could remove several generators, PJM will define the largest single contingency as the sum of the output of those generators.³¹

PJM can also increase the primary and synchronized reserve requirement in cases of hot weather or cold weather alerts or escalating emergency procedures.³² Such additional reserves are committed as part of the hourly (ASO) and three to five minute (RT SCED) processes. In the first three months of 2021, the average primary reserve requirement for the RTO Zone was 2,458.0 MW. The average primary reserve requirement in the MAD Subzone

²⁹ See PJM "Manual 12: Balancing Operations," Rev. 42 (January 27, 2021) Attachment D, "the Disturbance Recovery Period is 15 minutes after the start of a Reportable Disturbance. Subsequently, PJM must fully restore the Synchronized Reserve within 90 minutes."

³⁰ See PJM "Manual 10: Pre-Scheduling Operations," § 3.1.1 Day-ahead Scheduling (Operating) Reserve, Rev. 39 (Nov. 19, 2020).

³¹ PJM Manual 11: Energy & Ancillary Services Market Operations, Rev. 113 (March 29, 2021)

³² PJM Manual 11: Energy & Ancillary Services Market Operations, Rev. 113 (March 29, 2021), p. 84

was also 2,458.0 MW. These averages include the hours when PJM raised the requirements.

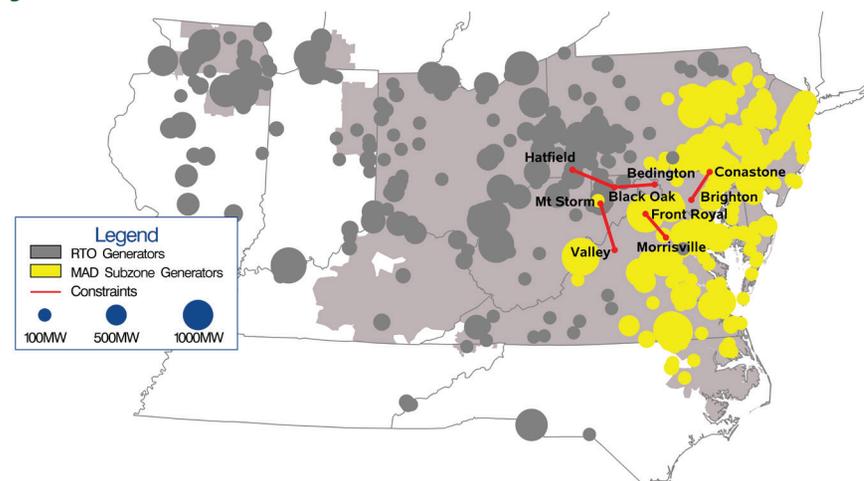
The MMU identified instances when PJM increased the primary and synchronized reserve requirements (Table 10-5).

Table 10-5 Temporary adjustments to primary and synchronized reserve: January through March, 2021

From	To	Number of Hours	Amount of Adjustment
6-Mar-21	8-Mar-21	34	Primary Reserve (255 MW), Synchronized Reserve (170 MW)
15-Mar-21	29-Mar-21	230	Primary Reserve (230 MW), Synchronized Reserve (160 MW)

Transmission constraints can limit the deliverability of reserves within the RTO, requiring the definition of a subzone. PJM defines a single subzone, the Mid-Atlantic Dominion (MAD) Subzone (Figure 10-1).³³ Figure 10-1 is a map of constraints and major generation sources. The constraints separating the RTO Zone and MAD Subzone are defined by underlying grid topology. The RTO Zone into MAD Subzone constraints reflect limits on the transmission line capacity that separate the RTO Zone and MAD Subzone. If, in the case of a spinning event, the current economic dispatch plus the current synchronized market dispatch would overload the constraint, then all additional synchronized reserve MW must be cleared from the unconstrained side of the constraints. When this occurs, the synchronized reserve prices between the RTO Zone and the MAD Subzone will diverge. PJM operators are authorized to define additional separate subzones under certain conditions.³⁴ In practice, PJM has always maintained only the MAD Subzone but for any market solution several distinct constraining paths are analyzed and the most limiting one becomes the definition for that solution.

Figure 10-1 PJM RTO Zone and MAD Subzone map of constraints and generation sources



The most limiting transmission constraint for power flow from the RTO Zone into the MAD Subzone since August 2017, has been the AP South Interface. The most frequent constraint is Brighton-Conastone, then Bedington-Black Oak, and Loudoun-Meadowbrook.

The NERC standard requires a control area to carry primary reserve MW equal to or greater than the most severe single contingency (MSSC) plus 190 MW.³⁵ PJM requires primary reserves in the amount of 150 percent of the largest single contingency with at least 100 percent of the requirement made up of synchronized reserves.³⁶ In the first three months of 2021, the average synchronized reserve requirement was 1,704.0 MW in the MAD Subzone and also 1,704.0 MW in the RTO Zone. The synchronized reserve requirement is calculated for every real-time market dispatch solution.

³³ Additional subzones may be defined by PJM to meet system reliability needs. PJM will notify stakeholders in such an event. See "PJM Manual 11: Energy & Ancillary Services Market Operations," § 4.2.2 Synchronized Reserve Requirement Determination, Rev. 113 (March 29, 2021).

³⁴ PJM Manual 11: Energy & Ancillary Services Market Operations, Rev. 113 (March 29, 2021), p. 86.

³⁵ NERC BAL-002-3. "Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event," September 25, 2018. <<https://www.nerc.com/pa/Stand/Reliability%20Standards/BAL-002-3.pdf>>.

³⁶ "PJM Manual 13: Emergency Operations," Rev 78 (Jan. 27, 2021), p. 18.

Supply

The demand for primary reserve is satisfied by tier 1 synchronized reserves, tier 2 synchronized reserves and nonsynchronized reserves, subject to the requirement that synchronized reserves equal 100 percent of the largest contingency. After the synchronized reserve requirement is satisfied, the remainder of primary reserves is from the least expensive combination of synchronized and nonsynchronized reserves.

Estimated tier 1 is credited against PJM's primary reserve requirement as well as PJM's synchronized reserve requirement. In the MAD Subzone, an average of 897.4 MW of tier 1 was identified by the dispatch solutions as available in the first three months of 2021 (Table 10-6).³⁷ Tier 1 synchronized reserve fully satisfied the MAD Subzone synchronized reserve requirement or reduced the need for tier 2 synchronized reserve to self-scheduled reserves in 6.4 percent of dispatch solutions in the first three months of 2021. In the RTO Zone, an average of 1,769.8 MW of tier 1 was available (Table 10-7) fully satisfying the synchronized reserve requirement in 48.2 percent of real-time dispatch solutions.

Regardless of online/offline state, all non-emergency generation capacity resources must submit a daily offer for tier 2 synchronized reserve in Markets Gateway prior to the offer submission deadline (14:15 the day prior to the operating day). Resources listed as available for tier 2 synchronized reserve without a synchronized reserve offer will have their offer price automatically set to \$0.00. Offer MW and other non-cost offer parameters can be changed during the operating day. Owners who opt in for intraday updates may change their offer price up to 65 minutes before the hour. Certain unit types including nuclear, wind, solar, and energy storage resources, are expected to have zero MW tier 2 synchronized reserve offer quantities.³⁸

After tier 1 is estimated, the remainder of the synchronized reserve requirement is met by tier 2.

³⁷ ASO, Ancillary Services Optimizer. This is the hour-ahead market software that optimizes ancillary services with energy. ASO schedules hourly the Tier 2 Synchronized Reserve, Regulation, and Nonsynchronized Reserves.

³⁸ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4.2 PJM Synchronized Reserve Market Business Rules, Rev. 113 (March 29, 2021).

In the first three months of 2021, in the MAD Subzone, there was an average of 1,341.4 MW of eligible nonsynchronized reserve supply available to meet the average interval demand for primary reserve. (Table 10-7) In the RTO Zone, an average of 1,738.0 MW of supply was available to meet the average demand of 1,486.5 MW (Table 10-7).

Table 10-6 provides the average dispatch solution reserves, by type of reserve, used by the RT SCED market solution to satisfy the primary reserve requirement in the MAD Subzone from January 2020 through March 2021.

Table 10-6 Average reserves used to satisfy the primary reserve requirement, MAD Subzone: January 2020 through March 2021

Year	Month	Tier 1 Total MW	Tier 2 Synchronized Reserve MW	Nonsynchronized Reserve MW	Total Primary Reserve MW
2020	Jan	1,276.6	325.9	1,249.0	2,851.5
2020	Feb	1,026.9	193.6	1,219.6	2,440.1
2020	Mar	980.7	259.0	1,231.8	2,471.4
2020	Apr	1,150.5	199.9	1,067.7	2,418.1
2020	May	911.1	200.5	1,177.5	2,289.0
2020	Jun	1,276.2	142.5	976.6	2,395.4
2020	Jul	995.4	210.5	1,216.0	2,421.9
2020	Aug	881.4	148.3	1,200.6	2,230.3
2020	Sep	1,016.9	88.5	1,123.2	2,228.6
2020	Oct	724.1	290.2	1,247.8	2,262.2
2020	Nov	566.4	257.2	1,188.8	2,012.5
2020	Dec	689.0	252.2	1,319.6	2,260.8
2020	Average	957.9	214.0	1,184.8	2,356.8
2021	Jan	835.6	251.1	1,330.6	2,417.3
2021	Feb	974.9	215.1	1,242.7	2,432.7
2021	Mar	881.9	213.2	1,162.6	2,257.7
2021	Average	897.5	226.5	1,245.3	2,369.2

Table 10-7 shows the average dispatch solution reserves, by type of reserve, satisfying the primary reserve requirement in the RTO Zone in January 2020 through March 2021.

Table 10-7 Average monthly reserves used to satisfy the primary reserve requirement, RTO Zone: January 2020 through March 2021

Year	Month	Tier 1 Total MW	Tier 2 Synchronized Reserve MW	Nonsynchronized Reserve MW	Total Primary Reserve MW
2020	Jan	2,416.4	486.8	1,364.8	4,268.0
2020	Feb	2,284.2	283.3	1,279.6	3,847.1
2020	Mar	2,155.1	458.7	1,365.6	3,979.4
2020	Apr	2,228.6	342.1	1,174.0	3,744.7
2020	May	2,128.3	297.4	1,250.6	3,676.3
2020	Jun	2,728.9	283.7	1,082.7	4,095.3
2020	Jul	2,109.4	402.2	1,363.5	3,875.1
2020	Aug	1,972.1	398.8	1,387.0	3,757.9
2020	Sep	2,053.8	299.4	1,271.0	3,624.1
2020	Oct	1,381.3	778.2	1,612.3	3,771.7
2020	Nov	1,499.7	683.9	1,509.5	3,693.1
2020	Dec	1,512.4	697.0	1,648.3	3,857.7
2020	Average	2,039.2	450.9	1,359.1	3,849.2
2021	Jan	1,761.2	506.7	1,512.5	3,780.4
2021	Feb	1,848.8	600.3	1,515.2	3,964.3
2021	Mar	1,705.5	593.1	1,454.1	3,752.7
2021	Average	1,771.8	566.7	1,493.9	3,832.5

Supply and Demand

The market solution software relevant to reserves consists of: the Ancillary Services Optimizer (ASO) solving hourly; the intermediate term security constrained economic dispatch market solution (IT SCED); and the real-time (short term) security constrained economic dispatch market solution (RT SCED).

All dispatch solutions determine the actual primary reserves required as 150 percent of the largest contingency plus 190 MW. Of this, synchronized reserves must be 100 percent of the largest contingency plus 190 MW.

If the tier 1 synchronized reserve plus ASO committed inflexible tier 2 synchronized reserve does not meet the requirement, RT SCED will commit

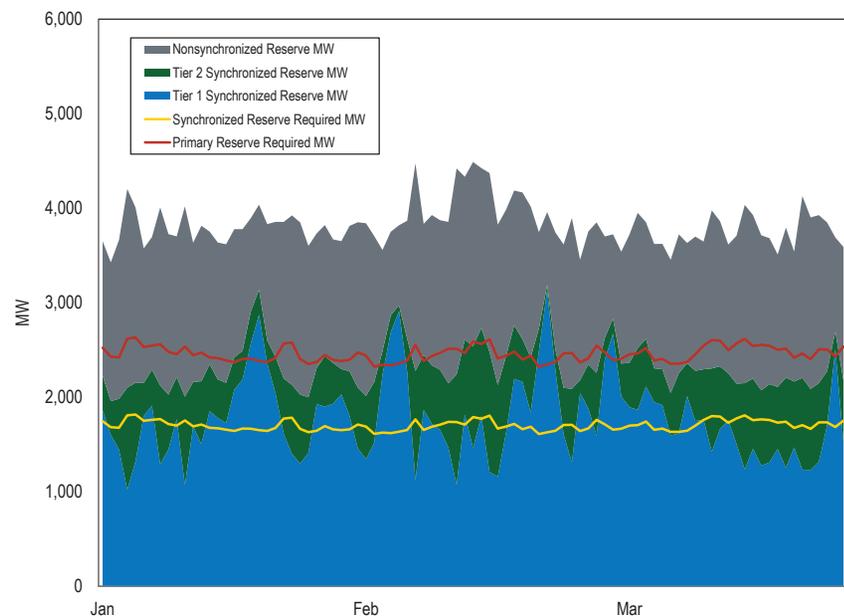
available flexible tier 2 synchronized reserve. If there is an excess of synchronized reserve, the RT SCED may decommit previously committed flexible synchronized reserve.

The ASO satisfied the primary reserve requirement for the RTO Zone and the MAD Subzone in all hours of the first three months of 2021. RT SCED for the MAD Subzone satisfied the primary reserve requirement in all but four dispatch solutions. All four shortage solutions were in March. Three of the dispatch solutions, occurred during temporary increases in the required synchronized reserve and nonsynchronized reserve on March 17 and March 22.

The market solution first estimates how much tier 1 synchronized reserve is available. If there is enough tier 1 MW available to satisfy the synchronized reserve requirement, then RT SCED economically assigns available synchronized reserve and nonsynchronized reserve to meet the remaining primary reserve requirement. If there is not enough tier 1 synchronized reserve then the remaining synchronized reserve requirement is filled with tier 2 synchronized reserve. After synchronized reserve is assigned, the primary reserve requirement is filled by economically assigning synchronized reserve and nonsynchronized reserve.

Figure 10-2 shows how the market solutions satisfy the primary reserve requirement for the RTO Zone.

Figure 10-2 RTO reserve zone primary reserve MW by source (Daily Averages): January through March, 2021



In the first three months of 2021, tier 1 and tier 2 were both essential to satisfying the synchronized reserve requirement. Tier 1 synchronized reserve remains the major contributor to satisfying the synchronized reserve requirement in both the RTO Zone and the MAD Subzone.

Price and Cost

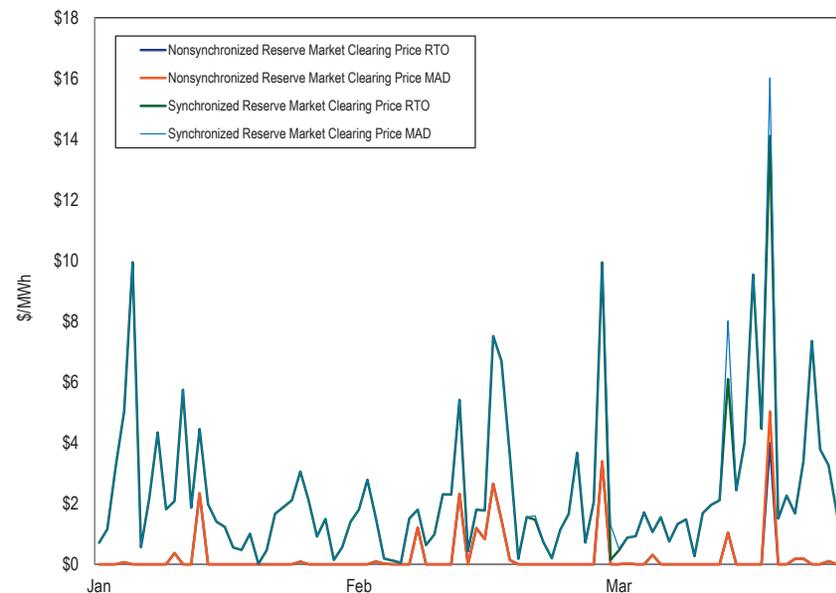
The price of primary reserves results from the demand curve for primary reserves and the supply of primary reserves. The demand curve is modeled in each of the primary reserve clearing engines (ASO, IT SCED, RT SCED).

The demand curve for primary reserves has two steps, with an \$850 penalty factor for primary reserve levels ranging from 0 MW to a MW amount equal to 150 percent of the MSSC and a constraint with a \$300 penalty factor for primary reserves ranging from 150 percent of MSSC to 150 percent of MSSC plus 190 MW.

The supply of primary reserves is made up of available tier 1 and tier 2 synchronized reserves and nonsynchronized reserves. Offer prices for synchronized reserve are capped at \$7.50 plus costs plus opportunity costs.

Figure 10-3 shows daily weighted average synchronized and nonsynchronized market clearing prices in the first three months of 2021. The MAD SRMCP and RTO SRMCP price diverged in 13 five minute intervals in the first three months of 2021.

Figure 10-3 Daily average market clearing prices (\$/MWh) for synchronized reserve and nonsynchronized reserve: January through March, 2021



PJM's primary reserves are made up of three components, tier 1 synchronized reserve, tier 2 synchronized reserve, and nonsynchronized reserve, each with its own price and cost determinants and interdependent scheduling algorithms. The overall price and cost, including uplift credits, for meeting the BAL-002-3 primary reserve requirement is calculated by combining the three components. Each of these three components is shown in Table 10-8. The Cost per MW column is the total credits divided by the total MW of reserves.

The ratio of price to cost for all primary reserve during first three months of 2021 was 55.4 percent. While tier 1 has zero actual incremental cost, estimated tier 1 is paid the tier 2 clearing price in any hour where nonsynchronized reserves clears at a nonzero price.

Table 10-8 Primary reserve requirement components, RTO Reserve Zone: January through March, 2021

Product	MW Share of Credited Primary Reserve Requirement	MWh	Credits Paid	Price Per MW Reserve	Cost Per MW Reserve
Tier 1 Synchronized Reserve Response	NA	451	\$23,492	NA	\$52.15
Tier 1 Synchronized Reserve in Market Solution	1.0%	31,348	\$1,125,792	\$35.91	\$35.91
Tier 2 Synchronized Reserve Scheduled	24.3%	764,396	\$7,450,041	\$5.81	\$9.75
Non Synchronized Reserve Scheduled	74.7%	2,345,861	\$2,743,776	\$0.22	\$1.17
Primary Reserve (total of above)	100.0%	3,142,055	\$11,343,101	\$2.00	\$3.61

Tier 1 Synchronized Reserve

Tier 1 synchronized reserve is a component of primary reserve comprised of all online resources following economic dispatch and able to ramp up from their current output in response to a synchronized reserve event. The tier 1 synchronized reserve for a unit is estimated as the lesser of the available 10 minute ramp or the difference between the economic dispatch point and the synchronized reserve maximum output. By default the synchronized reserve maximum for a resource is equal to its economic maximum. Resource owners may request a lower synchronized reserve maximum if a physical limitation exists.³⁹ Tier 1 resources are identified by the market solution. Tier 1 synchronized reserve has an incremental cost of zero. Tier 1 synchronized

³⁹ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.1 Synchronized Reserve Market Eligibility, Rev. 113 (March 29, 2021).

reserve is paid under two circumstances. Tier 1 reserves are paid when they respond to a synchronized reserve event. Tier 1 reserves are paid the synchronized reserve market clearing price when the nonsynchronized reserve market clearing price is above \$0.

While PJM relies on tier 1 resources to respond to a synchronized reserve event, tier 1 resources are not obligated to respond during an event. Tier 1 resources are credited if they do respond but are not penalized if they do not.

Market Structure

Supply

All generating resources operating on the PJM system with the exception of those assigned to tier 2 synchronized reserve are available for tier 1 synchronized reserve and any response to a spinning event will be credited at the Synchronized Energy Premium Price.

Beginning in 2014, DGP (Degree of Generator Performance) was introduced as a metric to improve the accuracy of the tier 1 MW estimate used by the market solution. The available tier 1 MW estimated by the market solution for each resource is based upon its economic dispatch, and submitted synchronized reserve ramp rate, adjusted by its DGP. PJM communicates to generation operators whose tier 1 MW is part of the market solution the latest estimate of units' tier 1 MW and units' current DGP.⁴⁰ DGP should be documented in PJM's market rules.⁴¹ DGP violates the basic PJM principle that generation owners are solely responsible for their own offers. In addition, DGP is a crude estimate of ramp rates and does not account for the actual discontinuities along unit offer curves.

The supply of tier 1 synchronized reserve available to the market solution is adjusted by eliminating tier 1 MW from unit types that cannot reliably provide synchronized reserve. These unit types are nuclear, wind, solar,

⁴⁰ PJM, Ancillary Services, "Communication of Synchronized Reserve Quantities to Resource Owners," (May 6, 2015). <<http://www.pjm.com/-/media/markets-ops/ancillary/communication-of-synchronized-reserve-quantities-to-resource-owners.ashx>>

⁴¹ See PJM, Generation Performance Monitor and Degree of Generator Performance Whitepaper. <<http://www.pjm.com/-/media/etools/osis/system-information/generation-performance-monitor-and-degree-of-generator-performance-white-paper.ashx>>.

landfill gas, energy storage, and hydro units.⁴² These unit types are credited the synchronized energy premium price, like any other responding unit, if they respond to a spinning event. These units will not, however, be paid as tier 1 resources when the nonsynchronized reserve market clearing price goes above \$0. There is a review process for resources excluded by default from the tier 1 estimate that request to be included.⁴³ PJM also excludes units, regardless of type, that it deems unreliable as tier 1, though it allows those resources to provide tier 2 synchronized reserve.

Table 10-9 provides tier 1 synchronized reserve supplied by unit and fuel type in the first three months of 2021, including all tier 1 credited for responding to synchronized reserve events and paid when the nonsynchronized reserve price exceeded \$0 per MW.

Table 10-9 Supply of tier 1 synchronized reserve by unit and fuel type: January through March, 2021

Unit / Fuel Type	Percent by MW	Percent by Credits
Steam - Coal	48.9%	56.8%
Combined Cycle	32.8%	26.0%
CT - Natural Gas	7.0%	4.6%
Hydro - Run of River	5.3%	7.4%
Wind	2.1%	2.0%
Steam - Natural Gas	1.3%	0.8%
Solar	1.0%	1.0%
Hydro - Pumped Storage	0.6%	0.1%
RICE - Natural Gas	0.5%	0.8%
Steam - Other	0.3%	0.3%
DSR	0.1%	0.1%
Nuclear	0.1%	0.1%
RICE - Other	0.0%	0.0%
CT - Oil	0.0%	0.0%
CT - Other	0.0%	0.0%
Battery	0.0%	0.0%

In the first three months of 2021, the SCED market solutions estimated that tier 1 MW from an average of 54 units could have an average of 1,885.1 MW of ramp available in a spinning event. For the two spinning events in

⁴² See PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.1 Synchronized Reserve Market Eligibility, Rev. 113(March 29, 2021).

⁴³ See PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.1 Synchronized Reserve Market Eligibility, Rev. 113 (March 29, 2021).

January through March 2021, PJM Settlements paid an average 2,688 total MW intervals from an average of 370 distinct units for an average 1,440.5 MW of real-time MW increase. Settlements include units like wind, solar, nuclear, and demand response which are not a part of the estimated tier 1 in the SCED market solutions.

By observing spin event response recorded in PJM's SCADA data, the MMU estimates actual response as the sum of the products contributing to total ACE increase from the time the event is initiated to 10 minutes after the event is initiated. Total increase in ACE is a summation not only of tier 1 response, but also of tier 2 response, regulation A and regulation D actual response (this is sometimes a MW increase and sometimes a MW decrease), and changes to net imports/exports across PJM's boundaries (sometimes an increase and sometimes a decrease in MW).

In the RTO Reserve Zone, the average estimated tier 1 synchronized reserve was 1,744.6 MW (Table 10-7). In 47.0 percent of dispatch solutions, the estimated tier 1 synchronized reserve was greater than the synchronized reserve requirement, meaning that the synchronized reserve requirement was met entirely by tier 1 synchronized reserve plus self scheduled tier 2.

In the first three months of 2021, the average estimated tier 1 synchronized reserve available was 886.5 MW in the MAD Subzone (Table 10-6). In 6.1 percent of dispatch solutions the estimated tier 1 synchronized reserve available within the MAD Subzone plus self scheduled tier 2 in MAD was greater than the synchronized reserve requirement and no tier 2 market needed to be cleared.

Demand

There is no required amount of tier 1 synchronized reserve. The estimated tier 1 MW are used to satisfy the total required amounts of synchronized and primary reserve.

The ancillary services market solution treats the cost of estimated tier 1 synchronized reserve as \$0, even when the nonsynchronized reserve market

clearing price is above \$0. As a result, the optimization cannot and does not minimize the total cost of primary reserves. The MMU recommends that tier 1 synchronized reserve not be paid when the nonsynchronized reserve market clearing price is above \$0.

Supply and Demand

The price of synchronized reserves results from the demand curve for synchronized reserves and the supply of synchronized reserves. The demand curve is modeled in each of the synchronized reserve clearing engines (ASO, IT SCED, RT SCED). The demand curve for synchronized reserves has two steps, with an \$850 penalty factor for synchronized reserve levels ranging from 0 MW to a MW amount equal to 100 percent of the MSSC and a constraint with a \$300 penalty factor for synchronized reserves ranging from 100 percent of MSSC to 100 percent of MSSC plus 190 MW.

When solving for the synchronized reserve requirement the market solution first estimates the amount of tier 1 available from the energy dispatch. If the requirement is not filled by tier 1, it then commits tier 2 beginning with all self scheduled synchronized reserve.

In the MAD Subzone, the market solution takes all tier 1 MW estimated to be available within the MAD Subzone as well as the synchronized reserve MW estimated to be available within the MAD Subzone from the RTO Zone (gray area of Figure 10-2). If the total tier 1 synchronized reserve is less than the synchronized reserve requirement, the remainder of the synchronized reserve requirement is filled with tier 2 synchronized reserve.

Tier 1 Synchronized Reserve Payments

Tier 1 synchronized reserve is awarded credits under two distinct circumstances. In response to a spinning event, all resources (except scheduled tier 2 resources) are paid for increasing output (or reducing load for demand response) at the rate of \$50 per MWh in addition to LMP.⁴⁴ This is the Synchronized Energy Premium Price. Spinning event response is calculated as the highest output between 9 minutes and 11 minutes after the event is declared minus the

⁴⁴ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.10 Settlements, Rev. 113 (March 29, 2021).

lowest output between one minute before and one minute after the event is declared. Generator outputs are measured and reported to PJM every four seconds via SCADA. Total response credited to a resource is capped at 110 percent of estimated capability. These rules apply to all resources that are not scheduled tier 2 resources. As a result, spinning event response involves more MW response than the original estimate of tier 1. Many resources that are not included in PJM's estimate of tier 1 nevertheless respond to spinning events and in accordance with the PJM Tariff are paid the Synchronized Energy Premium Price. This can include incidental response from nuclear units or steam turbines running at maximum output. Such response is expected when the response is measured as the highest output for the two minute period around the end of an event minus lowest output from the two minute period around the start of an event. Tier 1 synchronized reserve that is part of the estimate (at market solution time) when there is no spinning event is also credited for its full estimated MW whenever the nonsynchronized reserve market clearing price is above \$0.

In the event that the nonsynchronized reserve market clearing price is above \$0 and there is a spinning event, estimated tier 1 is credited with the lesser of its actual response or its estimated capability times the SRMCP. Tier 1 synchronized reserve not part of the estimate is credited the SRMCP times its actual response.⁴⁵ In the first three months of 2021, the nonsynchronized reserve market clearing price was above \$0 in 1.0 percent of intervals.

In the first three months of 2021, tier 1 synchronized reserve spinning event response credits of \$22,524 were paid for two spinning events covering five five-minute intervals. Table 10-10 shows the number of spinning events each month, the credits paid for tier 1 response, the number of MWh credited, and the actual response in MW.

⁴⁵ See PJM "Manual 28: Operating Agreement Accounting," Rev. 84 (Dec. 17, 2020) p. 54.

Table 10-10 Tier 1 synchronized reserve event response costs: January 2020 through March 2021

Year	Month	Number of Spinning Events	Total Tier 1 Spinning Event Credits	Total Tier 1 Spinning Event Credited (MWh)	Total Tier 1 Spinning Response from Event Start to Event End (MW)
2020	Jan	2	\$22,200	453.2	5,438.8
2020	Feb	4	\$56,595	1,148.2	13,778.8
2020	Mar	1	\$3,514	70.3	843.5
2020	Apr	1	\$5,873	118.2	1,418.5
2020	May	1	\$11,302	226.0	2,712.6
2020	Jun	0	NA	NA	NA
2020	Jul	3	\$34,249	699.8	8,397.2
2020	Aug	0	NA	NA	NA
2020	Sep	1	\$11,390	236.2	2,843.1
2020	Oct	2	\$23,038	460.8	5,713.0
2020	Nov	1	\$7,964	159.3	2,019.3
2020	Dec	1	\$10,050	201.0	2,426.1
2020	Total	17	\$186,176	3,773.0	45,590.9
2021	Jan	1	\$7,763	135.9	1,130.1
2021	Feb	0	NA	NA	NA
2021	Mar	1	\$15,729	314.6	1,599.1
2021	Total	2	\$23,492	450.5	2,729.2

Paying Tier 1 the Tier 2 Price

Tier 1 synchronized reserve has zero marginal cost and the corresponding competitive price for tier 1 synchronized reserves is also zero. However, the PJM rules artificially create a marginal cost of tier 1 when the price of nonsynchronized reserve is greater than zero and tier 1 is paid the tier 2 price. The PJM market solutions do not include that marginal cost and therefore do not solve for the efficient level of tier 1, tier 2 and nonsynchronized reserve in those cases. When called to respond to a spinning event, tier 1 is compensated at the Synchronized Energy Premium Price (Table 10-12). However, the shortage pricing tariff changes (October 1, 2012) modified the pricing of tier 1 so that tier 1 synchronized reserve is paid the tier 2 synchronized reserve market clearing price whenever the nonsynchronized reserve market clearing price rises above zero. The rationale for this change was and is unclear, but it has had a significant impact on the cost of tier 1 synchronized reserves (Table 10-11). In the first three months of 2021, the nonsynchronized reserve market

clearing price was above \$0.00 in 253 intervals. For those intervals, tier 1 synchronized reserve was paid \$1,125,792 for an average of 122.3 MWh per interval.

Table 10-11 Price of tier 1 synchronized reserve attributable to a nonsynchronized reserve price above zero: January 2020 through March 2021

Year	Month	Number of Intervals When NSRMCP>\$0	Weighted Average SRMCP When NSRMCP>\$0	Total Tier 1 MWh When NSRMCP>\$0	Total Tier 1 Credits When NSRMCP>\$0	Average Tier 1 MWh When NSRMCP>\$0
2020	Jan	0	NA	NA	NA	NA
2020	Feb	0	NA	NA	NA	NA
2020	Mar	0	NA	NA	NA	NA
2020	Apr	27	\$6.12	3,654.9	\$22,372	456.9
2020	May	24	\$6.20	3,105.4	\$19,262	310.5
2020	Jun	116	\$7.58	17,163.0	\$130,140	490.4
2020	Jul	166	\$11.18	22,696.6	\$253,682	687.8
2020	Aug	309	\$12.52	42,499.8	\$531,928	708.3
2020	Sep	50	\$3.94	7,277.5	\$28,658	519.8
2020	Oct	944	\$11.86	148,481.8	\$1,760,874	1,124.9
2020	Nov	255	\$13.55	32,994.0	\$447,060	673.4
2020	Dec	124	\$8.20	15,282.5	\$125,286	527.0
2020	Total	2015	\$9.02	293,155.5	\$3,319,263	611.0
2021	Jan	31	\$20.78	3,625.7	\$75,337	117.0
2021	Feb	160	\$16.36	19,953.0	\$326,372	124.7
2021	Mar	62	\$93.20	7,768.9	\$724,083	125.3
2021	Total	253	\$43.45	31,347.6	\$1,125,792	122.3

The additional payments to tier 1 synchronized reserves under the shortage pricing rule are a windfall. The additional payment does not create an incentive to provide more tier 1 synchronized reserves. The additional payment is not a payment for performance; all estimated tier 1 receives the higher payment regardless of whether they provide any response during any spinning event. Tier 1 resources are not obligated to respond to synchronized reserve events. In the first three months of 2021, there was one spinning event of 10 minutes or longer. In that event, 46.9 percent of the estimated tier 1 responded and 61.2 percent of tier 2 responded.

The MMU recommends that the rule requiring the payment of tier 1 synchronized reserve resources when the nonsynchronized reserve price is above zero be

eliminated immediately.⁴⁶ Tier 1 should be compensated only for a response to synchronized reserve events, as it was before the shortage pricing changes. This compensation requires that when a synchronized reserve event is called, all tier 1 response is paid the synchronized energy premium price.

PJM's current tier 1 compensation rules are presented in Table 10-12.

Table 10-12 Tier 1 compensation as currently implemented by PJM

Tier 1 Compensation by Type of Interval as Currently Implemented by PJM		
Interval Parameters	No Synchronized Reserve Event	Synchronized Reserve Event
NSRMCP=\$0	T1 credits = \$0	T1 credits = Synchronized Energy Premium Price * actual response MWi
NSRMCP>\$0	T1 credits = T2 SRMCP * estimated tier 1 MW	T1 credits = T2 SRMCP * min(estimated tier 1 MW, actual response MWi)

The MMU's recommended compensation rules for tier 1 MW are in Table 10-13.

Table 10-13 Tier 1 compensation as recommended by MMU

Tier 1 Compensation by Type of Hour as Recommended by MMU		
Interval Parameters	No Synchronized Reserve Event	Synchronized Reserve Event
NSRMCP=\$0	T1 credits = \$0	T1 credits = Synchronized Energy Premium Price * actual response MWi
NSRMCP>\$0	T1 credits = \$0	T1 credits = Synchronized Energy Premium Price * actual response MWi

Tier 2 Synchronized Reserve Market

Synchronized reserve is provided by generators or demand response resources synchronized to the grid and capable of increasing output or decreasing load within 10 minutes. Synchronized reserve consists of tier 1 and tier 2 synchronized reserves. When the synchronized reserve requirement cannot be met by tier 1 synchronized reserve, PJM clears a market to satisfy the requirement with tier 2 synchronized reserve. Tier 2 synchronized reserve is provided by online resources, either synchronized to the grid but not producing energy, or dispatched to provide synchronized reserve at an operating point

below their economic dispatch point. Tier 2 synchronized reserve is also provided by demand resources that have offered to reduce load in the event of a synchronized reserve event. Tier 2 synchronized reserves are committed to be available in the event of a synchronized reserve event. Tier 2 resources have a must offer requirement. Some tier 2 resources are scheduled by the ASO 60 minutes before the operating hour and are committed to provide synchronized reserve for the entire hour. Tier 2 resources are paid the higher of the SRMCP or their offer price plus lost opportunity cost (LOC). Demand response resources are paid the clearing price (SRMCP).

Synchronized reserve resources can be flexible or inflexible. Inflexible resources are defined as those resources that require an hourly commitment due to minimum run times or staffing constraints. Examples of inflexible reserves are synchronous condensers operating in condensing mode, resources with an economic minimum (EcoMin) equal to economic maximum (EcoMax), offline CTs and hydro that can operate in the condense mode, and demand resources. Inflexible tier 2 synchronized reserve resources are committed for a full hour by the hour ahead ASO market solution. Inflexible resources require a 30 minute notification time and cannot be released for energy during the operating hour. The inflexible commitments made by the hour ahead ASO solution may satisfy only part of the tier 2 requirement. The actual requirement is determined by the RT SCED solution and the requirement not satisfied by inflexible units is satisfied by flexible units. Flexible resources are already online for energy, require no notification time, and can be automatically dispatched.

During the operating hour, RT SCED can dispatch additional tier 2 resources. RT SCED can redispatch online tier 1 generating resources as tier 2 synchronized reserve to meet the synchronized and primary reserve requirements within the operational hour. Resources that are redispatched as tier 2 within the hour are required to maintain their available ramp and are paid the SRMCP plus any lost opportunity costs that exceed the SRMCP.

⁴⁶ This recommendation was presented as a proposal, "Tier 1 Compensation," to the Markets and Reliability Committee Meeting, October 22, 2015. The MMU proposal and a PJM counterproposal were both rejected.

Market Structure

Supply

PJM has a must offer tier 2 synchronized reserve requirement. All nonemergency generating resources are required to submit tier 2 synchronized reserve offers. All online, nonemergency generating resources are deemed available to provide both tier 1 and tier 2 synchronized reserve although certain unit types are exempt. If PJM issues a primary reserve warning, voltage reduction warning, or manual load dump warning, all offline emergency generation capacity resources available to provide energy must submit an offer for tier 2 synchronized reserve.⁴⁷

In the first three months of 2021, the Mid Atlantic Dominion (MAD) Reserve Subzone averaged 4,665.5 MW of tier 2 synchronized reserve offers, and the RTO Reserve Zone averaged 33,842.6 MW of tier 2 synchronized reserve offers (Figure 10-6).

The supply of tier 2 synchronized reserve offered in the first three months of 2021 was sufficient to cover the ASO hourly requirement net of tier 1 in both the RTO Reserve Zone and the MAD Reserve Subzone.

The largest portion of cleared tier 2 synchronized reserve in the first three months of 2021 was from CTs running on natural gas or oil (Table 10-14). Although demand resources are limited to providing no more than 33 percent of the total synchronized reserve requirement, the amount of tier 2 synchronized reserve required in any hour is often much less than the full synchronized reserve requirement because so much of it is met with tier 1 synchronized reserve. This means that in some hours demand resources make up considerably more than 33 percent of the cleared tier 2 MW. Demand resources often offer at a price of \$0, do not incur an LOC, and clear even when the price is \$0. As a result, their share of credits in the synchronized reserve market is much less than their share of cleared MW.

⁴⁷ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.1 Synchronized Reserve Market Eligibility, Rev. 113 March 29, 2021).

Table 10-14 Supply of Generation Tier 2 Synchronized Reserve by Unit Type and Fuel Type: January through March, 2021

Unit / Fuel Type	Percent by MW	Percent by Credits
CT - Natural Gas	32.6%	39.4%
DSR	30.1%	12.1%
Combined Cycle	11.3%	26.1%
CT - Oil	10.7%	10.9%
Hydro - Run of River	9.1%	3.9%
Steam - Coal	5.0%	6.0%
Hydro - Pumped Storage	0.5%	0.5%
RICE - Natural Gas	0.4%	0.6%
Steam - Natural Gas	0.1%	0.1%
Battery	0.0%	0.0%
CT - Other	0.0%	0.0%
Fuel Cell	0.0%	0.0%
Nuclear	0.0%	0.0%
RICE - Other	0.0%	0.0%
Solar	0.0%	0.0%
Solar + Storage	0.0%	0.0%
Solar + Wind	0.0%	0.0%
Steam - Oil	0.0%	0.0%
Steam - Other	0.0%	0.0%
Wind	0.0%	0.0%
Wind + Storage	0.0%	0.0%

Demand

On July 12, 2017, PJM adopted a dynamic synchronized reserve requirement set equal to 100 percent of the most severe single contingency (MSSC) as the first step, and extended by a 190 MW second step.⁴⁸ There are two circumstances in which PJM may alter the base portion of the synchronized reserve requirement from its 100 percent of the largest contingency value. Reserve requirements may be increased during a temporary switching condition when transmission outages or configuration problems cause several generation resources to be subject to a single contingency. When PJM operators anticipate periods of high load, they may bring on additional units to account for increased operational uncertainty in meeting load. When a Hot Weather Alert, Cold Weather Alert or an emergency procedure (as defined in Manual 11 § 4.2.2 Synchronized Reserve Requirement Determination) has been issued for the

⁴⁸ See the 2021 Quarterly State of the Market Report: January through March, Section 3: Energy Market, at "Operating Reserve Demand Curves".

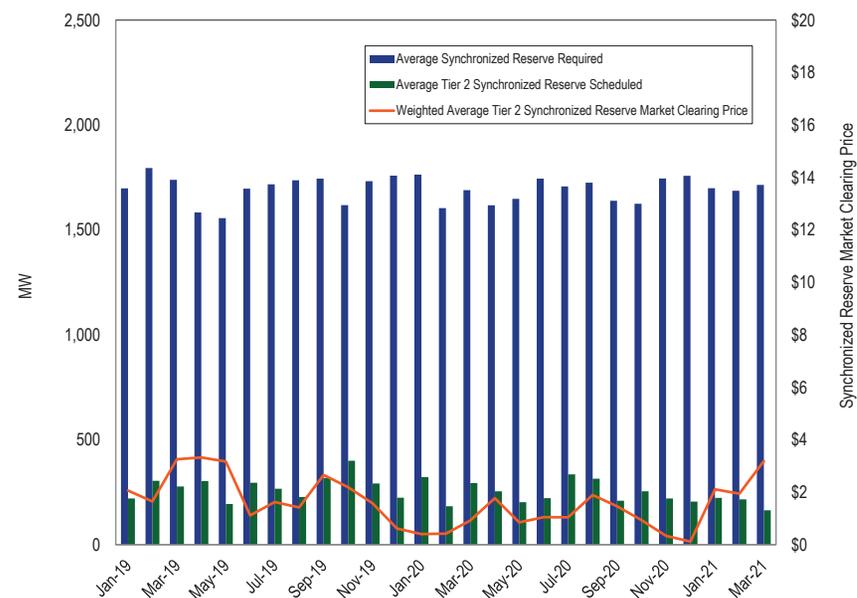
operating day, operators may increase the synchronized reserve requirement up to the full amount of the additional MW brought on line.⁴⁹

In the first three months of 2021, the average synchronized reserve requirement was 1,702.0 MW in both the RTO Zone and the MAD Subzone. These averages include temporary increases to the synchronized reserve requirement.

The RTO Reserve Zone scheduled and identified an average of 568.4 MW of tier 2 synchronized reserves in the first three months of 2021. Of this, an average of 408.9 MW was scheduled hourly.

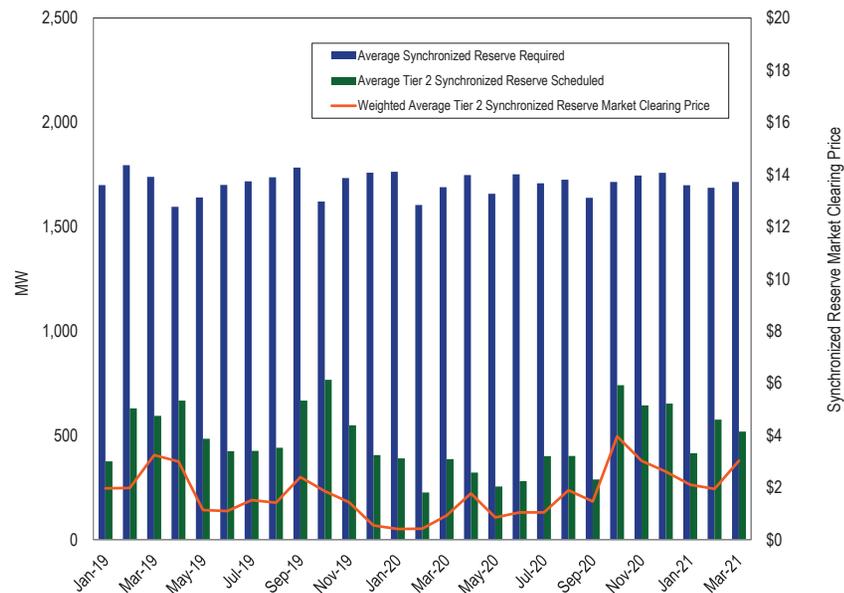
Figure 10-4 and Figure 10-5 show the average monthly synchronized reserve required and the average monthly tier 2 synchronized reserve MW scheduled (PJM scheduled plus self scheduled) from January 2019 through March 2021, for the RTO Reserve Zone and MAD Reserve Subzone. There were 33 intervals of shortage in 2019. There were 13 spinning events in 2019 but only two lasted longer than 10 minutes. There were seven intervals of shortage in 2020 and 16 spinning events with three longer than 10 minutes. In the first three months of 2021 there were four intervals of shortage and two spinning events.

Figure 10-4 MAD hourly average tier 2 synchronized reserve scheduled MW: January 2018 through March 2021



⁴⁹ PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.2 Synchronized Reserve Requirement Determination, Rev. 113 (March 29, 2021).

Figure 10-5 RTO hourly average tier 2 synchronized reserve scheduled MW: January 2018 through March 2021



Market Concentration

The average HHI for tier 2 synchronized reserve cleared intervals in the Mid-Atlantic Dominion Subzone Tier 2 Synchronized Reserve Market in the first three months of 2021 was 4895, which is defined as highly concentrated. In 65.5 percent of all cleared pricing intervals the maximum market share was greater than or equal to 40 percent.

The average HHI for tier 2 synchronized reserve for cleared pricing intervals of the RTO Zone Tier 2 Synchronized Reserve Market in the first three months of 2021 was 5376, which is defined as highly concentrated. In 89.0 percent of cleared intervals there was a maximum market share greater than or equal to 40 percent.

In the MAD Subzone, flexible synchronized reserve was 49.6 percent of all tier 2 synchronized reserve in the first three months of 2021. In the RTO Zone, flexible synchronized reserve was 44.6 percent of all tier 2 synchronized reserve in the first three months of 2021.

The market structure results indicate that the RTO Zone and Mid-Atlantic Dominion Subzone Tier 2 Synchronized Reserve Markets are not structurally competitive.

Market Behavior

Offers

Daily cost-based offers are submitted for each unit by the unit owner. For generators the offer must include, when relevant, a tier 1 synchronized reserve ramp rate, a tier 1 synchronized reserve maximum, self scheduled status, synchronized reserve availability, synchronized reserve offer quantity (MW), tier 2 synchronized reserve offer price, energy use for tier 2 condensing resources (MW), condense to gen cost, shutdown costs, condense startup cost, condense hourly cost, condense notification time, and spin as a condenser status. The synchronized reserve offer price made by the unit owner is subject to an offer cap of marginal cost plus a markup of \$7.50 per MW. The tier 1 synchronized reserve ramp rate must be greater than or equal to the real-time economic ramp rate. If the synchronized reserve ramp rate is greater than the economic ramp rate it must be justified by the submission of actual data from previous synchronized reserve events.⁵⁰ All suppliers are paid the higher of the market clearing price or their offer plus their unit specific opportunity cost. The offer quantity is limited to the economic maximum. PJM monitors this offer by checking to ensure that all offers are greater than or equal to 90 percent of the resource’s ramp rate times 10 minutes. A resource that is unable to participate in the synchronized reserve market during a given hour may set its hourly offer to zero MW. Certain defined resource types are not required to offer tier 2 because they cannot reliably provide synchronized reserve. These include: nuclear, wind, solar, landfill gas and energy storage resources.⁵¹

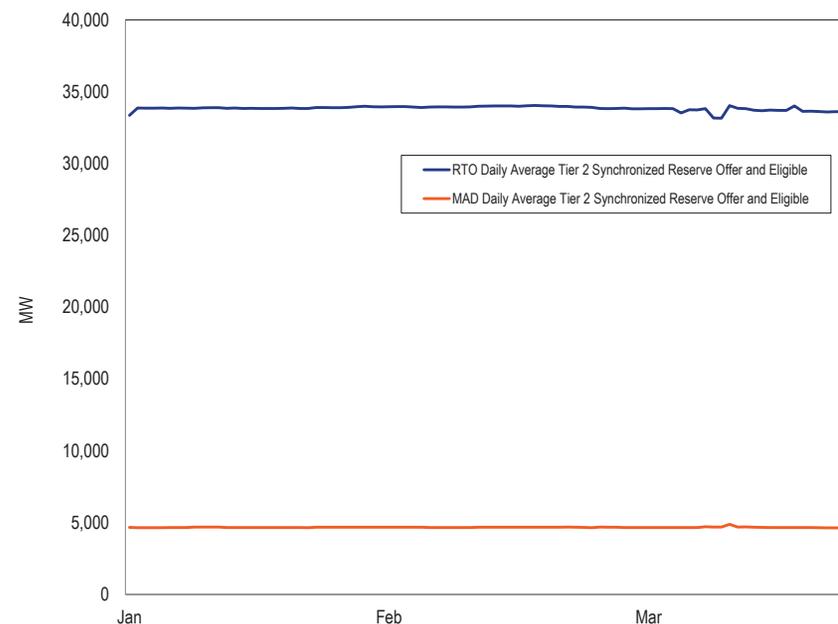
⁵⁰ See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 4.2.1 Synchronized Reserve Market Eligibility Rev. 113 March 29, 2021).

⁵¹ See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 4.2.1 Synchronized Reserve Market Eligibility Rev. 113 (March 29, 2021).

Figure 10-6 shows the daily average of hourly offered tier 2 synchronized reserve MW for both the RTO Synchronized Reserve Zone and the Mid-Atlantic Dominion Synchronized Reserve Subzone.

PJM has a tier 2 synchronized reserve must offer requirement for all generation that is online, nonemergency, and physically able to operate with an output less than dictated by economic dispatch. Tier 2 synchronized reserve offers are made on a daily basis with hourly updates permitted. Daily offers can be changed as a result of maintenance status or physical limitations only and are required regardless of online/offline state.⁵² The tier 2 synchronized reserve market is not cleared based on daily offers but based on hourly updates to the daily offers. As a result of hourly updates the actual amount of eligible tier 2 MW can change significantly every hour (Figure 10-6). Changes to the hourly offer status are only permitted when resources are physically unable to provide tier 2. Changes to hourly eligibility levels are the result of online status, minimum/maximum runtimes, minimum notification times, maintenance status and grid conditions including constraints. However, resource operators can make their units unavailable for an hour or block of hours without having to provide a reason.

Figure 10-6 Tier 2 synchronized reserve hourly offer and eligible volume (MW): January through March, 2021



For the first three months of 2021, 95.6 percent of generation resources expected to offer have daily tier 2 synchronized reserve offers. However, there were a large number of hours when many units made themselves unavailable for tier 2 synchronized reserve.

The MMU recommends that the tier 2 synchronized reserve must offer requirement be enforced. The MMU recommends that PJM define a set of acceptable reasons why a unit can be made unavailable daily or hourly and require unit owners to select a reason in Markets Gateway whenever making a unit unavailable either daily or hourly or setting the offer to 0 MW.⁵³

⁵² See *id.* ("Regardless of online/offline state, all non-emergency generation capacity resources must submit a daily offer for Tier 2 Synchronized Reserve in eMKT...").

⁵³ PJM adopted a new business rule in the third quarter of 2017 to enforce compliance with the tier 2 must-offer requirement. PJM enters a zero dollar offer price for all units with a must offer obligation for tier 2 synchronized reserves.

Market Performance

Price

The price of tier 2 synchronized reserve is calculated in real time every five minutes for the RTO Reserve Zone and the MAD Subzone. The tier 2 synchronized reserve market price is determined not only by the offer price of each cleared MW of tier 2, but additionally by the net cost of jointly optimizing the dispatch of energy and synchronized reserve. For each MW assigned, the clearing engines determine a product substitution price, i.e. the marginal cost of replacing the reserve MW with energy from other resources. The product substitution cost is a function of the LMPs of the MW of reserve, the marginal cost of energy for the resources providing reserves, and the minimized cost of substituted MW providing energy. At the margin, the price is the sum of the offer price plus the product substitution cost of the marginal unit(s).⁵⁴ The number of marginal units by schedule type is shown in Table 10-15.

Table 10-15 Schedule used for LOC of marginal units in Tier 2 Synchronized Reserve Market LOC calculation: January through March, 2021

Number of Marginal Units	Percent of Marginal Units with LOC Based on Cost Schedule	Percent of Marginal Units with LOC Based on Price Schedule
35,062	9.4%	90.6%

In the first three months of 2021, the RTO cleared a tier 2 synchronized reserve market in 51.9 percent of all dispatch solutions. In all other intervals there was enough tier 1 synchronized reserve to cover the synchronized reserve requirement. For intervals when the synchronized reserve requirement could not be met with tier 1, the market cleared an average of 406.5 MW of synchronized reserve including 115.0 MW of demand response at a MW weighted average or \$5.95 per hour.

The market clearing price for the MAD Subzone diverged from the RTO Zone in 13 intervals during the first three months of 2021.

⁵⁴ PJM Manual 11: Energy & Ancillary Services Market Operations, Rev. 113 (March 29, 2021), p. 92.

Supply, demand, and performance are reflected in the price of synchronized reserve (Table 10-16).

Table 10-16 RTO Zone, average SRMCP and average scheduled, tier 1 estimated and demand response MW in RT SCED market solutions: January 2020 through March 2021

Year	Month	Weighted Average Synchronized Reserve Market Clearing Price	Average Interval Tier 2 Generation Synchronized Reserve Purchased (MW)	Average Interval Tier 1 Synchronized Reserve Estimated (MW)	Average Interval Demand Response Cleared (MW)
2020	Jan	\$0.41	322.4	2,410.7	67.2
2020	Feb	\$0.42	183.7	2,285.5	42.6
2020	Mar	\$0.93	293.8	2,142.0	92.8
2020	Apr	\$1.77	255.0	2,223.8	66.5
2020	May	\$0.85	202.5	2,130.4	52.6
2020	Jun	\$1.05	221.9	2,723.9	58.6
2020	Jul	\$1.05	335.4	2,102.5	65.3
2020	Aug	\$1.90	314.7	1,961.6	86.5
2020	Sep	\$1.47	209.6	2,054.2	79.2
2020	Oct	\$3.96	575.1	1,380.2	165.3
2020	Nov	\$3.03	502.6	1,500.4	141.4
2020	Dec	\$2.61	507.7	1,506.8	145.0
2020	Average	\$1.62	327.0	2,035.2	88.6
2021	Jan	\$5.74	259.4	1,760.6	109.9
2021	Feb	\$4.84	330.0	1,845.7	170.9
2021	Mar	\$6.84	367.2	1,704.9	151.5
2021	Average	\$5.81	318.9	1,770.4	144.1

Settlement Cost

As a result of changing grid conditions, load forecasts, and unexpected generator performance, prices do not always cover the full cost to customers, including the final LOC for each resource. Because price formation occurs within the hour (on a five minute basis) but inflexible synchronized reserve commitment occurs prior to the hour, the realized, within hour price can be zero even when some tier 2 synchronized reserve is cleared. All resources cleared in the market are guaranteed to be made whole and are paid if the SRMCP does not compensate them for their offer plus LOC.

The full cost of tier 2 synchronized reserve including payments for the clearing price and out of market costs is calculated and compared to the price. The closer the price to cost ratio is to 100 percent, the more the market price reflects the full cost of tier 2 synchronized reserve. The price to cost ratio shows much tier 2 compensation results from price rather than uplift. A lower price to cost ratio indicates higher uplift.

In the first three months of 2021, the price to cost (including self scheduled) ratio of the RTO zone tier 2 synchronized reserve market averaged 59.6 percent, which was higher than the 44.7 percent price to cost ratio for 2020 (Table 10-17). Prices were significantly higher in the first three months of 2021 (\$5.81) than they were in 2020 (\$2.57) because of increases in the synchronized reserve requirement. The market clearing solution includes a constraint that forces all remaining synchronized reserve to be cleared from the MAD Subzone (Figure 10-1) when one of the constraints defining MAD binds. RTO/MAD prices diverged in only 13 intervals in the first three months of 2021. The average tier 2 synchronized reserve price in the RTO differed from the average Tier 2 synchronized reserve price in MAD by less than \$0.01.

Table 10-17 RTO Zone tier 2 synchronized reserve MW, credits, price, and cost: January 2019 through March 2021

Zone	Year	Month	Tier 2 Credited MW	Tier 2 SRMCP Credits	LOC Credits	Weighted Average Synchronized Reserve Market Clearing Price	Tier 2 Synchronized Reserve Cost	Tier 2 Price/Cost Ratio
RTO Zone	2020	Jan	260,488	\$248,407	\$668,973	\$0.95	\$3.52	27.1%
RTO Zone	2020	Feb	136,615	\$136,378	\$238,882	\$0.99	\$2.75	36.2%
RTO Zone	2020	Mar	232,757	\$455,181	\$374,827	\$1.96	\$3.57	54.8%
RTO Zone	2020	Apr	185,880	\$969,352	\$331,816	\$5.21	\$7.00	74.5%
RTO Zone	2020	May	153,053	\$336,361	\$378,671	\$2.20	\$4.67	47.0%
RTO Zone	2020	Jun	200,956	\$478,017	\$548,797	\$2.38	\$5.11	46.6%
RTO Zone	2020	Jul	306,725	\$882,101	\$2,532,837	\$2.87	\$11.13	25.7%
RTO Zone	2020	Aug	305,867	\$1,081,242	\$1,415,425	\$3.54	\$8.16	43.3%
RTO Zone	2020	Sep	194,802	\$584,764	\$531,167	\$3.00	\$5.73	52.4%
RTO Zone	2020	Oct	495,961	\$3,103,868	\$1,105,778	\$6.26	\$8.49	73.7%
RTO Zone	2020	Nov	425,670	\$1,818,452	\$704,908	\$4.27	\$5.93	72.1%
RTO Zone	2020	Dec	386,254	\$1,792,348	\$792,032	\$4.76	\$6.69	71.1%
RTO Zone	2020		1,977,144	\$5,171,801	\$7,021,397	\$2.57	\$5.74	44.7%
RTO Zone	2021	Jan	178,500	\$1,364,860	\$281,918	\$5.74	\$9.23	62.2%
RTO Zone	2021	Feb	299,383	\$1,372,679	\$1,056,759	\$4.84	\$8.11	59.6%
RTO Zone	2021	Mar	286,513	\$2,116,706	\$1,257,119	\$6.84	\$11.78	58.1%
RTO Zone	2021		764,396	\$4,854,245	\$2,595,796	\$5.81	\$9.75	59.6%

Performance

Tier 1 resource owners are paid for the actual amount of synchronized reserve they provide in response to a synchronized reserve event.⁵⁵ Tier 2 resource owners are paid for being available but are not paid based on the actual response to a synchronized reserve event. The MMU has identified and quantified the actual performance of scheduled tier 2 synchronized reserve resources when called on to deliver during synchronized reserve events since 2011.⁵⁶ When synchronized reserve resources self schedule or clear the Tier 2 Synchronized Reserve Market they are obligated to provide their full scheduled tier 2 MW during a synchronized reserve event. Actual synchronized reserve event response is determined by final output minus initial output where final output is the largest output between 9 and 11 minutes after start of the event, and initial output is the lowest output between one minute before the event and one minute after the event.⁵⁷ Tier 2 resources are obligated to sustain their final output for the shorter of the length of the event or 30 minutes. Penalties are assessed for failure of a scheduled tier 2 resource to perform during any synchronized reserve event lasting 10 minutes or longer.

Tier 2 performance has not been adequate. Compliance with calls to respond to actual synchronized reserve events remains significantly less than 100 percent. For the spinning events 10 minutes or longer in 2016, the average tier 2 synchronized reserve response was 85.5 percent of all scheduled MW. In 2017, the response rate was 87.6 percent. In 2018, the response rate was 74.2 percent. In 2019, the response rate was 86.8 percent. In 2020, there were five spinning events 10 minutes or longer with an average response rate of 59.5 percent of scheduled tier 2 MW. There was only one spinning event in the first three months of 2021 that was 10 minutes or longer. It had a tier 2 synchronized reserve response rate of 61.2 percent. Actual participant performance means that the penalty structure is not adequate to incent performance.

The penalty structure when a tier 2 resource fails to respond fully to a spinning event includes two components. The resource forfeits all SRMCP

⁵⁵ See *id.* at 98.

⁵⁶ See 2011 *State of the Market Report for PJM*, Vol. II, Section 9, "Ancillary Services," at 250.

⁵⁷ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.10 Settlements Rev. 113 (March 29, 2021).

credits and LOC credits in the amount of the MW shortage for the day on which the event occurred. The resource also receives a penalty for all hours in the Immediate Past Interval (IPI) in the amount of MW it falls short of its scheduled MW. The penalty is applied only to the SRMCP credits, not to the LOC credits. The penalty period is calculated as the lesser of the average number of days between spinning events over the past two years (ISI) or the number of days since the resource last failed to respond fully. There are several problems with this penalty structure. Resource owners are permitted to aggregate the response of multiple units to offset an underresponse from one unit with an overresponse from a different unit to reduce an underresponse penalty.⁵⁸ The IPI uses the last spinning event when the resource did comply. But for all spin events less than 10 minutes, compliance is automatically counted as 100 percent. This incorrectly truncates the IPI. The penalty applies only to the SRMCP credits not the LOC credits. But most credits awarded are for LOC (Table 10-18).

Under the current penalty structure it is possible for a resource to not respond to any spin events and yet be paid for providing tier 2. The current penalty structure for tier 2 synchronized reserve nonperformance is not adequate to provide appropriate performance incentives.

The IPI is defined as the number of days between spinning events, regardless of duration. This definition artificially shortens the period since the last requirement to perform. The MMU continues to recommend that the IPI be defined as the number of days between spinning events 10 minutes or longer. In the first quarter of 2021, PJM had two spin events, January 24 and March 9. The March 9 event lasted 10 minutes. The previous 10 minute event was on December 16, 2020. If only events 10 minutes or longer were considered, the IPI would increase to 75 days from its current level of 29 days. Use of the currently defined average IPI is not appropriate. The penalty should be based on the actual time since the last spinning event of 10 minutes or longer during which the resource performed because performance is only measured for events 10 minutes or longer. Even using the proposed IPI the penalties may

be insufficient to ensure response. A tier 2 shortfall penalty should include LOC payments as well as SRMCP and MW of shortfall.

Table 10-18 Comparison of tier 2 shortfall penalties under current IPI vs. MMU recommended IPI: January through March, 2021

Actual SRMCP Credits Using Current IPI	Actual Retroactive Penalty Charges Using Current IPI	Retroactive Penalty Using MMU Recommended IPI	Retroactive Penalty Using MMU Recommended IPI and LOC Forfeiture
\$673,133	\$75,157	\$168,602	\$356,912

Including aggregate responses from all online resources weakens the incentive to perform and creates an incentive to withhold reserves from other resources. Synchronized reserve commitment is unit specific, so the obligation to respond should also be unit specific. Any potentially offsetting response from an affiliated tier 1 resource should have been included as part of the reserves in the tier 1 estimate. Any potentially offsetting response from a tier 2 resource should have been included in that tier 2 offer.

The MMU recommends that aggregation not be permitted to offset unit specific penalties for failure to respond to a synchronized reserve event.

Spinning event response data as reported by PJM in its Operating Committee meetings is shown in Table 10-19. The tier 1 estimate is from the most recent RT SCED market solution. The tier 1 estimate includes estimated ramp only from the units that are eligible and excludes resources that have ramp available but are not part of the estimate.

Tier 1 synchronized reserve that responds to a spinning event receives a bonus payment of \$50 per MWh, based on a calculation using SCADA data, regardless of whether PJM included those reserves in the estimate.

Table 10-19 shows synchronized reserve event response compliance for tier 1 and tier 2 reserves as reported by PJM, using only response from tier 1 estimated and tier 2 cleared reserves. Actual synchronized reserve response is the total increase in MW from all resources from the moment the spinning event is called to ten minutes after. To determine the actual tier 1 response,

⁵⁸ See PJM "Manual 28: Operating Agreement Accounting," § 6.3 Charges for Synchronized Reserve, Rev. 84 (Dec. 17, 2020.)

the calculation would subtract tier 2 response, changes in assigned regulation output (net compliance level to both RegA and RegD), and changes to net power flow across PJM's interface boundary. The overall response to spinning events is adequate or more than adequate to meet NERC requirements. PJM not only corrects the ACE disturbance that led to the event but over corrects. In 7 of the 8 spinning events the ACE recovers not just to the NERC required level (which is the lesser of 0 or the value before the disturbance which caused the event) but overshoots.

Table 10-19 Synchronized reserve events 10 minutes or longer, tier 1 and tier 2 response compliance as reported by PJM, RTO Reserve Zone: January 2019 through March 2021

Spin Event (Day, EPT Time)	Duration (Minutes)	Tier 1 Estimate		Response from		Tier 2		Tier 2		DGP Estimated	Tier 2
		(Market Solution MW Adj by DGP)		Tier 1 DGP Estimated (MW)	Scheduled (MW)	Response (MW)	Penalty (MW)	Tier 1 Response Percent	Response Percent		
Sep 23, 2019 12:07	11	1,485.1		1,212.1	723.2	632.1	91.1	81.6%	87.4%		
Oct 1, 2019 14:56	11	265.4		143.7	1,177.4	1,016.4	161.0	54.1%	86.3%		
2019 Average	11	924.7		664.1	723.2	632.1	91.1	71.8%	87.4%		
Feb 18, 2020 20:15	10	2,216.1		1,434.8	40.0	1.7	38.3	64.7%	4.3%		
Jul 6, 2020 21:22	10	1,464.0		526.1	479.7	415.1	64.6	35.9%	86.5%		
Jul 25, 2020 16:39	11	868.4		421.6	302.3	264.8	37.5	48.5%	87.6%		
Sep 10, 2020 00:29	10	1,275.4		453.6	782.6	782.6	0.0	35.6%	100.0%		
Dec 16, 2020 16:49	10	268.4		196.9	527.6	413.2	114.4	73.4%	78.3%		
2020 Average	10	1,218.5		606.6	426.4	375.5	51.0	49.7%	59.5%		
Mar 9, 2021 07:50	10	1,354.9		635.4	884.0	540.8	343.2	46.9%	61.2%		

Until April 2019, PJM's ASO market solution software allowed operators to bias the inflexible tier 2 synchronized reserve solution by forcing the software to assume a different tier 1 MW value than the actual estimate. PJM, in response to the MMU recommendation, no longer uses tier 1 biasing in any of its market solutions. Biasing means manually modifying (decreasing or increasing) the tier 1 synchronized reserve estimate of the market solution.

Tier 1 biasing was never referenced in PJM manuals or any public document. PJM could resume tier 1 biasing at its discretion. Although tier 1 biasing has been discontinued, PJM can and does still deselect tier 1 resources based on PJM judgment. The impact of tier 1 deselection can be very significant (Table 10-20 and Table 10-21).

Table 10-20 Units deselected for tier 1 by market solutions but awarded credits for actual response: 2021

Spinning Event	Number of Units Awarded T1 Credits	Percent of Units		Percent of		
		Deselected for T1 but Awarded T1 Credits	Total T1 Credits Awarded	T1 Credits Deselected for T1	Total T1 Credited MW	Percent of T1 MW Awarded Credits But Deselected
1/24/2021 3:25	472	59.3%	\$6,592	46.0%	1,582.2	46.0%
3/9/2021 12:50	1386	67.7%	\$14,658	46.4%	3,518.0	46.4%

Table 10-21 Comparison of market solution tier 1 estimate, tier 1 response with PJM Settlements tier 1 MW credited: January through March, 2021

Start Time	Duration (Minutes)	PJM Market Solution DGP Estimated Tier 1 Estimate MW	PJM Market Solution DGP Estimated Tier 1 Response MW	PJM Settlements Tier 1 Credited Response MW
Jan 20, 2020 14:06	7.8	1,903.6	765.9	1,306.3
Jan 23, 2020 16:17	8.7	2,084.6	1,073.0	1,860.4
Feb 7, 2020 12:06	6.4	1,233.0	730.2	2,883.9
Feb 8, 2020 03:44	8.4	1,961.4	826.1	1,517.6
Feb 10, 2020 20:15	9.6	1,333.3	824.3	1,573.8
Feb 18 2020 11:16	10.0	2,216.1	1,434.8	2,528.6
Mar 8, 2020 05:17	5.6	1,541.4	660.1	843.5
Apr 13, 2020 19:53	7.9	433.0	207.2	886.5
May 3, 2020 12:23	6.6	4,154.4	1,369.6	2,260.5
Jul 6, 2020 21:22	10.4	1,464.0	526.1	1,554.5
Jul 24, 2020 01:03	9.9	1,562.7	852.8	1,762.7
Jul 25, 2020 16:39	11.7	868.4	421.6	961.5
Sep 10, 2020 00:19	9.5	1,275.4	453.6	1,417.0
Oct 10, 2020 18:52	7.7	2,134.3	1,234.3	2,187.8
Oct 12, 2020 04:29	9.3	1,625.8	670.5	1,229.2
Nov 13, 2020 11:36	5.9	1,687.9	882.4	1,682.8
Dec 16, 2020 16:38	10.0	268.4	196.9	1,213.0
Jan 25, 2021 03:22	6.5	2,134.5	577.9	1,582.2
Mar 9, 2021 12:50	10.8	1,354.9	635.4	3,518.0

History of Synchronized Reserve Events

Synchronized reserve is designed to provide relief for disturbances.⁵⁹ ⁶⁰ A disturbance is defined as loss of the lesser of 900 MW or 80 percent of the most severe single contingency within 60 seconds. In the absence of a disturbance, PJM operators have used synchronized reserve as a source of energy to provide relief from low ACE.

The risk of using synchronized reserves for energy or any other nondisturbance reason is that it reduces the amount of synchronized reserve available for a disturbance. Disturbances are unpredictable. Synchronized reserve has a requirement to sustain its output for only up to 30 minutes. When the need is for reserve extending past 30 minutes, secondary reserve is the appropriate source of the response. The use of synchronized reserve is an expensive solution during an hour when the hour ahead market solution and reserve dispatch indicate no shortage of primary reserve. PJM's primary reserve levels have been sufficient to recover from disturbances and should remain available in the absence of disturbances.

From January 2010 through March 2021, PJM experienced 260 synchronized reserve events (Table 10-22), approximately two events per month. During this period, synchronized reserve events had an average duration of 11.5 minutes.

⁵⁹ 2013 State of the Market Report for PJM, Appendix F – PJM's DCS Performance, at 451–452.

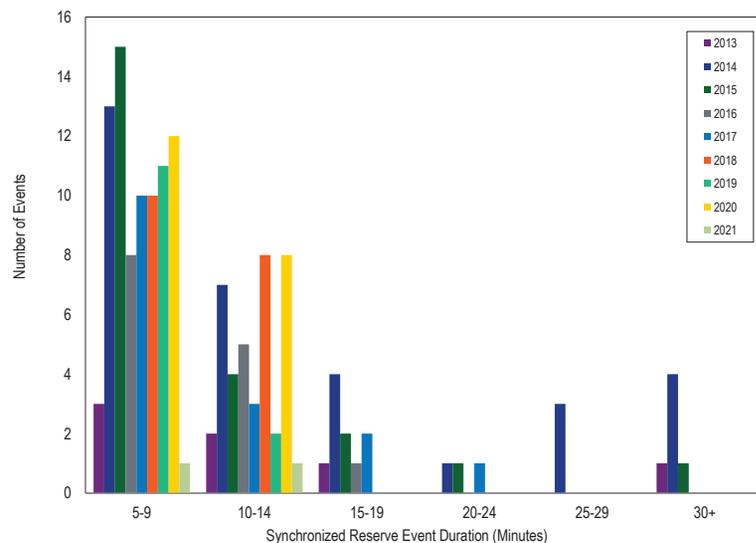
⁶⁰ See PJM "Manual 12: Balancing Operations," Rev. 42 (Jan. 27, 2021) § 4.1.2 Loading Reserves.

Table 10-22 Synchronized reserve events: January 2017 through March 2021⁶¹

Effective Time	Region	Duration (Minutes)									
JAN-01-2018 02:41	RTO	7	JAN-22-2019 22:30	RTO	8	JAN-20-2020 14:06	MAD	8	JAN-24-2021 22:32	RTO	6
JAN-03-2018 03:00	RTO	13	JAN-31-2019 01:26	RTO	5	JAN-23-2020 16:17	RTO	9	MAR-9-2021 07:51	RTO	11
JAN-07-2018 14:15	RTO	9	JAN-31-2019 09:26	RTO	9	FEB-07-2020 12:06	RTO	6			
APR-12-2018 13:28	RTO	10	FEB-25-2019 00:25	RTO	9	FEB-08-2020 03:44	RTO	8			
JUN-04-2018 10:22	RTO	6	MAR-03-2019 12:31	RTO	9	FEB-10-2020 20:15	RTO	9			
JUN-29-2018 15:21	RTO	9	MAR-06-2019 22:06	RTO	9	FEB-18-2020 11:16	RTO	10			
JUN-30-2018 09:46	RTO	11	JUL-27-2019 23:31	RTO	7	MAR-08-2020 05:17	MAD	5			
JUL-04-2018 10:56	RTO	7	AUG-11-2019 12:14	RTO	8	APR-13-2020 20:01	RTO	8			
JUL-10-2018 15:45	RTO	13	SEP-03-2019 13:39	MAD	9	MAY-03-2020 12:29	RTO	6			
JUL-23-2018 09:02	RTO	8	SEP-23-2019 16:06	RTO	11	JUL-06-2020 21:22	RTO	10			
JUL-23-2018 15:43	RTO	6	OCT-01-2019 18:56	RTO	11	JUL-24-2020 01:03	RTO	9			
JUL-24-2018 16:17	RTO	7	DEC-11-2019 21:08	RTO	8	JUL-25-2020 16:39	MAD	11			
AUG-12-2018 11:06	RTO	11	DEC-18-2019 15:07	RTO	9	SEP-10-2020 00:19	RTO	10			
SEP-13-2018 09:47	RTO	7				OCT-10-2020 18:52	RTO	8			
SEP-14-2018 13:24	RTO	7				OCT-12-2020 04:29	RTO	9			
SEP-26-2018 19:08	RTO	8				NOV-13-2020 07:46	RTO	6			
SEP-30-2018 11:29	RTO	11				DEC-16-2020 16:38	MAD	10			
OCT-30-2018 10:40	RTO	11									

Figure 10-8 shows spin event durations over the past eight years.

Figure 10-7 Synchronized reserve events duration distribution curve: January 2013 through March 2021



61 For full history of spinning events, see the 2019 State of the Market Report for PJM, Appendix E - Ancillary Service Markets.

Nonsynchronized Reserve Market

Nonsynchronized reserve consists of MW available within 10 minutes but not synchronized to the grid. Startup time for nonsynchronized reserve resources is not subject to testing and is based on parameters in offers submitted by resource owners. There is no defined requirement for nonsynchronized reserves. It is available to meet the primary reserve requirement. Generation resources that have designated their entire output as emergency are not eligible to provide nonsynchronized reserves. Generation resources that are not available to provide energy are not eligible to provide nonsynchronized reserves.

The market mechanism for nonsynchronized reserve does not include any direct participation by market participants. PJM defines the demand curve for nonsynchronized reserve and PJM defines the supply curve based on nonemergency generation resources that are available to provide energy and can start in 10 minutes or less and on the associated resource opportunity costs calculated by PJM. Generation owners do not submit supply offers. Since nonsynchronized reserve is a lower quality product, its clearing price is less than or equal to the synchronized reserve market clearing price. In most hours, the nonsynchronized reserve clearing price is zero.

Market Structure

Demand

Demand for primary reserve is established by PJM as one and a half times the largest contingency. Demand for primary reserve is calculated dynamically in every synchronized and nonsynchronized reserve market solution. After filling the synchronized reserve requirement the balance of primary reserve can be made up by the most economic combination of synchronized and nonsynchronized reserve. In practice this means that the primary reserve requirement minus the scheduled synchronized reserve is the nonsynchronized requirement for the interval. PJM may increase the primary reserve requirement to cover times when a single contingency could cause an

outage of several generating units or in times of high load conditions causing operational uncertainty.⁶²

The average scheduled nonsynchronized reserve in the RTO Zone in the first three months of 2021 was 1,493.3 MW. The average scheduled nonsynchronized reserve in the MAD Subzone for primary reserve was 1,245.0 MW.

Supply

Figure 10-2 shows that when tier 1 synchronized reserve does not fully meet the synchronized reserve requirement, then most of the primary reserve requirement (red line) in excess of the synchronized reserve requirement (yellow line) is satisfied by nonsynchronized reserve (gray area).

There are no offers for nonsynchronized reserve. The market solution considers the available supply of nonsynchronized reserve to be all generation resources currently not synchronized to the grid but available and capable of providing energy within 10 minutes. Generators that have set themselves as unavailable or have set their output to be emergency only will not be considered. The market solution considers the offered MW to be the lesser of the economic maximum or the ramp rate times 10 minutes minus the startup and notification time. The market supply curve is constructed from the nonsynchronized units' opportunity cost of providing reserves. PJM and generation owners may agree upon exceptions to the requirements.

Nonsynchronized reserve resources are scheduled economically based on estimated LOC until the Primary Reserve requirement is filled. The nonsynchronized reserve market clearing price is determined every five minutes based on the LOC of the marginal unit. When a unit clears the nonsynchronized reserve market and is scheduled, it is committed to remain offline and available to provide 10 minute reserves.

Resources that generally qualify as nonsynchronized reserve include run of river hydro, pumped hydro, combustion turbines, combined cycles that can

⁶² See PJM "Manual 11: Energy and Ancillary Services Market Operations," § 4.2.2 Synchronized Reserve Requirement Determination, Rev. 113 (March 29, 2021).

start in 10 minutes or less, and diesels.⁶³ In the first three months of 2021, an average of 1,338.0 MW of nonsynchronized reserve was scheduled per five minute interval out of 1,419.2 eligible MW as part of the primary reserve requirement in the RTO Zone. If only intervals when the price was greater than \$0 are looked at, then an average of 500.9 MW of nonsynchronized reserve is scheduled out of 1,078.9 MW available.

In the first three months of 2021, CTs provided 89.7 percent of scheduled nonsynchronized reserve (Table 10-23). Natural gas was the primary fuel for nonsynchronized reserve.

Table 10-23 Supply of nonsynchronized reserve by fuel and unit type: January through March, 2021

Unit / Fuel Type	Percent by MW	Percent by Credits
CT - Natural Gas	56.6%	63.8%
CT - Oil	33.1%	27.0%
Hydro - Run of River	10.1%	9.0%
Hydro - Pumped Storage	0.1%	0.1%
RICE - Other	0.1%	0.0%
Combined Cycle	0.0%	0.0%
Steam - Coal	0.0%	0.0%
RICE - Natural Gas	0.0%	0.0%
Steam - Natural Gas	0.0%	0.0%
Battery	0.0%	0.0%
CT - Other	0.0%	0.0%
Fuel Cell	0.0%	0.0%
Nuclear	0.0%	0.0%
Solar	0.0%	0.0%
Solar + Storage	0.0%	0.0%
Solar + Wind	0.0%	0.0%
Steam - Oil	0.0%	0.0%
Steam - Other	0.0%	0.0%
Wind	0.0%	0.0%
Wind + Storage	0.0%	0.0%

⁶³ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 4b.2 Non-Synchronized Reserve Market Business Rules, Rev. 113 (March 29, 2021)

Market Concentration

The supply of nonsynchronized reserves in the Mid-Atlantic Dominion Subzone and the RTO Zone was highly concentrated in the first three months of 2021.

Table 10-24 Nonsynchronized reserve market pivotal supplier test: January through March, 2021

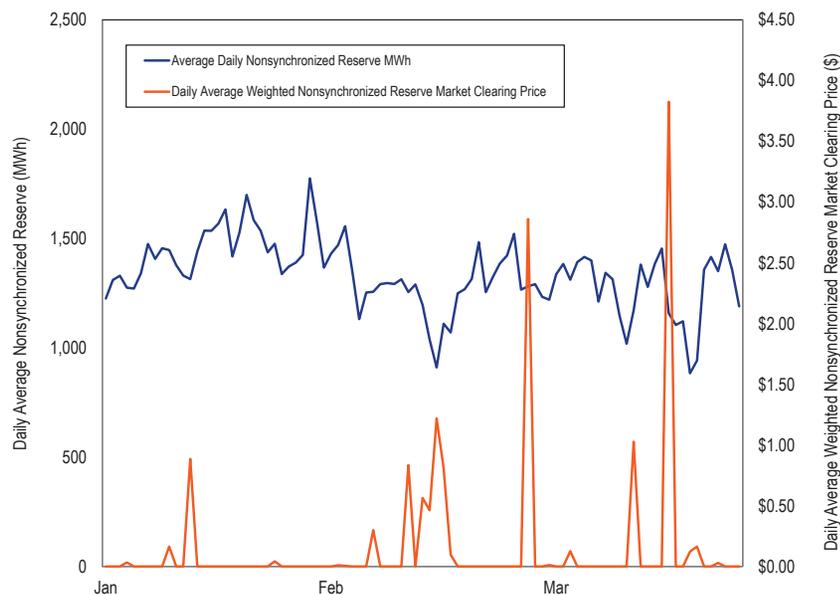
Year	Month	Number Intervals of Clearing	Percent of Intervals
		Price > \$0.01	NSRMCP > \$0.01 Pivotal
2021	Jan	28	100.0%
2021	Feb	98	89.8%
2021	Mar	62	83.9%
2021	Average	63	91.2%

Price

The settled price of nonsynchronized reserve is calculated in real time every five minutes for the RTO Reserve Zone and the Mid-Atlantic Dominion Reserve Subzone.

Figure 10-8 shows the daily average nonsynchronized reserve market clearing price (NSRMCP) and average scheduled MW for the RTO Zone. In the first three months of 2021, the weighted average nonsynchronized market clearing price was \$0.22 per MW. The average nonsynchronized reserve scheduled was 1,338.0 MW.

Figure 10-8 Daily average RTO Zone nonsynchronized reserve market clearing price and MW purchased: January through March, 2021



Price and Cost

As a result of changing grid conditions, load forecasts, incorrect LMP and lost opportunity cost projections, and unexpected generator performance, prices frequently do not cover the full LOC of each resource. All resources cleared in the market are guaranteed to be made whole and are paid uplift credits if the NSRMCP does not fully compensate them. When real-time LMP is greater than the generator’s incremental energy offer at economic minimum, then an LOC is paid, even if LMP revenue would not have covered the unit’s start and no load costs.⁶⁴

The full cost to customers of nonsynchronized reserve, including payments for the clearing price and uplift costs is calculated and compared to the

⁶⁴ See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 2.16 Minimum Capacity Emergency in Day-ahead Market, Rev. 113 (March 29, 2021).

price (Table 10-25). The closer the price to cost ratio comes to one, the more compensation is provided through market prices rather than uplift.

In the first three months of 2021, the average price of nonsynchronized reserve was \$0.22. The average cost per MW of nonsynchronized reserve was \$1.19.

Resources that are not synchronized to the grid are generally off because it is not economic for them to produce energy. A resource scheduled for nonsynchronized reserve is obligated to remain unsynchronized even if its LMP changes and it becomes economic to start. In that case, the unit has a positive LOC.

Table 10-25 RTO zone nonsynchronized reserve MW, charges, price, and cost: January 2020 through March 2021

Market	Year	Month	Total Nonsynchronized Reserve MW	Total Nonsynchronized Reserve Charges	Weighted Nonsynchronized Reserve Market Price	Nonsynchronized Reserve Cost	Price/Cost Ratio
RTO Zone	2020	Jan	775,929	\$377,336	\$0.00	\$0.49	NA
RTO Zone	2020	Feb	758,614	\$138,939	\$0.00	\$0.18	NA
RTO Zone	2020	Mar	806,059	\$170,156	\$0.00	\$0.21	NA
RTO Zone	2020	Apr	665,747	\$644,306	\$0.02	\$0.97	2.1%
RTO Zone	2020	May	774,183	\$425,791	\$0.01	\$0.55	1.1%
RTO Zone	2020	Jun	619,391	\$649,601	\$0.11	\$1.05	10.4%
RTO Zone	2020	Jul	767,222	\$648,118	\$0.24	\$0.84	28.4%
RTO Zone	2020	Aug	799,233	\$1,106,678	\$0.49	\$1.38	35.4%
RTO Zone	2020	Sep	761,617	\$750,028	\$0.02	\$0.98	2.0%
RTO Zone	2020	Oct	773,420	\$1,588,183	\$0.93	\$2.05	45.2%
RTO Zone	2020	Nov	725,048	\$809,177	\$0.36	\$1.12	31.9%
RTO Zone	2020	Dec	851,859	\$921,357	\$0.07	\$1.08	6.4%
RTO Zone	2020	Total	9,078,323	\$8,229,669	\$0.19	\$0.91	18.10%
RTO Zone	2021	Jan	878,568	\$531,437	\$0.05	\$0.60	8.3%
RTO Zone	2021	Feb	706,486	\$600,304	\$0.27	\$0.85	31.8%
RTO Zone	2021	Mar	760,807	\$1,612,035	\$0.34	\$2.12	16.0%
RTO Zone	2021	Total	2,345,861	\$2,743,776	\$0.22	\$1.19	18.5%

Secondary Reserve (DASR)

There is no NERC standard for secondary reserve. PJM defines secondary reserve as reserves (online or offline available for dispatch) that can be converted to energy in 30 minutes. PJM defines a secondary reserve requirement but does not currently have a defined reserve product to maintain this reserve requirement in real time.

PJM maintains a day-ahead, offer based market for 30 minute day-ahead secondary reserve. The Day-Ahead Scheduling Reserve Market (DASR) has no performance obligations except that a unit which clears the DASR market is required to be available for dispatch in real time.⁶⁵

Market Structure

Supply

Both generation and demand resources are eligible to offer DASR. DASR offers consist of price only. Available DASR MW are calculated by the market clearing engine. DASR MW are the lesser of the energy ramp rate per minute for online units times 30 minutes, or the economic maximum MW minus the day-ahead dispatch point. For offline resources capable of being online in 30 minutes, the DASR quantity is the economic maximum. In the first three months of 2021, the average available hourly DASR was 46,303.2 MW, an 11.5 percent decrease from 2020. The DASR hourly MW purchased averaged 4,705.2 MW.

PJM excludes resources that cannot reliably provide reserves in real time from participating in the DASR market. Such resources include nuclear, run of river hydro, self scheduled pumped hydro, wind, solar, and energy storage resources.⁶⁶ The intent of this proposal is to limit cleared DASR resources to those resources actually capable of providing reserves in the real-time market. Owners of excluded resources may request an exemption from their default noneligibility.

⁶⁵ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 10.5 Aggregation for Economic and Emergency Demand Resources, Rev. 113 (March 29, 2021).

⁶⁶ See PJM "Manual 11: Energy & Ancillary Services Market Operations," § 11.2.2 Day-Ahead Scheduling Reserve Market Eligibility, Rev. 113 (March 29, 2021).

Of the scheduled DASR MW cleared in the first three months of 2021, 87.0 percent was from CTs (Table 10-26).

Table 10-26 Scheduled DASR by fuel and unit type: January through March, 2021

Unit Type	Percentage of DASR MW	Percentage of DASR Credits
CT - Natural Gas	69.0%	65.8%
CT - Oil	18.0%	22.7%
Hydro - Pumped Storage	7.3%	2.8%
Combined Cycle	3.8%	4.4%
Steam - Coal	1.7%	3.1%
RICE - Oil	0.1%	0.3%
Steam - Natural Gas	0.1%	0.0%
RICE - Other	0.0%	0.6%
RICE - Natural Gas	0.0%	0.2%
Hydro - Run of River	0.0%	0.0%
Battery	0.0%	0.0%
CT - Other	0.0%	0.0%
Fuel Cell	0.0%	0.0%
Nuclear	0.0%	0.0%
Solar	0.0%	0.0%
Solar + Storage	0.0%	0.0%
Solar + Wind	0.0%	0.0%
Steam - Oil	0.0%	0.0%
Steam - Other	0.0%	0.0%
Wind	0.0%	0.0%
Wind + Storage	0.0%	0.0%

Demand

Secondary reserve (30 minute reserve) requirements are determined by PJM for each reliability region. In the ReliabilityFirst (RFC) region, secondary reserve requirements are calculated based on historical under forecasted load rates and generator forced outage rates.⁶⁷ The DASR requirement is calculated daily and is equal to the peak load forecast for the ReliabilityFirst region (RFC) and EKPC times the sum of the forced outage rate and the load forecast error, plus Dominion's share of the VACAR contingency reserve commitment. Effective November 1, 2020 through October 31, 2021, the day-ahead scheduling

⁶⁷ See PJM "Manual 13: Emergency Operations," § 2.2 Reserve Requirements, Rev. 78 (Jan. 27, 2021).

reserve requirement is 4.78 percent of the peak load forecast. This is based on a 2.18 percent load forecast error component and a 2.60 percent forced outage rate component. The DASR requirement is applicable for all hours of the operating day.

The DASR requirement can be increased by PJM operators under conditions of “hot weather or cold weather alert or max emergency generation alert or other escalating emergency.”⁶⁸ The amount of additional DASR MW that may be required is the Adjusted Fixed Demand (AFD) determined by a Seasonal Conditional Demand (SCD) factor.⁶⁹ The SCD factor is calculated separately for the winter (November through March) and summer (April through October) seasons. The SCD factor is calculated every year based on the top 10 peak load days from the prior year. For November 2020 through October 2021, the SCD values are 2.12 percent for winter and 4.78 percent for summer. PJM Dispatch may also schedule additional Day-Ahead Scheduling Reserves as deemed necessary for conservative operations.⁷⁰ PJM has defined the reasons for conservative operations to include, potential fuel delivery issues, forest/brush fires, extreme weather events, environmental alerts, solar disturbances, unknown grid operating state, physical or cyber attacks.⁷¹ The result is substantial discretion for PJM to increase the demand for DASR under a variety of circumstances. PJM did not invoke adjusted fixed demand during the first three months of 2021.

The MMU recommends that PJM modify the DASR market to ensure that all resources cleared incur a real-time performance obligation. The MMU further recommends that PJM attach a reason code to all hours when adjusted fixed demand is dispatched.

Market Concentration

DASR market three pivotal supplier test results are provided in Table 10-27.

68 PJM. “Energy and Reserve Pricing & Interchange Volatility Final Proposal Report,” <<http://www.pjm.com/~media/committees-groups/committees/mrc/20141030/20141030-item-04-erpriv-final-proposal-report.ashx>>.

69 See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 11.2.1 Day-Ahead Scheduling Reserve Market Requirement, Rev. 113 (March 29, 2021).

70 See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 11.2.1 Day-Ahead Scheduling Reserve Market Requirement, Rev. 113 (March 29, 2021).

71 See PJM “Manual 13: Emergency Operations,” § 3.2 Conservative Operations, Rev. 78 (Jan. 27, 2021).

Table 10-27 DASR market three pivotal supplier test results and number of hours with DASRMCP above \$0.01: January 2020 through March 2021

Year	Month	Number of Hours When DASRMCP > \$0	Percent of Hours Where DASRMCP>0 Pivotal
2020	Jan	1	33.3%
2020	Feb	1	50.0%
2020	Mar	1	100.0%
2020	Apr	17	70.8%
2020	May	70	49.3%
2020	Jun	73	22.7%
2020	Jul	89	42.0%
2020	Aug	73	22.7%
2020	Sep	59	66.3%
2020	Oct	86	50.6%
2020	Nov	47	67.1%
2020	Dec	35	50.7%
2020	Average	46	0.0%
2021	Jan	9	60.0%
2021	Feb	15	57.7%
2021	Mar	10	43.5%
2021	Average	11	53.7%

Market Conduct

PJM rules allow any unit with reserve capability that can be converted into energy within 30 minutes to offer into the DASR market.⁷² Units that do not offer have their offers set to \$0.00 per MW during the day-ahead market clearing process.

Economic withholding remains an issue in the DASR market. The marginal cost of providing DASR is zero. All offers greater than zero constitute economic withholding. In the first three months of 2021, 39.4 percent of generation units offered DASR at a daily price above \$0.00 per MW. In the first three months of 2021 16.2 percent of daily offers were above \$5.00 per MW.

The MMU recommends that market solutions for the DASR market be based on opportunity cost only in order to eliminate economic withholding.

72 See PJM “Manual 11: Energy & Ancillary Services Market Operations,” § 11.2.2 Day-Ahead Scheduling Reserve Market Eligibility, Rev. 113 (March 29, 2021).

Market Performance

In the first three months of 2021, the DASR market cleared at a price above \$0.00 per MW in 3.9 percent of all hours. The weighted average DASR price for all cleared hours was \$0.14 per MW. The average cleared MW in all hours was 4,597.9 MW. The average cleared MW in all hours when the DASRMCP was above \$0.00 was 4,750.5 MW. The highest DASR price was \$1.00 per MW for two hours on February 17, 2021.

The introduction of Adjusted Fixed Demand (AFD) on March 1, 2015, created a bifurcated market. In 2015, PJM added AFD to the normal 5.93 percent of forecast load in 367 hours. In 2016, PJM added AFD to the normal 5.7 percent of forecast load in 522 hours. In 2017, PJM added AFD to the normal 5.52 percent of forecast load in 336 hours. In 2018, PJM added AFD to the normal 5.28 percent in 598 hours. In 2019, PJM added AFD to the normal 5.29 percent in 447 hours. In 2020, PJM added AFD to the normal 5.07 percent in 430 hours. There were no AFD hours in the first three months of 2021. The difference in market clearing price, MW cleared, obligation incurred, and charges to PJM load are substantial. Table 10-28 shows the differences in price and MW between AFD hours and non-AFD hours in 2020. PJM has not declared adjusted fixed demand in 2021.

Table 10-28 Impact of Adjusted Fixed Demand on DASR prices and demand: January through December, 2020

Metric	Number Hours	Weighted Day-Ahead Scheduling	
		Reserve Market Clearing Price (DASRMCP)	Average Hourly Total DASR MW
All Hours	8,784	\$0.30	4,911.5
All Hours when DASRMCP > \$0	1,235	\$1.75	6,079.1
All Hours when AFD is used	430	\$2.55	9,253.7

While the new rules allow PJM operators' substantial discretion to add to DASR demand for a variety of reasons, the rationale for each specific increase is not always clear. The MMU recommends that PJM Market Operations attach a reason code to every hour in which PJM operators add additional DASR MW above the default DASR hourly requirement. The addition of such a code would make the reason explicit, increase transparency and facilitate analysis of the use of PJM's ability to add DASR MW.

Comparing the Normal Hour column against the AFD Hour column for five metrics (Table 10-29) shows that the use of AFD for 552 hours in 2020 significantly increased the cost of DASR. Table 10-29 shows that the cost increase was a result of a substantial increase in DASR MW cleared. The average DASR clearing price in 2020 was \$0.61 for hours when the clearing price was above \$0.00 and \$2.55 during hours when adjusted fixed demand was invoked by PJM Dispatch.

Table 10-29 DASR market, regular hours vs. adjusted fixed demand hours: January 2020 through March 2021

Year	Month	Number of Hours				Hourly Average Cleared				Average Hourly DASR Credits	
		DASRMCP > \$0		Weighted DASRMCP		Average PJM Load MW		DASR MW			
		Normal Hour	AFD Hour	Normal Hour	AFD Hour	Normal Hour	AFD Hour	Normal Hour	AFD Hour	Normal Hour	AFD Hour
2020	Jan	1	NA	\$0.00	NA	89,919	NA	4,939	NA	\$2	NA
2020	Feb	1	NA	\$0.00	NA	88,655	NA	4,863	NA	\$2	NA
2020	Mar	1	NA	\$0.00	NA	78,508	NA	4,449	NA	\$1	NA
2020	Apr	17	NA	\$0.00	NA	70,687	NA	4,045	NA	\$0	NA
2020	May	70	NA	\$0.01	NA	71,826	NA	4,106	NA	\$57	NA
2020	Jun	73	48	\$1.28	\$1.87	110,779	97,191	6,512	10,250	\$8,788	\$20,556
2020	Jul	89	358	\$3.20	\$2.41	123,379	110,399	8,269	9,055	\$27,660	\$22,838
2020	Aug	73	24	\$1.71	\$5.74	118,231	110,971	6,051	10,223	\$10,535	\$59,981
2020	Sep	59	NA	\$0.39	NA	102,265	NA	5,064	NA	\$1,982	NA
2020	Oct	86	NA	\$0.31	NA	80,004	NA	4,195	NA	\$1,295	NA
2020	Nov	47	NA	\$0.21	NA	89,150	NA	4,484	NA	\$928	NA
2020	Dec	35	NA	\$0.20	NA	100,845	NA	4,820	NA	\$977	NA
2020		552	430	\$0.61	\$2.55	93,687	106,187	5,150	9,843	\$4,352	\$34,458
2021	Jan	9	NA	\$0.08	NA	106,153	NA	4,848	NA	\$381	NA
2021	Feb	15	NA	\$0.16	NA	108,947	NA	4,983	NA	\$821	NA
2021	Mar	10	NA	\$0.17	NA	92,014	NA	4,327	NA	\$732	NA
2021		34	NA	\$0.14	NA	102,371	NA	4,719	NA	\$645	NA

Table 10-30 shows total number of hours when a DASR market cleared at a price above \$0 along with average load, cleared MW, additional MW under AFD, and total charges for the DASR market in January 2020 through March 2021.

Table 10-30 DASR market all hours of DASR market clearing price greater than \$0: January 2020 through March 2021

Year	Month	Number of Hours		Weighted DASR Market Clearing Price	Average Hourly RT Load MW	Total PJM Cleared DASR MW	Total PJM Cleared		Total Credits
		DASRMCP > \$0					Additional DASR MW		
2020	Jan	1		\$0.08	111,016	14,817		0	\$1,462
2020	Feb	1		\$0.16	109,218	15,961		0	\$1,524
2020	Mar	1		\$0.17	92,457	4,532		0	\$861
2020	Apr	17		NA	NA	NA		0	NA
2020	May	70		\$0.29	96,413	146,365		0	\$42,334
2020	Jun	73		\$1.28	110,779	1,015,850		491,982	\$2,357,557
2020	Jul	89		\$3.20	123,379	2,753,429		3,241,749	\$17,386,688
2020	Aug	73		\$1.71	118,232	1,349,321		245,362	\$3,788,869
2020	Sep	59		\$0.39	102,265	531,772		0	\$207,765
2020	Oct	86		\$0.31	80,004	851,671		0	\$262,925
2020	Nov	47		\$0.21	89,150	385,608		0	\$79,842
2020	Dec	35		\$0.20	100,845	438,634		0	\$88,929
2020	Total	552		\$0.73	103,069	7,507,959		3,979,093	\$24,218,754
2021	Jan	9		\$0.08	106,153	135,755		0	\$10,654
2021	Feb	15		\$0.16	108,947	159,442		0	\$26,275
2021	Mar	10		\$0.17	92,014	103,848		0	\$17,574
2021	Total	34		\$0.14	102,371	399,045		0	\$54,504

When the DADR requirement is increased by PJM dispatch, the reserve requirement frequently cannot be met without redispatching online resources which significantly affects the price by creating an LOC. Adjusted Fixed Demand related increases in the DADR requirement (Table 10-30) in 2020 caused prices to increase. The lack of Adjusted Fixed Demand in January through March of 2021 has kept DADR price and cost lower than in 2020.

Regulation Market

Regulation matches generation with very short term changes in load by moving the output of selected resources up and down via an automatic control signal. Regulation is provided by generators with a short-term response capability (less than five minutes) or by demand response (DR). The PJM Regulation Market is operated as a single real-time market.

Market Design

PJM's regulation market design is a result of Order No. 755.⁷³ The objective of PJM's regulation market design is to minimize the cost to provide regulation using two resource types in a single market.

The regulation market includes resources following two signals: RegA and RegD. Resources responding to either signal help control ACE (area control error). RegA is PJM's slow-oscillation regulation signal and is designed for resources with the ability to sustain energy output for long periods of time, with slower ramp rates. RegD is PJM's fast-oscillation regulation signal and is designed for resources with limited ability to sustain energy output and with faster ramp rates. Resources must qualify to follow one or both of the RegA and RegD signals, but will be assigned by the market clearing engine to follow only one signal in a given market hour.

The PJM regulation market design includes three clearing price components: capability (\$/MW, based on the MW being offered); performance (\$/mile, based on the total MW movement requested by the control signal, known as mileage); and lost opportunity cost (\$/MW of lost revenue from the energy market as a result of providing regulation). The marginal benefit factor (MBF)

⁷³ Order No. 755, 137 FERC ¶ 61,064 at P 2 (2011).

and performance score translate a RegD resource's capability (actual) MW into marginal effective MW and offers into \$/effective MW.

The regulation market solution is intended to meet the regulation requirement with the least cost combination of RegA and RegD. When solving for the least cost combination of RegA and RegD MW to meet the regulation requirement, the regulation market will substitute RegD MW for RegA MW when RegD is cheaper. Performance adjusted RegA MW are used as the common unit of measure, called effective MW, of regulation service. All resource MW (RegA and RegD) are converted into effective MW. RegA MW are converted into effective MW by multiplying the RegA MW offered by their performance score. RegD MW are converted into effective MW by multiplying the RegD offered by their performance score and by the MBF. The regulation requirement is defined as the total effective MW required to provide a defined amount of area control error (ACE) control.

The regulation market converts performance adjusted RegD MW into effective MW using the MBF in the PJM design. The MBF is used to convert incremental additions of RegD MW into incremental effective MW. The total effective MW for a given amount of RegD MW equal the area under the MBF curve (the sum of the incremental effective MW contributions). RegA and RegD resources should be paid the same price per marginal effective MW.

The marginal rate of technical substitution (MRTS) is the marginal measure of substitutability of RegD resources for RegA resources in satisfying a defined regulation requirement at feasible combinations of RegA and RegD MW. While resources following RegA and RegD can both provide regulation service in PJM's Regulation Market, PJM's joint optimization is intended to determine and assign the optimal mix of RegA and RegD MW to meet the hourly regulation requirement. The optimal mix is a function of the relative effectiveness and cost of available RegA and RegD resources.

At any valid combination of RegA and RegD, regulation offers are converted to dollars per effective MW using the RegD offer and the MBF associated with that combination of RegA and RegD. The marginal contribution of a RegD

MW to effective MW is equal to the MRTS associated with that RegA/RegD combination.

For example, a 1.0 MW RegD resource with a total offer price of \$2 per MW with a MBF of 0.5 and a performance score of 100 percent would be calculated as offering 0.5 effective MW (0.5 MBF times 1.00 performance score times 1 MW). The total offer price would be \$4 per effective MW (\$2 per MW offer divided by the 0.5 effective MW).

Regulation performance scores (0.0 to 1.0) measure the response of a regulating resource to its assigned regulation signal (RegA or RegD) every 10 seconds by measuring: delay, the time delay of the regulation response to a change in the regulation signal; correlation, the correlation between the regulating resource output and the regulation signal; and precision, the difference between the regulation response and the regulation requested.⁷⁴ Performance scores are reported on an hourly basis for each resource.

Table 10-31 and Figure 10-9 show the average performance score by resource type and the signal followed in the first three months of 2021. In these figures, the MW used are actual MW and the performance score is the hourly performance score of the regulation resource.⁷⁵ Each category (color bar) is based on the percentage of the full performance score distribution for each resource (or signal) type. As Figure 10-9 shows, 74.3 percent of RegD resources had average performance scores within the 0.91-1.00 range, and 26.3 percent of RegA resources had average performance scores within that range in the first three months of 2021. These scores are lower than the scores for both product types in the first three months of 2020, where 87.2 percent of RegD resources had average performance scores within the 0.91-1.00 range, and 33.8 percent of RegA resources had average performance scores within that range.

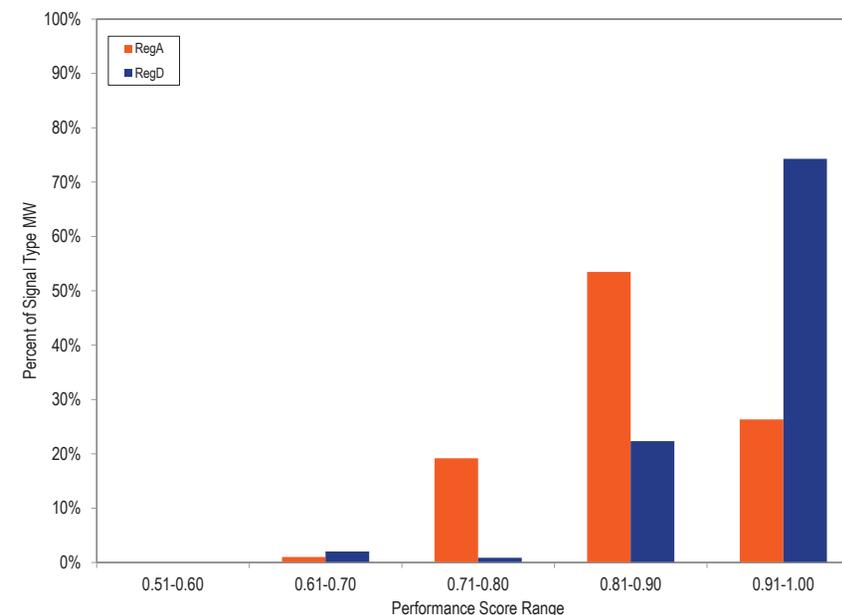
⁷⁴ PJM "Manual 12: Balancing Operations," § 4.5.6 Performance Score Calculation, Rev. 40 (March 26, 2020).

⁷⁵ Except where explicitly referred to as effective MW or effective regulation MW, MW means actual MW unadjusted for either MBF or performance factor.

Table 10-31 Hourly average performance score by unit type: January through March, 2021

		Performance Score Range				
		51-60	61-70	71-80	81-90	91-100
RegA	Battery	-	-	-	-	-
	CT	-	0.0%	2.2%	31.0%	66.8%
	Diesel	-	-	-	-	82.5%
	DSR	-	0.0%	12.0%	62.0%	25.9%
	Hydro	-	-	0.0%	39.5%	60.4%
	Steam	0.0%	1.5%	27.5%	59.8%	11.2%
RegD	Battery	-	2.1%	0.1%	20.5%	76.7%
	CT	-	0.0%	74.4%	25.6%	0.0%
	Diesel	-	-	0.0%	100.0%	-
	DSR	0.0%	0.0%	16.5%	50.6%	32.9%
	Hydro	-	0.0%	-	70.7%	29.3%
	Steam	-	-	-	-	-

Figure 10-9 Hourly average performance score by regulation signal type: January through March, 2021



Each cleared resource in a class (RegA or RegD) is allocated a portion of the class signal (RegA or RegD). This portion of the class signal is based on the cleared regulation MW of the resource relative to the cleared MW for that class. This signal is called the Total Regulation Signal (TREG) for the resource. A resource with 10 MW of capability will be provided a TREG signal asking for a positive or negative regulation movement between negative and positive 10 MW around its regulation set point.

Resources are paid Regulation Market Clearing Price (RMCP) credits and lost opportunity cost credits, which are uplift payments. If a resource's lost opportunity costs for an hour are greater than its RMCP credits, that resource receives lost opportunity cost credits equal to the difference. PJM posts clearing prices for the regulation market (RMCCP, RMPCP and RMCP) in dollars per effective MW. The regulation market clearing price (RMCP in \$/effective MW) for the hour is the simple average of the 12 five minute RMCPs within the hour. The RMCP is set in each five minute interval based on the marginal offer in each interval. The performance clearing price (RMPCP in \$/effective MW) is based on the marginal performance offer (RMPCP) for the hour. The capability clearing price (RMCCP in \$/effective MW) is equal to the difference between the RMCP for the hour and the RMPCP for the hour. This is done so the total of RMPCP plus RMCCP equals the total clearing price (RMCP) but the RMPCP is maximized.

Market solution software relevant to regulation consists of the Ancillary Services Optimizer (ASO) solving hourly; the intermediate term security constrained economic dispatch market solution (IT SCED) solving every 15 minutes; and the real-time security constrained economic dispatch market solution (RT SCED) solving approximately every five minutes. The market clearing price is determined by pricing software (LPC) that looks at the units cleared in the most recently approved RT SCED case, approximately 10 minutes ahead of the target solution time. The marginal prices assigned by the LPC to five minute intervals are averaged over the hour for an hourly regulation market clearing price.

Market Design Issues

PJM's current regulation market design is severely flawed and is not efficient or competitive. The market results do not represent the least cost solution for the defined level of regulation service.

In a well functioning market, every resource should be paid the same clearing price per unit produced. That is not true in the PJM Regulation Market. RegA and RegD resources are not paid the same clearing price in dollars per effective MW. RegD resources are being paid more than the market clearing price. This flaw in the market design has caused operational issues, has caused over investment in RegD resources.

If all MW of regulation were treated the same in both the clearing of the market and in settlements, many of the issues in the PJM Regulation Market would be resolved. However, the current PJM rules result in the payment to RegD resources being up to 1,000 times the correct price.

RegA and RegD have different physical capabilities. In order to permit RegA and RegD to compete in the single PJM Regulation Market, RegD must be translated into the same units as RegA. One MW of RegA is one effective MW. The translation is done using the marginal benefit factor (MBF). As more RegD is added to the market, the relative value of RegD declines, based on its actual performance attributes. For example, if the MBF is 0.001, a MW of RegD is worth 0.001 MW of RegA (or 1/1,000 of a MW of RegA). This is the same thing as saying that 1.0 MW of RegD is equal to 0.001 effective MW when the MBF is 0.001.

Almost all of the issues in PJM's Regulation Market are caused by the inconsistent application of the MBF. Because the MBF is not included in settlements, when the MBF is less than 1.0, RegD resources are paid too much. When the MBF is less than 1.0, each MW of RegD is worth less than 1.0 MW of RegA. The market design buys the correct amount of RegD, but pays RegD as if the MBF were 1.0. In an extreme case, when the MBF is 0.001, RegD MW are paid 1,000 times too much. If the market clearing price is \$1.00 per MW of RegA, RegD is paid \$1,000 per effective MW. Resolution of this

problem requires that PJM pay RegD for the same effective MW it provides in regulation, 0.001 MW.

To address the identified market flaws, the MMU and PJM developed a joint proposal which was approved by the PJM Members Committee on July 27, 2017, and filed with FERC on October 17, 2017. The PJM/MMU joint proposal addresses issues with the inconsistent application of the marginal benefit factor throughout the optimization and settlement process in the PJM Regulation Market. FERC rejected the proposal finding it inconsistent with Order No. 755.

The MBF related issues with the regulation market have been raised in the PJM stakeholder process. In 2015, PJM stakeholders approved an interim, partial solution to the RegD over procurement problem which was implemented on December 14, 2015. The interim solution was designed to reduce the relative value of RegD MW in all hours and to cap purchases of RegD MW during critical performance hours. But the interim solution did not address the fundamental issues in the optimization or the lack of consistency in the application of the MBF.

Additional changes were implemented on January 9, 2017. These modifications included changing the definition of off peak and on peak hours, adjusting the currently independent RegA and RegD signals to be interdependent, and changing the 15 minute neutrality requirement of the RegD signal to a 30 minute neutrality requirement.

The January 9, 2017, design changes appear to have been intended to make RegD more valuable. That is not a reasonable design goal. The design goal should be to determine the least cost way to provide needed regulation. The RegA signal is now slower than it was previously, which may make RegA following resources less useful as ACE control. RegA is now explicitly used to support the conditional energy neutrality of RegD. The RegD signal is now the difference between ACE and RegA. RegA is required to offset RegD when RegD moves in the opposite direction of that required by ACE control in order to permit RegD to recharge. These changes in the signal design will

allow PJM to accommodate more RegD in its market solutions. The new signal design is not making the most efficient use of RegA and RegD resources. The explicit reliance on RegA to offset issues with RegD is a significant conceptual change to the design that is inconsistent with the long term design goal for regulation. PJM increased the regulation requirement as part of these changes.

The January 9, 2017, design changes replaced off peak and on peak hours with nonramp and ramp hours with definitions that vary by season. The regulation requirement for ramp hours was increased from 700 MW to 800 MW (Table 10-32). These market changes still do not address the fundamental issues in the optimization or the lack of consistency in the application of the MBF.

Table 10-32 Seasonal regulation requirement definitions⁷⁶

Season	Dates	Nonramp Hours	Ramp Hours
Winter	Dec 1 - Feb 28(29)	00:00 - 03:59	04:00 - 08:59
		09:00 - 15:59	16:00 - 23:59
Spring	Mar 1 - May 31	00:00 - 04:59	05:00 - 07:59
		08:00 - 16:59	17:00 - 23:59
Summer	Jun 1 - Aug 31	00:00 - 04:59	05:00 - 13:59
		14:00 - 17:59	18:00 - 23:59
Fall	Sep 1 - Nov 30	00:00 - 04:59	05:00 - 07:59
		08:00 - 16:59	17:00 - 23:59

Performance Scores

Performance scores, by class and unit, are not an indicator of how well resources contribute to ACE control. Performance scores are an indicator only of how well the resources follow their TREG signal. High performance scores with poor signal design are not a meaningful measure of performance. For example, if ACE indicates the need for more regulation but RegD resources have provided all their available energy, the RegD regulation signal will be in the opposite direction of what is needed to control ACE. So, despite moving in the wrong direction for ACE control, RegD resources would get a good performance score for following the RegD signal and will be paid for moving in the wrong direction.

⁷⁶ See PJM. "Regulation Requirement Definition," <<http://www.pjm.com/~media/markets-ops/ancillary/regulation-requirement-definition.ashx>>.

The RegD signal prior to January 9, 2017, is an example of a signal that resulted in high performance scores, but due to 15 minute energy neutrality built into the signal, ran counter to ACE control at times. Energy neutrality means that energy produced equals energy used within a defined timeframe. With 15 minute energy neutrality, if a battery were following the regulation signal to provide MWh for 7.5 minutes, it would have to consume the same amount of MWh for the next 7.5 minutes. When neutrality correction of the RegD signal is triggered, it overrides ACE control in favor of achieving zero net energy over the 15 minute period. When this occurs, the RegD signal runs counter to the control of ACE and hurts rather than helps ACE. In that situation, the control of ACE, which must also offset the negative impacts of RegD, depends entirely on RegA resources following the RegA signal. High performance scores under the signal design prior to January 9, 2017, was not an indication of good ACE control.

The January 9, 2017, design changes did not address the fundamental issues with the definition of performance or the nature of payments for performance in the regulation market design. The regulation signal should not be designed to favor a particular technology. The signal should be designed to result in the lowest cost of regulation to the market. Only with a performance score based on full substitutability among resource types should payments be based on following the signal. The MRTS must be redesigned to reflect the actual capabilities of technologies to provide regulation. The PJM regulation market design remains fundamentally flawed.

In addition, the absence of a performance penalty, imposed as a reduction in performance score and/or as a forfeiture of revenues, for deselection initiated by the resource owner within the hour, creates a possible gaming opportunity for resources which may overstate their capability to follow the regulation signal. The MMU recommends that there be a penalty enforced as a reduction in performance score and/or a forfeiture of revenues when resource owners elect to deassign assigned regulation resources within the hour, to prevent gaming.

Battery Settlement

The change from 15 to 30 minute signal neutrality, implemented in the January 9, 2017, design changes, resulted in the reduction of performance scores for short duration batteries. In April 2017 several participants filed a complaint with FERC, stating that these changes discriminated against their battery units.⁷⁷ The MMU objected to these complaints. On April 7, 2020, FERC approved a settlement between PJM and the complainants.⁷⁸ Starting July 1, 2020, the affected battery units began receiving compensation based on the greater of their current performance score, or their rolling average actual hourly performance score for the last 100 hours the resource operated prior to the January 9, 2017, implementation of the 30 minute conditional neutrality. The FERC settlement also requires that the affected battery units be cleared in the regulation market regardless of whether their offer would have cleared under normal circumstances, as long as they are offered as either self-scheduled with a zero offer, or as a zero priced offer.⁷⁹ In order to comply with this condition, PJM is clears additional MW beyond what is needed for the regulation requirement in cases where the settlement battery units did not clear but met the offer rules of the settlement. This results in excess charges to customers for regulation service.

Regulation Signal

As with any signal design for substitutable resources, the MBF function should be determined by the ability of RegA and RegD resources to follow their signals, including conditions under which neutrality cannot be maintained by RegD resources. The ability of energy limited RegD to provide ACE control depends on the availability of excess RegA capability to support RegD under the conditional neutrality design. When RegD resources are largely energy limited resources, a correctly calculated MBF would exhibit a rapid decrease in the MBF value for every MW of RegD added. The result is that only a small amount of energy limited RegD is economic. The current and proposed signals and corresponding MBF functions do not reflect these principles or the actual substitutability of resource types.

⁷⁷ See FERC Docket Nos. EL17-64-000 and EL17-65-000.

⁷⁸ See 170 FERC ¶ 61,258.

⁷⁹ See *id.* at P 17.

Marginal Benefit Factor Issues

The MBF function, as implemented in the PJM Regulation Market, is not equal to the MRTS between RegA and RegD. The MBF is not consistently applied throughout the market design, from optimization to settlement, and market clearing does not confirm that the resulting combinations of RegA and RegD are realistic and can meet the defined regulation demand. The calculation of total regulation cleared using the MBF is incorrect.⁸⁰

The result has been that the PJM Regulation Market has over procured RegD relative to RegA in most hours, has provided a consistently inefficient market signal to participants regarding the value of RegD in every hour, and has overpaid for RegD. This over procurement has degraded the ability of PJM to control ACE in some hours while at the same time increasing the cost of regulation. When the price paid for RegD is above the level defined by an accurate MBF function, there is an artificial incentive for inefficient entry of RegD resources.

PJM and the MMU filed a joint proposal with FERC on October 17, 2017, to address issues with the inconsistent application of the marginal benefit factor throughout the optimization and settlement process in the PJM Regulation Market, but the proposal was rejected by FERC.⁸¹

Marginal Benefit Factor Not Correctly Defined

The MBF used in the PJM Regulation Market prior to the December 14, 2015, changes did not accurately reflect the MRTS between RegA and RegD resources under the old market design, and it does not accurately reflect the MRTS between RegA and RegD resources under the current design. The MBF function is incorrectly defined and improperly implemented in the current PJM Regulation Market.

The MBF should be the marginal rate of technical substitution between RegA and RegD MW at different, feasible combinations of RegA and RegD that can be used to provide a defined level of regulation service. The objective of the market design is to find, given the relative costs of RegA and RegD MW, the

⁸⁰ The MBF, as used in this report, refers to PJM's incorrectly calculated MBF and not the MBF equivalent to the MRTS.

⁸¹ 162 FERC ¶ 61,295 (2018), *reh'g denied*, 170 FERC ¶ 61,259 (2020).

least cost feasible combination of RegA and RegD MW. If the MBF function is incorrectly defined, or improperly implemented in the market clearing and settlement, the resulting combinations of RegA and RegD will not represent the least cost solution and may not be a feasible way to reach the target level of regulation.

The MBF is not included in PJM's settlement process. This is a design flaw that results in incorrect payments for regulation. The issue results from two FERC orders. From October 1, 2012, through October 31, 2013, PJM implemented a FERC order that required the MBF to be fixed at 1.0 for settlement calculations only. On October 2, 2013, FERC directed PJM to eliminate the use of the MBF entirely from settlement calculations of the capability and performance credits and replace it with the RegD to RegA mileage ratio in the performance credit paid to RegD resources, effective retroactively to October 1, 2012.⁸² That rule continues in effect. The result of the current FERC order is that the MBF is used in market clearing to determine the relative value of an additional MW of RegD, but the MBF is not used in the settlement for RegD.

If the MBF were consistently applied, every resource would receive the same clearing price per marginal effective MW. But the MBF is not consistently applied and resources do not receive the same clearing price per marginal effective MW.

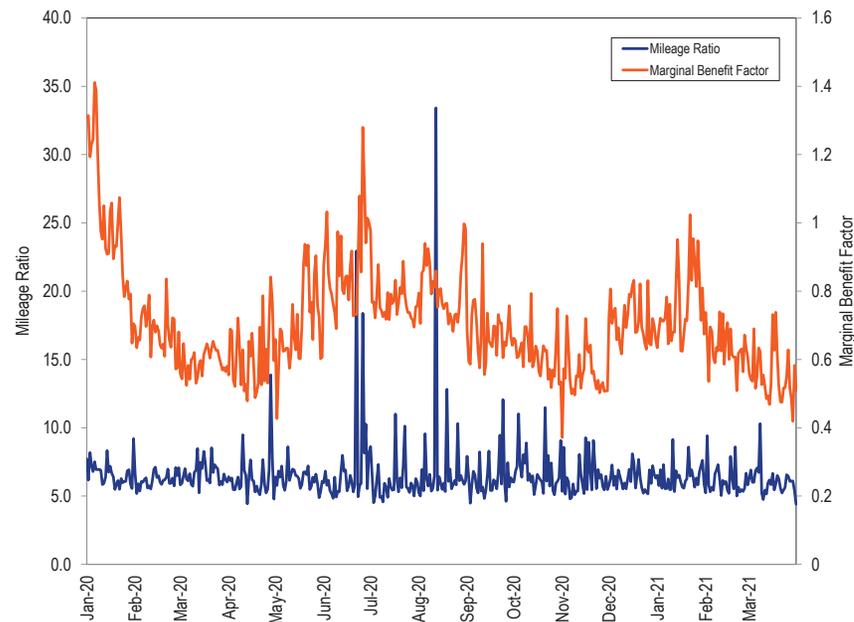
The change in design decreased RegA mileage (the change in MW output in response to regulation signal per MW of capability), increased the proportion of cleared RegD resources' capability that was called by the RegD signal (increased REG for a given MW) to better match offered capability, increased the mileage required of RegD resources and changed the energy neutrality component of the signal from a strict 15 minute neutrality to a conditional 30 minute neutrality. The changes in signal design increased the mileage ratio (the ratio of RegD mileage to RegA mileage). In addition, to adapt to the 30 minute neutrality requirement, some RegD resources decreased their offered capability to maintain their performance.

⁸² 145 FERC ¶ 61,011 (2013).

Figure 10-10 shows the daily average MBF and the mileage ratio. The weighted average mileage ratio decreased from 6.50 in the first three months of 2020, to 6.19 in the first three months of 2021 (a decrease of 4.8 percent). The average MBF decreased from 0.76 in the first three months of 2020, to 0.65 in the first three months of 2021 (a decrease of 14.5 percent). This decrease was primarily due to the additional RegD MW clearing as a result of the FERC settlement ruling, which went into effect on July 1, 2020. The high mileage ratios are the result of the mechanics of the mileage ratio calculation. Extreme mileage ratios result when the RegA signal is fixed at a single value (pegged) to control ACE and the RegD signal is not. If RegA is held at a constant MW output, mileage is zero for RegA. The result of a fixed RegA signal is that RegA mileage is very small and therefore the mileage ratio is very large.

These results are an example of why it is not appropriate to use the mileage ratio, rather than the MBF, to measure the relative value of RegA and RegD resources. In these events, RegA resources are providing ACE control by providing a fixed level of MW output which means zero mileage, while RegD resources alternate between helping and hurting ACE control, both of which result in positive mileage.

Figure 10-10 Daily average MBF and mileage ratio: January 2020 through March 2021



The increase in the average mileage ratio caused by the signal design changes introduced on January 9, 2017, caused a large increase in payments to RegD resources on a performance adjusted MW basis.

Table 10-33 shows RegD resource payments on a performance adjusted actual MW basis and RegA resource payments on a performance adjusted MW basis by month, from January 1, 2020, through March 31, 2021. The average regulation market clearing price in the first three months of 2021 was \$6.19 higher than in the first three months of 2020 (See Table 10-47). Coupled with the lower average MBF, RegD continued to be overpaid compared to RegA on a performance adjusted actual MW basis. In the first three months of 2021, RegD resources earned 19.7 percent more per performance adjusted actual

MW than RegA resources (26.3 percent in the first three months of 2020) due to the inclusion of the mileage ratio in RegD MW settlement.

Table 10-33 Average monthly price paid per performance adjusted actual MW of RegD and RegA: January 2020 through March 2021

Settlement Payments				
Year	Month	RegD (\$/Performance Adjusted MW)	RegA (\$/Performance Adjusted MW)	Percent RegD Overpayment (\$/Performance Adjusted MW)
2020	Jan	\$16.51	\$13.05	26.5%
	Feb	\$11.83	\$9.57	23.6%
	Mar	\$11.06	\$8.60	28.6%
	Apr	\$14.29	\$11.45	24.8%
	May	\$14.72	\$12.46	18.2%
	Jun	\$15.09	\$11.85	27.3%
	Jul	\$18.02	\$15.63	15.3%
	Aug	\$18.11	\$14.83	22.2%
	Sep	\$12.68	\$10.33	22.7%
	Oct	\$21.82	\$17.31	26.0%
	Nov	\$19.45	\$15.25	27.5%
	Dec	\$18.18	\$15.34	18.6%
Yearly		\$16.01	\$13.00	23.2%
2021	Jan	\$14.29	\$11.43	25.1%
	Feb	\$23.87	\$19.90	19.9%
	Mar	\$20.81	\$17.93	16.0%
Average		\$19.52	\$16.30	19.7%

The current settlement process does not result in paying RegA and RegD resources the same price per effective MW. RegA resources are paid on the basis of dollars per effective MW of RegA. RegD resources are not paid in terms of dollars per effective MW of RegA because the MBF is not used in settlements. Instead of being paid based on the MBF, (RMCCP + RMPCP)*MBF, RegD resources are paid based on the mileage ratio (RMCCP + (RMPCP*mileage ratio)). Because the RMCCP component makes up the majority of the overall clearing price, when the MBF is above one, RegD resources can be underpaid on a per effective MW basis by the current payment method, unless offset by a high mileage ratio. When the MBF is less than one, RegD resources are overpaid on a per effective MW basis, unless offset by a low mileage ratio. The average MBF was less than 1.0 in the first three months of 2021 (0.65).

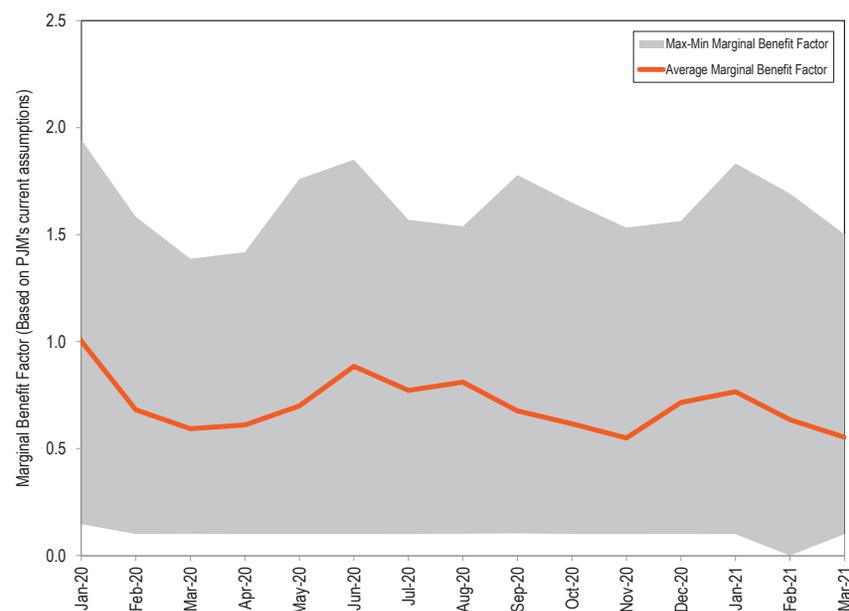
The effect of using the mileage ratio instead of the MBF to convert RegD MW into effective MW for purposes of settlement is illustrated in Table 10-34. Table 10-34 compares the monthly average payment of RegD per effective MW to the monthly average payment RegD resources should have received using the MBF to convert RegD MW to effective MW. Using the MBF would result in RegA and RegD resources being paid exactly the same on a per effective MW basis. In the first three months of 2021, the MBF averaged 0.65, while the average daily mileage ratio was 6.19, resulting in RegD resources being paid \$37.8 million more than they would have been if the MBF were correctly implemented.

Table 10-34 Average monthly price paid per effective MW of RegD and RegA under mileage and MBF based settlement: January 2020 through March 2021

RegD Settlement Payments						
Year	Month	Marginal Rate of		RegA (\$/Effective MW)	Percent RegD Overpayment (\$/Effective MW)	Total RegD Overpayment (\$)
		Mileage Based RegD (\$/Effective MW)	Technical Substitution Based RegD (\$/Effective MW)			
2020	Jan	\$19.61	\$13.05	\$13.05	50.3%	\$3,822,718
	Feb	\$25.79	\$9.57	\$9.57	169.5%	\$6,060,440
	Mar	\$29.47	\$8.60	\$8.60	242.6%	\$7,982,625
	Apr	\$38.85	\$11.45	\$11.45	239.4%	\$8,946,335
	May	\$37.37	\$12.46	\$12.46	199.9%	\$8,953,641
	Jun	\$25.00	\$11.85	\$11.85	111.0%	\$6,584,760
	Jul	\$34.99	\$15.63	\$15.63	123.9%	\$7,891,533
	Aug	\$31.78	\$14.83	\$14.83	114.4%	\$9,038,391
	Sep	\$28.51	\$10.33	\$10.33	175.9%	\$7,942,871
	Oct	\$69.18	\$17.31	\$17.31	299.6%	\$18,415,455
	Nov	\$63.11	\$15.25	\$15.25	313.8%	\$15,834,343
	Dec	\$43.39	\$15.34	\$15.34	182.9%	\$10,642,479
Yearly		\$37.30	\$13.00	\$13.00	186.9%	\$112,115,592
2021	Jan	\$30.47	\$11.43	\$11.43	166.6%	\$6,700,761
	Feb	\$88.91	\$19.90	\$19.90	346.7%	\$15,723,391
	Mar	\$61.03	\$17.93	\$17.93	240.4%	\$15,334,201
Average		\$59.18	\$16.30	\$16.30	263.0%	\$37,758,352

Figure 10-11 shows, the monthly maximum, minimum and average MBF, for January 2020 through March 2021. The average daily MBF in the first three months of 2021 was 0.65. The average daily MBF in the first three months of 2020 was 0.76. The bottom of the MBF range results from PJM's administratively defined MBF minimum threshold of 0.1.⁸³

Figure 10-11 Maximum, minimum, and average PJM calculated MBF by month: January 2020 through March 2021



The MMU recommends that the regulation market be modified to incorporate a consistent and correct application of the MBF throughout the optimization, assignment and settlement process.⁸⁴

⁸³ In February 2021 the minimum MBF was lower than the 0.1 threshold.

⁸⁴ See "Regulation Market Review," Operating Committee (May 5, 2015) <<http://www.pjm.com/~media/committees-groups/committees/oc/20150505/20150505-item-17-regulation-market-review.ashx>>.

The overpayment of RegD has resulted in offers from RegD resources that are almost all at an effective cost of \$0.00 (\$0.00 offers plus self scheduled offers). RegD MW providers are ensured that such offers will clear and will be paid a price determined by the offers of RegA resources. This is evidence of the impact of the flaws in the clearing engine and the overpayment of RegD resources on the offer behavior of RegD resources.

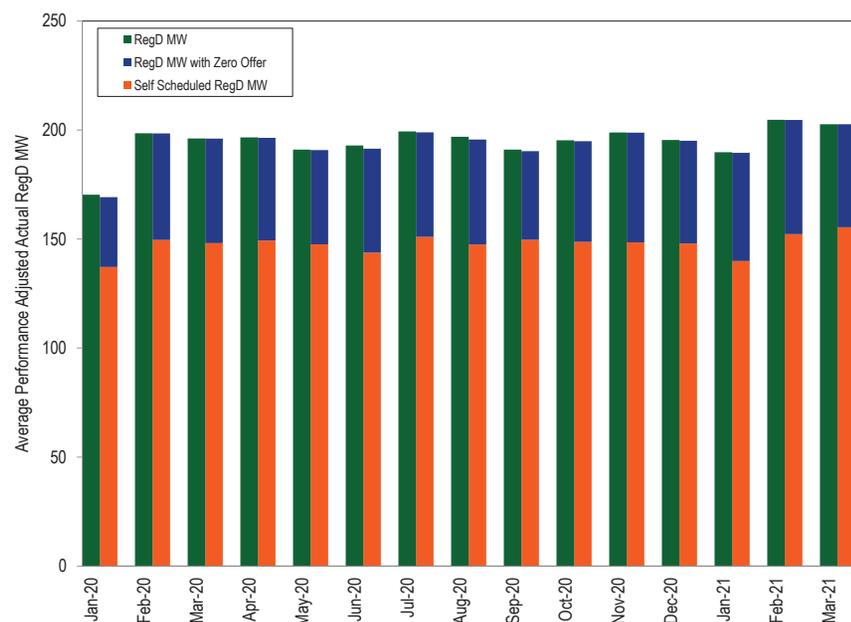
Figure 10-12 shows, by month, cleared RegD MW with an effective price of \$0.00 (units with zero offers plus self scheduled units) for January 2020 through March 2021. In the first three months of 2021, an average of 100.0 percent of all RegD MW clearing the market had an effective offer of \$0.00. In the first three months of 2020, an average of 99.8 percent of all cleared RegD MW had an effective cost of \$0.00. In the first three months of 2021, an average of 74.9 percent of all RegD offers were self scheduled, compared to an average of 77.1 percent of all RegD offers in the first three months of 2020.

The high percentage of self scheduled offers is a result of the incentives created by the flaws in the regulation market. Because self scheduled offers are price takers, they are cleared along with the zero cost offers in the market clearing engine. However, unlike zero cost offers, self scheduled offers do not risk having an LOC added to their offer during the market clearing process, ensuring that self scheduled offers have a zero cost during market clearing. Given the increasing saturation of the regulation market with RegD MW, specifically demand response and battery units which do not receive LOC, market participants eligible for LOC that offer at zero instead of self scheduling, run the risk of an LOC added to their offer, and thus not clearing the market.

The average monthly RegD cleared in the market increased 10.7 MW (5.7 percent), from 188.3 MW in the first three months of 2020 to 199.0 MW in the first three months of 2021. The average monthly RegD cleared with an effective cost of zero increased 11.0 MW (5.9 percent), from 187.9 MW in the first three months of 2020 to 198.9 MW in the first three months of 2021. Self scheduled RegD cleared MW increased 4.2 MW (2.9 percent), from 145.0 MW in the first three months of 2020 to 149.2 MW in the first three months

of 2021. Average cleared RegD MW with a zero cost offer increased 6.8 MW (15.8 percent), from 43.0 MW in the first three months of 2020 to 49.7 MW in the first three months of 2021. The increase in the average monthly RegD cleared resulted in the reduction of the average monthly MBF seen in Figure 10-11.

Figure 10-12 Average cleared RegD MW and average cleared RegD with an effective price of \$0.00 by month: January 2020 through March 2021



Incorrect MBF and total effective MW when clearing units with dual product offers

Under PJM market rules, regulation units that have the capability to provide both RegA and RegD MW are permitted to submit an offer for both signal types in the same market hour. While the objective of the PJM market design is to find the least cost combination of RegA and RegD resources to provide the required level of regulation service, the method of clearing the regulation

market for an hour in which one or more units has a dual offer is incorrect and leads to solutions that are not the most economic.

In order for the clearing engine to provide the correct economic solution when the pool of available resources contains one or more units with dual offers, the calculation would have to be performed iteratively to determine which of the dual offers would provide the least cost solution. But this is not how PJM clears the regulation market when there are dual offer units. PJM rank orders the regulation supply curve by potential effective cost assuming the dual offer resources are available as both RegA and RegD resources simultaneously, and assigns every RegD resource, including dual offer resources, a unit specific benefit factor.

Each dual offer resource is assigned to run as either a RegD or RegA resource based on which of the two offers has a lower effective cost. But PJM does not redefine the supply curve using appropriately recalculated unit specific benefit factors for the remaining RegD resources prior to clearing the market.

During the clearing phase, the MBF of RegD resources is a function of the RegD MW that clear. The MBF for all RegD resources declines as more RegD resources are cleared. Based on this relationship, in the case where a dual offer unit is assigned to be a RegA resource rather than a RegD resource, the MBF of remaining RegD resources in the supply curve should increase. The placeholder RegD MW from the dual offer should be removed, the cleared MW from below the placeholder should be shifted up the supply/MBF curve, and additional RegD MW offers that were pushed below an MBF of zero and initially not included, should be considered. But PJM does not recalculate the MBF values for the remaining RegD resources when determining the cleared effective MW needed to satisfy the regulation requirement during the clearing phase. The result is that the MBF in the clearing phase is incorrectly low, and the actual amount of effective MW procured is higher.

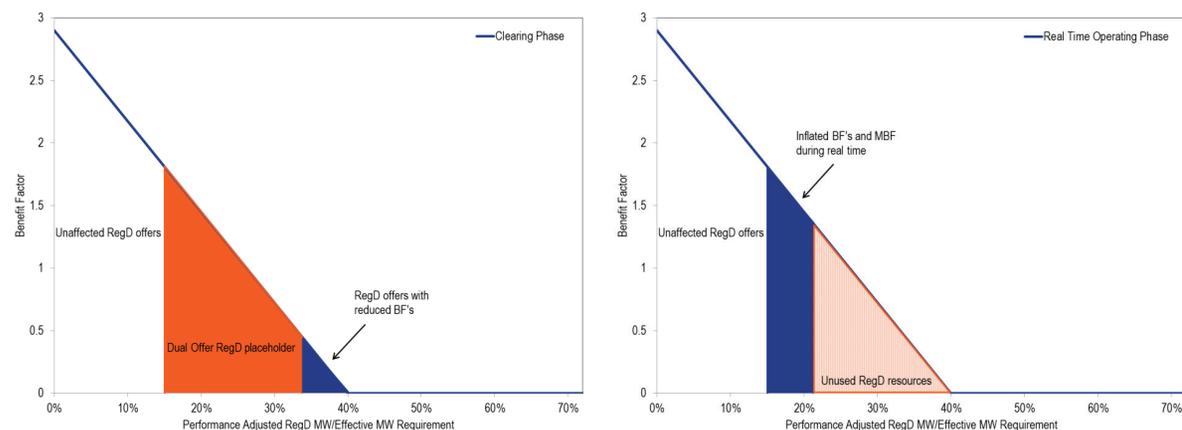
After meeting the target effective MW to satisfy the regulation requirement for that hour through the clearing process, the unit specific benefit factors of those displaced units are recalculated in the real-time operating phase and

increased based on their actual contribution. The effective MW contributions of those originally displaced units are correctly calculated in the operating phase, but because the supply for that hour has already been set based on their incorrect effective MW, the solution includes more effective MW than calculated in the clearing phase. As a result, the market solution includes more than the target level of effective MW in the actual operating hour.

The issue is illustrated in Figure 10-13. The example shows a clearing phase and a real time operating phase. In this example, a 150 MW unit offers both RegA and RegD. The 150 MW unit's position in the RegD effective cost curve and the potential effective MW are represented as the orange area under the curve in the clearing phase. The effective MW of the cleared RegD resources with higher effective costs are represented by the blue triangle in the clearing phase. Not shown are additional RegD MW with higher effective costs that were assigned an MBF of 0 and not cleared. The 150 MW dual offer unit is chosen to operate as a RegA resource in the operational hour. As a result, the cleared supply for RegA in the clearing phase is the same RegA supply realized in the real time operating phase. But that is not the case for the RegD supply. Since the supply curve and unit specific benefit factors of RegD MW are not recalculated in the clearing phase after the 150 MW RegD offer is removed, the amount of effective MW realized in the real-time operating phase is inconsistent with the clearing phase. Because the RegD portion of the 150 MW dual offer unit was not chosen to be RegD MW, the RegD resources represented by the blue triangle in the clearing phase will contribute more effective MW (the blue area in the real-time solution phase) in the real-time solution phase than was assumed in the clearing phase because the MBF in the clearing phase was too low. Since the blue area under the curve in the real-time solution phase is greater than the blue area in the clearing phase and the amount of RegA remains the same

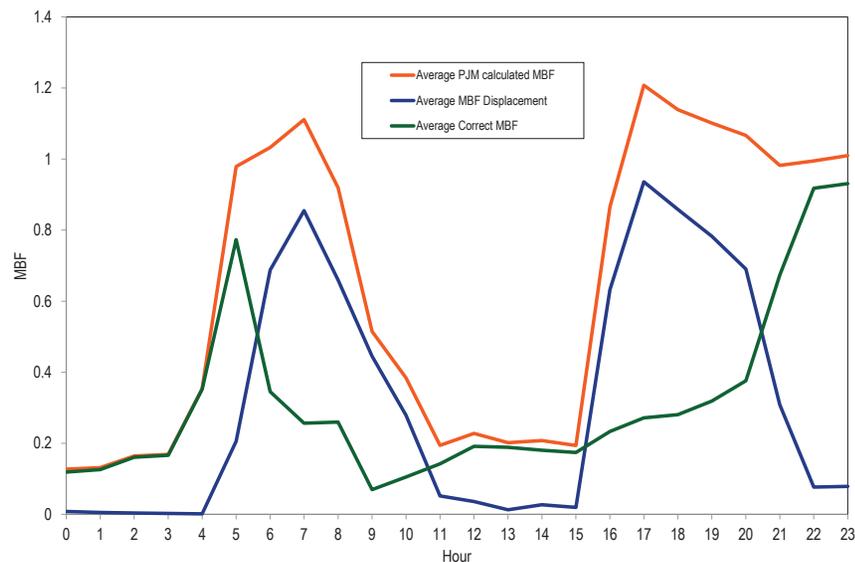
between the clearing phase and real-time operating phase, the market will have cleared too many effective MW relative to the effective MW requirement. The MBF in the operating phase is higher than if the clearing had been solved correctly.

Figure 10-13 Clearing phase BF/effective MW reduction, real-time BF/effective MW inflation, and exclusion of available RegD resources



In the first three months of 2021, all hours had at least one unit with a dual offer. In the first three months of 2021, 87.3 percent of all hours had at least one dual offer unit that was chosen to run as RegA, resulting in an average MBF increase of 0.54 in the operating phase. If the market had been cleared correctly, the correct average MBF would have been significantly lower in real time (operating phase), because additional RegD offers with lower benefit factors that were initially excluded, would have been included after the removal of the dual offer placeholder, reducing the MBF. Figure 10-14 illustrates the PJM calculated average MBF in real time (operating phase), the average MBF displacement due to dual offers clearing as RegA, and what the correct average MBF would have been in each hour of the day for the first three months of 2021 if the clearing solution were solved correctly.

Figure 10-14 Effect of PJM's current dual offer clearing method on the average MBF in each hour of the day: January through March, 2021



Absent the ability to correctly clear dual offers, the MMU recommends that the ability of resources to submit dual offers be removed. Under this revision to the rules, resources could offer as either RegA or RegD in a given hour, but not both within the same market hour.

Price Spikes

Beginning in 2018, extreme price spikes were identified in the regulation market. The price spikes were caused by a combination of the inconsistent application of the MBF in the market design and the discrepancy between the hour ahead estimated LOC and the actual realized within hour LOC.

The regulation market is cleared on an hour ahead basis, using offers that are adjusted by dividing each component of an offer (capability, performance, and lost opportunity cost) by the product of the unit specific benefit factor and unit specific performance score. To calculate the hour ahead estimate

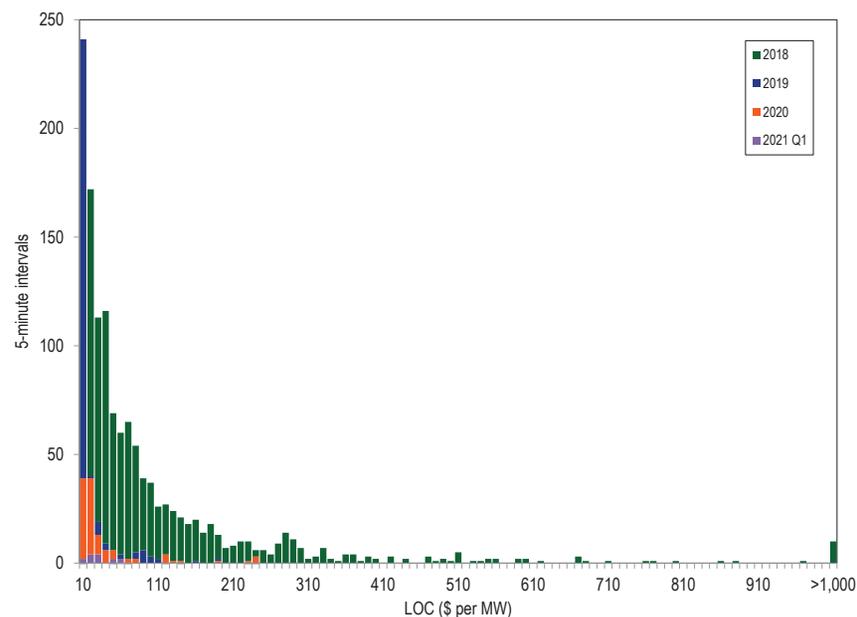
of the adjusted LOC offer component, hour ahead projections of LMPs are used. Units are then cleared based on the sum of each of their hour ahead adjusted offer components. The actual LOC is used to determine the final, actual interval specific all in offer of RegD resources.

In some cases the estimated LOC is very low or zero but the actual within hour LOC is a positive number. In instances where the MBF of the within hour marginal unit is less than one (e.g. the marginal unit is a RegD unit), this discrepancy in the estimated and realized LOC will cause a large discrepancy between the expected offer price (as low as \$0/MW) and the realized offer price of the resource in the actual market result. This will cause a significant price spike in the regulation market. In cases where the MBF of the marginal resource is very low, such as 0.001, the price spikes can be very significant for a small change between expected and actual LOC. In January 2019, FERC approved PJM's proposal to create a 0.1 floor for the MBF to reduce the occurrence of these price spikes.⁸⁵ This change reduced the amount and frequency of the price spikes, but it was not designed to eliminate them and it did not eliminate them.

Figure 10-15 shows the LOC in each five minute interval in which the marginal unit had a unit specific benefit factor less than one (e.g. a RegD unit) and the LOC was greater than zero in 2018, 2019, 2020, and in the first three months of 2021.

⁸⁵ See 166 FERC ¶ 61,040 (2019).

Figure 10-15 LOC distribution in each five minute interval with a RegD marginal unit and an LOC greater than zero: 2018 through March 2021



For a RegD resource to clear the regulation market with an MBF of 0.001, the resource's offer, in dollars per marginal effective MW, must be less than or equal to competing offers from RegA MW. A RegD offer of 1 MW with an MBF of 0.001 and a price of \$1 per MW, would provide 0.001 effective MW at a price of \$1,000 per effective MW. So long as RegA MW are available for less than \$1,000 per effective MW, this resource will not clear. The only way for RegD MW to clear is to the point where the MBF of the last MW is 0.001, is if the offer price of the relevant resources that clear, including estimated LOC, is \$0.00. But, if the same resource(s) has a positive LOC within the hour, based on real-time changes in LMP, the zero priced offer is adjusted to reflect the positive LOC, resulting in an extremely high offer and clearing price for regulation.

While an incorrect estimate of a potential LOC can result in an extremely high price, the resulting regulation market prices are mathematically correct for the price of each effective MW. The prices in every interval reflect the marginal costs of regulation given the resources dispatched and accurately reflect the marginal offer of minimally effective resources which had unexpectedly high LOC components of their within hour offers. But, due to the current market design's failure to use the MBF in settlement, RegD is not paid on a dollar per effective MW basis. This disconnect between the process of setting price and the process of paying resources is the primary source of the market failure in PJM's Regulation Market and the cause of the observed price spikes in the regulation market. In the example, the 0.001 MW from the RegD resource should be paid \$1,000 times 0.001 MW or \$1.00. But the current rules would pay the RegD resource \$1,000 times 1.0 MW or \$1,000. If the market clearing and the settlements rules were consistent, the incentive for this behavior would be eliminated. The current rules provide a strong incentive for this behavior.

The price spikes observed in PJM's Regulation Market are a symptom of a market failure in PJM's Regulation Market. The market failure in PJM's Regulation Market is caused by an inconsistent application of the MBF between market clearing and market settlement. Due to the inconsistent application of the MBF, the current market results are not consistent with a competitive market outcome. In any market, resources should be paid the marginal clearing price for their marginal contribution. In the regulation market, all resources should be paid the marginal clearing price per effective MW and all resources in the regulation market should be paid for each of their effective MW. PJM's Regulation Market does not do this. PJM's market applies the MBF in determining the relative and total value of RegD MW in the market solution for purposes of market clearing and price, but does not apply the same logic in determining the payment of RegD for purposes of settlement. As a result, market prices do not align with payment for contributions to regulation service in market settlements.

The inconsistent application of the MBF in PJM's regulation market design is generating perverse incentives and perverse market results. The price spikes are a symptom of the problem, not the problem itself.

Lost Opportunity Cost Calculation Issues

The calculation of regulation LOC results in the overpayment of uplift in some cases. The desired amount of MW output at LMP used in the calculation of regulation LOC is determined based on a unit's energy offer. This desired MW does not account for the ability of a unit to actually produce the desired output, given its current output and its ramp rate. This can result in overpayment of uplift.

Table 10-35 shows the amount of such overpayment for the first three months of 2021. The overpayments are calculated using a desired MW level that can be achieved based on the units' ramp rates.

This calculation may underestimate the overpayment because it does not include the impact when a marginal unit is overpaid LOC. If a marginal unit is overpaid LOC, the correct LOC could affect the clearing price, the marginal unit, and change the set of units that clear for a particular hour. This would affect the clearing price for all units, as well as the uplift payments to individual units.

Table 10-35 Amount of LOC overpayment: January through March, 2021

Month	LOC overpayment
Jan	\$352,006
Feb	\$509,824
Mar	\$694,115
Total	\$1,555,945

Market Structure

Supply

Table 10-36 shows average hourly offered MW (actual and effective), and average hourly cleared MW (actual and effective) for all hours in the first three months of 2021.⁸⁶ Actual MW are adjusted by the historic 100-hour moving average performance score to get performance adjusted MW, and by the resource specific benefit factor to get effective MW. A resource can choose to

follow either signal. For that reason, the sum of each signal type's capability can exceed the full regulation capability. Offered MW are calculated based on the offers from units that are designated as available for the day. These are daily offers that can be modified on an hourly basis up to 65 minutes before the hour.⁸⁷ Eligible MW are calculated from the hourly offers from units with daily offers and units that are offered as unavailable for the day, but still offer MW into some hours. Units with daily offers are permitted to offer above or below their daily offer from hour to hour. As a result of these hourly MW adjustments, the average hourly Eligible MW can be higher than the Offered MW.

In the first three months of 2021, the average hourly offered supply of regulation for nonramp hours was 778.5 actual MW (762.2 effective MW). This was a decrease of 88.0 actual MW (a decrease of 64.8 effective MW) from the first three months of 2020, when the average hourly offered supply of regulation was 690.5 actual MW (697.5 effective MW). In the first three months of 2021, the average hourly offered supply of regulation for ramp hours was 1,106.5 actual MW (1,115.1 effective MW). This was an increase of 173.5 actual MW (a decrease of 125.5 effective MW) from the first three months of 2020, when the average hourly offered supply of regulation was 933.0 actual MW (989.6 effective MW).

The ratio of the average hourly offered supply of regulation to average hourly regulation demand (actual cleared MW) for ramp hours was 1.55 in the first three months of 2021 (1.33 in the first three months of 2020). The ratio of the average hourly offered supply of regulation to average hourly regulation demand (actual cleared MW) for nonramp hours was 1.57 in the first three months of 2021 (1.41 in the first three months of 2020).

⁸⁶ Unless otherwise noted, analysis provided in this section uses PJM market data based on PJM's internal calculations of effective MW values, based on PJM's currently incorrect MBF curve. The MMU is working with PJM to correct the MBF curve.

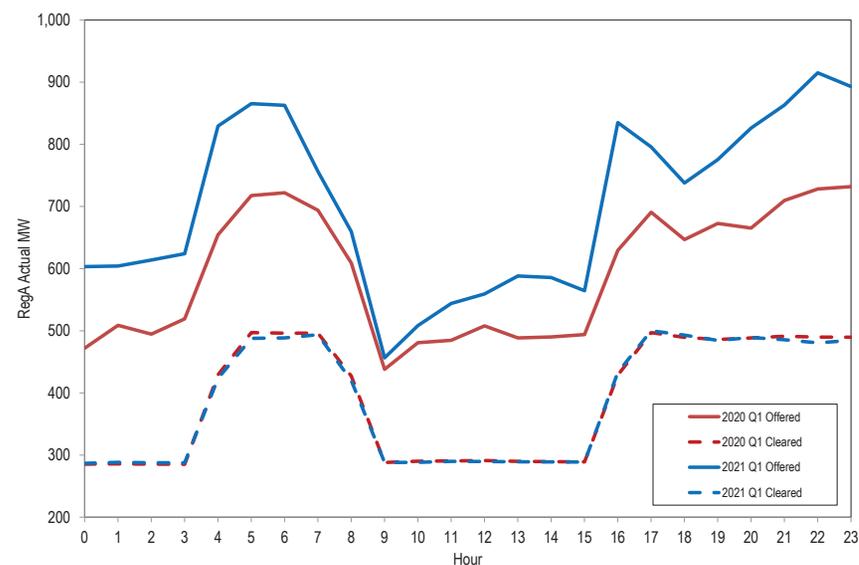
⁸⁷ See "PJM Manual 11: Energy & Ancillary Services Market Operations," § 3.2.2 Regulation Market Eligibility, Rev. 112 (Jan. 5, 2021).

Table 10-36 Hourly average actual and effective MW offered and cleared: January through March, 2021⁸⁸

		By Resource Type			By Signal Type	
		All Regulation	Generating Resources	Demand Resources	RegA Following Resources	RegD Following Resources
Actual Offered MW	Ramp	1,106.5	1,094.7	11.8	837.2	269.3
	Nonramp	778.5	770.2	8.3	569.0	209.5
Effective Offered MW	Ramp	1,115.1	1,101.2	13.9	718.8	396.3
	Nonramp	762.2	754.6	7.6	484.8	277.5
Actual Cleared MW	Ramp	712.2	700.5	11.7	490.3	221.9
	Nonramp	496.9	488.6	8.3	288.3	208.6
Effective Cleared MW	Ramp	800.0	786.2	13.8	424.6	375.4
	Nonramp	525.2	517.7	7.5	248.1	277.1

The average hourly offered and cleared actual MW from RegA resources are shown in Figure 10-16. The average hourly offered MW from RegA resources during ramp hours for the first three months of 2021 was 837.2 actual MW, an increase of 19.6 percent from the first three months of 2020 (700.3 actual MW.) The average hourly offered MW from RegA resources during nonramp hours for the first three months of 2021 was 569.0 actual MW, an increase of 16.7 percent from the first three months of 2020 (487.6 actual MW). The average hourly cleared MW from RegA resources during ramp hours for the first three months of 2021 was 490.3 actual MW, a decrease of 0.8 percent from the first three months of 2020 (494.1 actual MW). The average hourly cleared MW from RegA resources during nonramp hours for the first three months of 2021 was 288.3 actual MW, an increase of 0.2 percent from the first three months of 2020 (287.6 actual MW).

Figure 10-16 Average hourly RegA actual MW offered and cleared: January through March, 2020 through 2021



The average hourly offered MW from RegD resources during ramp hours for the first three months of 2021 was 269.3 actual MW, an increase of 15.7 percent from the first three months of 2020 (232.7 actual MW). (Figure 10-17) The average hourly offered MW from RegD resources during nonramp hours for the first three months of 2021 was 209.5 actual MW, an increase of 3.2 percent from the first three months of 2020 (203.0 actual MW) (Figure 10-17). The average hourly cleared MW from RegD resources during ramp hours for the first three months of 2021 was 221.9 actual MW, an increase of 7.4 percent from the first three months of 2020 (206.5 actual MW). The average hourly cleared MW from RegD resources during nonramp hours for the first three months of 2021 was 208.6 actual MW, an increase of 3.2 percent from the first three months of 2020 (202.0 actual MW). These increases in the amount of RegD offered and cleared MW were the result of the battery settlement that went into effect on July 1, 2020. If settlement battery units do not clear through the normal clearing process, PJM clears those units anyway, procuring

⁸⁸ PJM operations treats some nonramp hours as ramp hours, with a regulation requirement of 800 MW rather than 525 MW. All ramp/nonramp analysis performed is based on the requirement used in each hour rather than the definitions given in Table 10-32. A ramp hour occurring during what is normally a nonramp period is treated as a ramp hour.

excess MW beyond the regulation requirement and charging customers for the excess.

Figure 10-17 Average hourly RegD actual MW offered and cleared: January through March, 2020 through 2021

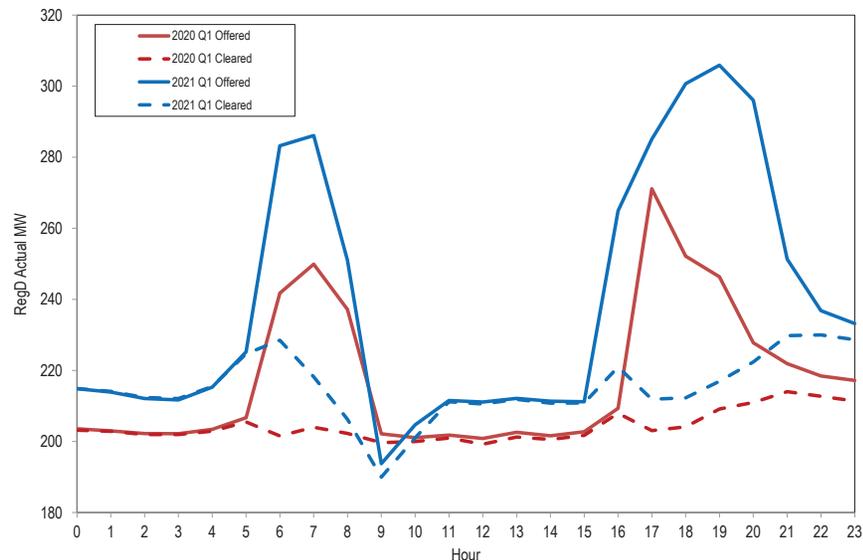


Table 10-37 provides the settled regulation MW by source unit type, the total settled regulation MW provided by all resources, the percent of settled regulation provided by unit type, and the clearing price, uplift, and total regulation credits. In Table 10-37 the MW have been adjusted by the performance score since this adjustment forms the basis of payment for units providing regulation. Total regulation performance adjusted settled MW increased 0.67 percent from 1,146,762.0 MW in the first three months of 2020 to 1,154,421.5 MW in the first three months of 2021. The average proportion of regulation provided by battery units had the largest increase (2.6 percent), providing 33.2 percent of regulation in the first three months of 2020 and 35.8 percent of regulation in the first three months of 2021. Natural gas units had the largest decrease in average proportion of regulation provided (4.5

percent), decreasing from 39.0 percent in 2019, to 34.5 percent in the first three months of 2021. The total regulation credits in the first three months of 2021 were \$24,193,570, an increase of 53.8 percent from \$15,731,926 in the first three months of 2020. The increase in regulation credits is due, in part, to a higher LOC component of regulation prices as a result of higher energy prices in the first three months of 2021 compared to the first three months of 2020.

When a resource offers into the regulation market, an estimated regulation LOC is added by PJM to form a total offer (units self scheduled, or not providing in the energy market, have a regulation LOC of zero). After a unit clears and has provided regulation, their regulation LOC is calculated again during settlements, using the actual LMP. If this actual regulation LOC causes the unit's total offer to be larger than the clearing price, the unit receives uplift credits. The uplift credits received for each unit type are shown in Table 10-37. The total uplift credits received increased 41.9 percent from \$1,902,524 in the first three months of 2020 to \$2,699,531 in the first three months of 2021. This increase, like the increase in total credits, is due in part to higher LOC components of regulation prices and offers as a result of higher energy prices in the first three months of 2021 compared to the first three months of 2020. Natural gas units had the largest increase in uplift payments, increasing 22.0 percentage points from 21.5 percent in the first three months of 2020, to 43.6 percent in the first three months of 2021. Hydro units had the largest decrease in uplift payments, decreasing 12.0 percentage points from 43.9 percent in the first three months of 2020, to 31.9 percent in the first three months of 2021.

Table 10-37 PJM regulation by source: January through March, 2020 and 2021⁸⁹

Source	2020 (Jan-Mar)						2021 (Jan-Mar)					
	Number of Units	Performance Adjusted Settled Regulation (MW)	Percent of Settled Regulation	Clearing Price Credits	Uplift Credits	Total Regulation Credits	Number of Units	Performance Adjusted Settled Regulation (MW)	Percent of Settled Regulation	Clearing Price Credits	Uplift Credits	Total Regulation Credits
Battery	21	380,545	33.2%	\$4,963,739	\$0	\$4,963,739	21	413,602	35.8%	\$8,323,574	\$0	\$8,323,574
Coal	18	84,545	7.4%	\$1,035,542	\$657,898	\$1,693,439	19	104,463	9.0%	\$1,796,115	\$662,455	\$2,458,570
Hydro	26	210,981	18.4%	\$2,424,808	\$834,694	\$3,259,502	25	219,580	19.0%	\$4,030,442	\$860,331	\$4,890,774
Natural Gas	118	447,331	39.0%	\$5,074,704	\$409,933	\$5,484,637	119	398,381	34.5%	\$6,961,921	\$1,176,745	\$8,138,666
DR	21	23,359	2.0%	\$330,609	\$0	\$330,609	16	18,394	1.6%	\$381,987	\$0	\$381,987
Total	204	1,146,762.0	100.0%	\$13,829,402	\$1,902,524	\$15,731,926	200	1,154,421.5	100.0%	\$21,494,039	\$2,699,531	\$24,193,570

Significant flaws in the regulation market design have led to an over procurement of RegD MW primarily in the form of storage capacity. The incorrect market signals have contributed to more storage projects entering PJM's interconnection queue, despite clear evidence that the market design is flawed and despite operational evidence that the RegD market is saturated (Table 10-38).

Table 10-38 Active battery storage projects by submitted year: 2014 through March 2021

Year	Number of Storage Projects	Total Capacity (MW)
2014	1	10.0
2015	5	61.0
2016	0	0.0
2017	1	2.0
2018	19	690.1
2019	66	4,157.7
2020	157	9,855.6
2021	22	1,216.2
Total	271	15,992.5

The supply of regulation can be affected by regulating units retiring from service. If all units that are requesting retirement through the first three months of 2021 retire, the supply of regulation in PJM will be reduced by less than one percent.

⁸⁹ Biomass data have been added to the natural gas category for confidentiality purposes.

Demand

The demand for regulation does not change with price. The regulation requirement is set by PJM to meet NERC control standards, based on reliability objectives, which means that a significant amount of judgment is exercised by PJM in determining the actual demand. Prior to October 1, 2012, the regulation requirement was 1.0 percent of the forecast peak load for on peak hours and 1.0 percent of the forecast valley load for off peak hours. Between October 1, 2012, and December 31, 2012, PJM changed the regulation requirement several times. It had been scheduled to be reduced from 1.0 percent of peak load forecast to 0.9 percent on October 1, 2012, but instead it was changed from 1.0 percent of peak load forecast to 0.78 percent of peak load forecast. It was further reduced to 0.74 percent of peak load forecast on November 22, 2012 and reduced again to 0.70 percent of peak load forecast on December 18, 2012. On December 14, 2013, it was reduced to 700 effective MW during peak hours and 525 effective MW during off peak hours. The regulation requirement remained 700 effective MW during peak hours and 525 effective MW during off peak hours until January 9, 2017. A change to the regulation requirement was approved by the RMISTF in 2016, with an implementation date of January 9, 2017. The regulation requirement was increased from 700 effective MW to 800 effective MW during ramp hours (Table 10-32).

Table 10-39 shows the average hourly required regulation by month and the ratio of supply to demand for both actual and effective MW, for ramp and nonramp hours. The average hourly required regulation by month is an average of the ramp and nonramp hours in the month. Changes in the actual MW required to satisfy the regulation requirement are the result of the amount of RegD actual MW cleared. When more RegD MW are cleared, the MBF is lower, resulting in those actual MW being worth less effective MW, requiring more actual MW to satisfy the requirement. When MBFs are higher, the actual MW of RegD are worth more effective MW, reducing the amount of actual MW needed to satisfy the requirement.

The nonramp regulation requirement of 525.0 effective MW was provided by a combination of RegA and RegD resources equal to 497.1 hourly average

performance adjusted actual MW in the first three months of 2021. This is an increase of 5.1 performance adjusted actual MW from the first three months of 2020, when the average hourly total regulation cleared performance adjusted actual MW for nonramp hours were 492.0 performance adjusted actual MW. The ramp regulation requirement of 800.0 effective MW was provided by a combination of RegA and RegD resources equal to 712.2 hourly average performance adjusted actual MW in the first three months of 2021. This is an increase of 9.8 performance adjusted actual MW from the first three months of 2020, where the average hourly regulation cleared MW for ramp hours were 702.5 performance adjusted actual MW.

Table 10-39 Required regulation and ratio of supply to requirement: January 2020 through March 2021

Hours	Month	Average Required Regulation (MW)		Average Required Regulation (Effective MW)		Ratio of Supply MW to MW Requirement		Ratio of Supply Effective MW to Effective MW Requirement	
		2020	2021	2020	2021	2020	2021	2020	2021
Ramp	Jan	712.9	713.2	800.1	800.0	1.36	1.59	1.25	1.42
	Feb	694.3	709.7	800.0	800.0	1.31	1.53	1.22	1.37
	Mar	692.5	713.8	800.1	800.0	1.33	1.54	1.24	1.38
	Apr	707.5	-	800.1	-	1.41	-	1.29	-
	May	711.8	-	800.1	-	1.42	-	1.31	-
	Jun	705.5	-	800.0	-	1.52	-	1.38	-
	Jul	702.8	-	800.1	-	1.57	-	1.42	-
	Aug	705.1	-	800.0	-	1.47	-	1.34	-
	Sep	694.8	-	799.8	-	1.46	-	1.33	-
	Oct	696.0	-	800.1	-	1.46	-	1.33	-
	Nov	700.9	-	800.1	-	1.43	-	1.30	-
	Dec	705.5	-	800.1	-	1.56	-	1.40	-
Nonramp	Jan	479.5	495.1	525.1	525.2	1.43	1.52	1.33	1.42
	Feb	495.9	500.4	525.1	525.1	1.45	1.59	1.37	1.47
	Mar	493.1	495.9	525.1	525.2	1.36	1.59	1.29	1.47
	Apr	492.7	-	525.2	-	1.46	-	1.36	-
	May	486.6	-	525.3	-	1.45	-	1.36	-
	Jun	490.0	-	525.1	-	1.45	-	1.36	-
	Jul	498.1	-	525.4	-	1.46	-	1.38	-
	Aug	489.8	-	525.0	-	1.43	-	1.35	-
	Sep	484.8	-	525.2	-	1.46	-	1.36	-
	Oct	491.3	-	525.2	-	1.50	-	1.41	-
	Nov	501.8	-	525.5	-	1.50	-	1.41	-
	Dec	500.8	-	525.1	-	1.63	-	1.50	-

Market Concentration

In the first three months of 2021, the effective MW weighted average HHI of RegA resources was 2528 which is highly concentrated and the weighted average HHI of RegD resources was 1786 which is moderately concentrated. The weighted average HHI of all resources was 1334, which is moderately concentrated. The weighted average HHI reflects the fact that different owners have large market shares in the RegA and RegD markets.

Table 10-40 includes a monthly summary of three pivotal supplier (TPS) results. In the first three months of 2021, 89.1 percent of hours had three or fewer pivotal suppliers. The MMU concludes that the PJM Regulation Market in the first three months of 2021 was characterized by structural market power. The results presented here are calculated by PJM.

The MMU has been unable to verify these results, as some of the underlying data necessary to replicate these calculations is not saved. PJM has submitted a request to the vendor to save all data necessary for verification.

Table 10-40 Regulation market monthly three pivotal supplier results: 2019 through March 2021

Month	Percent of Hours Pivotal		
	2019	2020	2021
Jan	77.8%	99.1%	91.4%
Feb	76.0%	97.4%	88.7%
Mar	93.3%	98.3%	87.2%
Apr	93.1%	96.5%	-
May	94.0%	94.9%	-
Jun	91.0%	89.8%	-
Jul	92.7%	89.0%	-
Aug	93.1%	94.6%	-
Sep	93.3%	93.3%	-
Oct	96.1%	94.0%	-
Nov	90.7%	91.0%	-
Dec	96.1%	83.6%	-
Average	90.6%	93.5%	89.1%

Market Conduct

Offers

Resources seeking to regulate must qualify to follow a regulation signal by passing a test for that signal with at least a 75 percent performance score. The regulating resource must be able to supply at least 0.1 MW of regulation and not allow the sum of its regulating ramp rate and energy ramp rate to exceed its overall ramp rate.⁹⁰ When offering into the regulation market, regulating resources must submit a cost-based offer and may submit a price-based offer (capped at \$100 per MW) by 14:15 the day before the operating day.⁹¹

⁹⁰ See "PJM Manual 11: Energy & Ancillary Services Market Operations," § 3.2.1 Regulation Market Eligibility, Rev. 112 (Jan. 5, 2021).

⁹¹ Id. at 3.2.2, at p 62.

Offers in the PJM Regulation Market consist of a capability component for the MW of regulation capability provided and a performance component for the miles (Δ MW of regulation movement) provided. The capability component for cost-based offers is not to exceed the increased fuel costs resulting from operating the regulating unit at a lower output level than its economically optimal output level, plus a \$12.00 per MW margin. The \$12.00 margin embeds market power in the regulation offers, is not part of the cost of regulation, and should be eliminated. The performance component for cost-based offers is not to exceed the increased costs (increased short run marginal costs including increased fuel costs) resulting from moving the unit up and down to provide regulation. Batteries and flywheels have zero cost for lower efficiency from providing regulation instead of energy, as they are not net energy producers. There is an energy storage loss component for batteries and flywheels as a cost component of regulation performance offers to reflect the net energy consumed to provide regulation service.⁹²

Up until one hour before the operating hour, the regulating resource must provide: status (available, unavailable, or self scheduled); capability (movement up and down in MW); regulation maximum and regulation minimum (the highest and lowest levels of energy output while regulating in MW); and the regulation signal type (RegA or RegD). Resources may offer regulation for both the RegA and RegD signals, but will be assigned to follow only one signal for a given operating hour. Resources have the option to submit a minimum level of regulation they are willing to provide.⁹³

All LSEs are required to provide regulation in proportion to their load share. LSEs can purchase regulation in the regulation market, purchase regulation from other providers bilaterally, or self schedule regulation to satisfy their obligation (Table 10-42).⁹⁴ Figure 10-18 compares average hourly regulation and self scheduled regulation during ramp and nonramp hours on an effective MW basis. The average hourly regulation is the amount of regulation that actually cleared and is not the same as the regulation requirement because PJM clears the market within a two percent band around the requirement.⁹⁵ Self scheduled

⁹² See "PJM Manual 15: Cost Development Guidelines," § 7.8 Regulation Cost, Rev. 37 (Dec. 9, 2020).
⁹³ See "PJM Manual 11: Energy & Ancillary Services Market Operations," § 3.2.1 Regulation Market Eligibility, Rev. 112 (Jan. 5, 2021).
⁹⁴ See "PJM Manual 28: Operating Agreement Accounting," § 4.1 Regulation Accounting Overview, Rev. 84 (Dec. 17, 2020).
⁹⁵ See "PJM Manual 11: Energy & Ancillary Services Market Operations," § 3.2.1 Regulation Market Eligibility, Rev. 112 (Jan. 5, 2021).

regulation comprised an average of 49.0 percent during ramp hours and 64.3 percent during nonramp hours in the first three months of 2021.

Figure 10-18 Nonramp and ramp regulation levels: January 2020 through March 2021

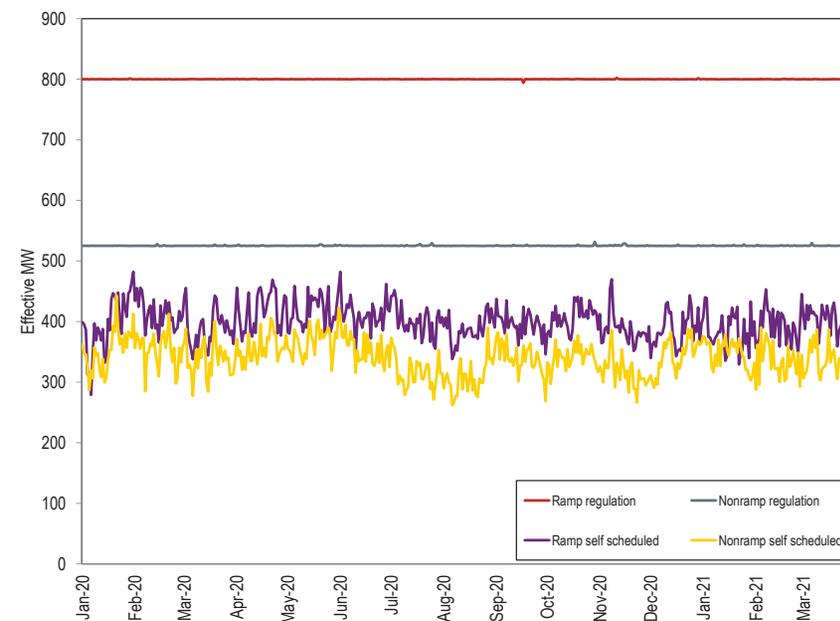


Table 10-41 shows the role of RegD resources in the regulation market. RegD resources are both a growing proportion of the market (10.9 percent of the total effective MW at the start of the performance based regulation market design in October 2012 and 50.3 percent of the total effective MW in March 2021) and a growing proportion of resources that self schedule (25.0 percent of all self scheduled effective MW in October 2012 and 73.3 percent of all self scheduled effective MW in March 2021). In the first three months of 2021, the average RegD percentage of total self scheduled effective MW was 70.9 percent, an increase of 1.7 percent from the first three months of 2020, when the average was 69.2 percent. This increase in RegD self scheduling has led

the increased amount of RegD cleared (Figure 10-12), and the decrease in the MBF (Figure 10-11).

Table 10-41 RegD self scheduled regulation by month: January 2020 through March 2021

Year	Month	RegD Self Scheduled Effective MW	RegD Effective MW	Total Self Scheduled Effective MW	Total Effective MW	RegD Percent of Total Self Scheduled Effective MW	RegD Percent of Total Effective MW
2020	Jan	253.3	311.9	376.5	674.0	67.3%	46.3%
2020	Feb	263.6	333.5	385.3	674.0	68.4%	49.5%
2020	Mar	257.9	319.9	358.9	639.9	71.9%	50.0%
2020	Apr	267.2	318.1	382.9	639.7	69.8%	49.7%
2020	May	274.6	312.2	388.5	639.8	70.7%	48.8%
2020	Jun	281.8	335.1	390.5	697.2	72.2%	48.1%
2020	Jul	252.6	343.3	369.3	697.1	68.4%	49.2%
2020	Aug	258.7	341.0	357.2	697.0	72.4%	48.9%
2020	Sep	275.4	317.2	363.3	639.6	75.8%	49.6%
2020	Oct	265.7	319.2	368.3	639.8	72.1%	49.9%
2020	Nov	255.1	321.4	346.5	640.6	73.6%	50.2%
2020	Dec	262.1	329.8	366.8	674.0	71.4%	48.9%
2020	Average	264.0	325.2	371.2	662.7	71.2%	49.1%
2021	Jan	250.5	322.4	367.7	674.0	68.1%	47.8%
2021	Feb	262.0	335.3	366.7	674.3	71.4%	49.7%
2021	Mar	263.0	321.7	359.0	639.9	73.3%	50.3%
	Average	258.5	326.4	364.5	662.7	70.9%	49.3%

Increased self scheduled regulation lowers the requirement for cleared regulation, resulting in fewer MW cleared in the market and lower clearing prices. Of the LSEs' obligation to provide regulation in the first three months of 2021, 47.1 percent was purchased in the PJM market, 48.3 percent was self scheduled, and 4.6 percent was purchased bilaterally (Table 10-42). Table 10-43 shows the total regulation by source including spot market regulation, self scheduled regulation, and bilateral regulation for January through March, 2012 through 2021. Table 10-42 and Table 10-43 are based on settled (purchased) MW.

Table 10-42 Regulation sources: spot market, self scheduled, bilateral purchases: January 2020 through March 2021

Year	Month	Spot Market Regulation	Spot Market Percent of Total	Self Scheduled Regulation	Self Scheduled Percent of Total	Bilateral Regulation	Bilateral Percent of Total	Total Regulation
		(Unadjusted MW)		(Unadjusted MW)		(Unadjusted MW)		(Unadjusted MW)
2020	Jan	179,061.4	46.2%	190,434.8	49.1%	18,166.0	4.7%	387,662.1
2020	Feb	160,674.9	43.8%	185,702.6	50.6%	20,815.5	5.7%	367,193.0
2020	Mar	175,560.8	46.5%	181,566.1	48.1%	20,266.0	5.4%	377,392.8
2020	Apr	154,642.4	42.4%	187,819.3	51.5%	22,195.5	6.1%	364,657.2
2020	May	167,682.0	44.2%	191,949.3	50.5%	20,125.5	5.3%	379,756.8
2020	Jun	192,336.9	49.3%	178,239.7	45.7%	19,479.5	5.0%	390,056.1
2020	Jul	189,151.3	46.4%	198,595.7	48.7%	19,997.5	4.9%	407,744.5
2020	Aug	207,948.6	51.1%	181,392.4	44.6%	17,756.0	4.4%	407,097.0
2020	Sep	181,955.4	49.6%	171,428.3	46.7%	13,358.0	3.6%	366,741.7
2020	Oct	178,179.3	46.9%	186,687.3	49.1%	15,309.5	4.0%	380,176.1
2020	Nov	180,188.6	48.9%	172,941.0	46.9%	15,668.5	4.2%	368,798.1
2020	Dec	189,587.0	47.8%	188,798.6	47.6%	18,505.0	4.7%	396,890.6
	Total	2,156,968.5	47.0%	2,215,555.1	48.2%	221,642.5	4.8%	4,594,166.0
2021	Jan	186,762.8	46.6%	192,708.2	48.1%	21,466.0	5.4%	400,937.0
2021	Feb	172,967.1	47.4%	174,470.7	47.9%	17,095.5	4.7%	364,533.3
2021	Mar	182,812.8	47.3%	189,176.1	48.9%	14,910.0	3.9%	386,898.9
	Total	542,542.7	47.1%	556,355.1	48.3%	53,471.5	4.6%	1,152,369.2

Table 10-43 Regulation sources: January through March, 2012 through 2021

Year	(Jan-Mar)	Spot Market Regulation	Spot Market Percent of Total	Self Scheduled Regulation	Self Scheduled Percent of Total	Bilateral Regulation	Bilateral Percent of Total	Total Regulation
		(Unadjusted MW)		(Unadjusted MW)		(Unadjusted MW)		(Unadjusted MW)
2012		1,510,190.1	73.4%	485,672.8	23.6%	61,563.0	3.0%	2,057,425.9
2013		1,026,962.9	73.0%	342,003.1	24.3%	38,538.5	2.7%	1,407,504.5
2014		724,996.3	61.1%	404,832.1	34.1%	56,853.5	4.8%	1,186,681.9
2015		670,281.4	58.5%	411,928.8	36.0%	63,367.6	5.5%	1,145,577.7
2016		583,928.2	48.9%	546,238.8	45.8%	63,234.0	5.3%	1,193,401.0
2017		534,901.2	47.4%	520,871.7	46.2%	71,824.5	6.4%	1,127,597.4
2018		678,027.7	59.9%	395,994.0	35.0%	58,042.5	5.1%	1,132,064.2
2019		539,672.1	49.5%	500,324.0	45.9%	50,946.0	4.7%	1,090,942.1
2020		515,297.0	45.5%	557,703.5	49.3%	59,247.5	5.2%	1,132,248.0
2021		542,542.7	47.1%	556,355.1	48.3%	53,471.5	4.6%	1,152,369.2

In the first three months of 2021, DR provided an average of 11.7 MW of regulation per hour during ramp hours (13.8 MW of regulation per hour during ramp hours in the first three months of 2020), and an average of 8.3 MW of regulation per hour during nonramp hours (11.5 MW of regulation per hour during nonramp hours in the first three months of 2020). Generating units supplied an average of 700.5 MW of regulation per hour during ramp hours in the first three months of 2021 (686.8 MW of regulation per hour during ramp hours in the first three months of 2020), and an average of 488.6 MW per hour during nonramp hours in the first three months of 2021 (478.2 MW of regulation per hour during nonramp hours in the first three months of 2020).

Market Performance

Price

Table 10-47 shows the regulation price and regulation cost per MW for January through March, 2009 through 2021. The weighted average RMCP for the first three months of 2021 was \$17.18 per MW. This is an increase of \$6.19 per MW, or 56.3 percent, from the weighted average RMCP of \$10.00 per MW in the first three months of 2020. This increase in the regulation clearing price was the result of an increase in energy prices in the first three months of 2021 and the related decrease in the opportunity cost component of RMCP.

Figure 10-19 shows the capability price, performance price, and the opportunity cost component for the PJM Regulation Market on a performance adjusted MW basis. The regulation clearing price is determined based on the marginal unit's total offer (RCP + RPP + PJM calculated LOC). Then the maximum performance offer price (RPP) of any of the cleared units is used to set the marginal performance clearing price for the purposes of settlements. The difference between the marginal total clearing price and the highest performance clearing price (RMPCP) is the marginal capability clearing price (RMCCP). The capability price presented here is equal to the clearing price, minus the maximum cleared performance offer price. This data is based on actual five minute interval operational data.

Figure 10-19 illustrates the components of the regulation market clearing price. Each section represents the contribution of the lost opportunity cost (green area), capability price (blue area), and performance price (orange area), to the total price. From this figure, it is clear that the lost opportunity cost is the predominant component of the total clearing price.

Figure 10-19 Regulation market clearing price components (Dollars per MW): January through March, 2021

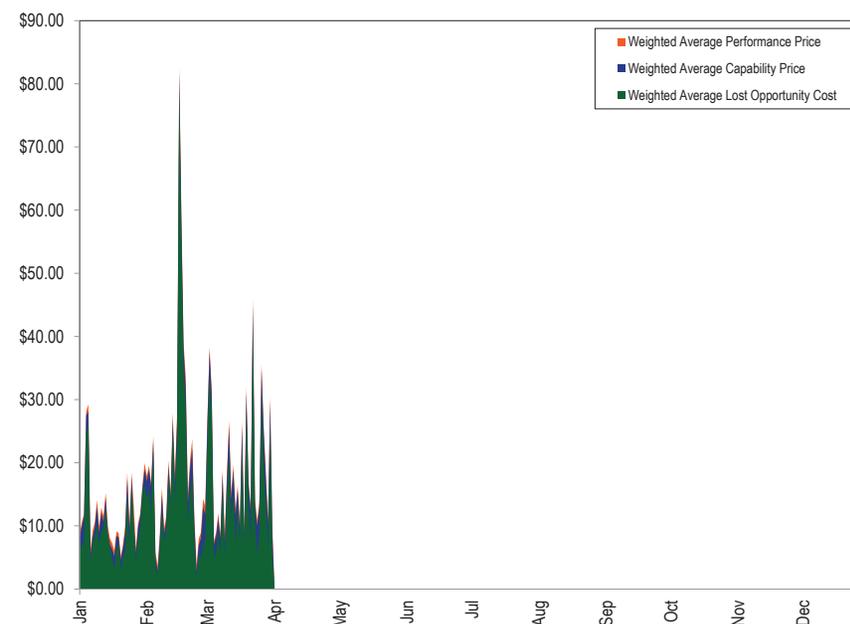


Table 10-44 shows the capability and performance components of the monthly average regulation prices. These components differ from the components of the marginal unit's offers in Figure 10-19 because the performance component of the settlement price for each hour is determined from the average of the highest performance offers in each five minute interval, calculated independent of the marginal unit's offers in those intervals.

Table 10-44 Regulation market monthly component of price (Dollars per MW): January through March, 2021

Month	Weighted Average Regulation Market Capability Clearing Price (\$/Perf. Adj. Actual MW)		Weighted Average Regulation Market Performance Clearing Price (\$/Perf. Adj. Actual MW)		Weighted Average Regulation Market Clearing Price (\$/Perf. Adj. Actual MW)	
	Price (\$/Perf. Adj. Actual MW)	Actual MW	Price (\$/Perf. Adj. Actual MW)	Actual MW	Price (\$/Perf. Adj. Actual MW)	Actual MW
Jan		\$11.26		\$0.86		\$12.12
Feb		\$19.53		\$1.07		\$20.60
Mar		\$18.30		\$0.87		\$19.20
Average		\$16.24		\$0.93		\$17.18

Monthly and total annual scheduled regulation MW and regulation charges, as well as monthly average regulation price and regulation cost are shown in Table 10-45. Total scheduled regulation is based on settled performance adjusted MW. The total of all regulation charges in the first three months of 2021 was \$24.2 million, compared to \$15.7 million in the first three months of 2020.

Table 10-45 Total regulation charges: January 2020 through March 2021

Year	Month	Scheduled Regulation (MW)	Total Regulation Charges (\$)	Weighted Average Regulation Market Price (\$/MW)	Cost of Regulation (\$/MW)	Price as Percent of Cost
2020	Jan	387,662.1	\$6,495,664	\$13.70	\$16.76	81.7%
2020	Feb	367,193.0	\$4,630,253	\$10.12	\$12.61	80.3%
2020	Mar	377,392.8	\$4,619,257	\$9.06	\$12.24	74.0%
2020	Apr	364,657.2	\$5,646,138	\$12.10	\$15.48	78.1%
2020	May	379,756.8	\$6,078,957	\$12.97	\$16.01	81.0%
2020	Jun	390,056.1	\$6,072,212	\$12.31	\$15.57	79.1%
2020	Jul	407,744.5	\$7,732,029	\$16.14	\$18.96	85.1%
2020	Aug	407,097.0	\$7,566,611	\$15.36	\$18.59	82.6%
2020	Sep	366,741.7	\$4,909,677	\$10.88	\$13.39	81.2%
2020	Oct	380,176.1	\$8,168,776	\$17.64	\$21.49	82.1%
2020	Nov	368,798.1	\$7,381,789	\$15.95	\$20.02	79.7%
2020	Dec	396,890.6	\$7,562,483	\$15.79	\$19.05	82.9%
	Yearly	4,594,166.0	\$76,860,642	\$13.55	\$16.73	81.0%
2021	Jan	400,937.0	\$6,035,683	\$12.12	\$15.05	80.5%
2021	Feb	364,533.3	\$9,388,411	\$20.60	\$25.75	80.0%
2021	Mar	386,898.9	\$8,786,324	\$19.20	\$22.71	84.5%
	Total	1,152,369.2	\$24,210,418	\$17.18	\$21.01	81.8%

The capability, performance, and opportunity cost components of the cost of regulation are shown in Table 10-46. Total scheduled regulation is based on settled performance adjusted MW. In the first three months of 2021, the average total cost of regulation was \$21.01 per MW, 51.1 percent higher than \$13.91 in the first three months of 2020. In the first three months of 2021, the monthly average capability component cost of regulation was \$16.65, 56.0 percent higher than \$10.67 in the first three months of 2020. In the first three months of 2021, the monthly average performance component cost of regulation was \$2.00, 30.0 percent higher than \$1.54 in the first three months of 2020. The increase of the average total cost in the first three months of 2021 versus the first three months of 2020, was primarily a result of higher LOC values due to higher prices in the energy market.

Table 10-46 Components of regulation cost: January 2020 through March 2021

Year	Month	Scheduled Regulation (MW)	Cost of Regulation			Total Cost (\$/MW)
			Cost of Regulation Capability (\$/MW)	Performance (\$/MW)	Opportunity Cost (\$/MW)	
2020	Jan	387,662.1	\$13.32	\$1.80	\$1.64	\$16.76
	Feb	367,193.0	\$9.90	\$1.35	\$1.36	\$12.61
	Mar	377,392.8	\$8.71	\$1.46	\$2.07	\$12.24
	Apr	364,657.2	\$11.68	\$1.77	\$2.03	\$15.48
	May	379,756.8	\$12.66	\$1.39	\$1.95	\$16.01
	Jun	390,056.1	\$11.74	\$1.94	\$1.88	\$15.57
	Jul	407,744.5	\$15.74	\$1.54	\$1.68	\$18.96
	Aug	407,097.0	\$14.80	\$2.01	\$1.78	\$18.59
	Sep	366,741.7	\$10.42	\$1.49	\$1.47	\$13.39
	Oct	380,176.1	\$16.90	\$2.80	\$1.78	\$21.49
	Nov	368,798.1	\$15.21	\$2.70	\$2.11	\$20.02
	Dec	396,890.6	\$15.40	\$1.72	\$1.94	\$19.05
	Yearly	4,594,166.0	\$13.09	\$1.83	\$1.81	\$16.73
2021	Jan	400,937.0	\$11.71	\$1.67	\$1.67	\$15.05
	Feb	364,533.3	\$19.90	\$2.52	\$3.34	\$25.75
	Mar	386,898.9	\$18.70	\$1.86	\$2.15	\$22.71
	Total	1,152,369.2	\$16.65	\$2.00	\$2.36	\$21.01

Table 10-47 provides a comparison of the average price and cost for PJM regulation. The ratio of regulation market price to the cost of regulation in the first three months of 2021 was 81.8 percent, a 3.5 percent increase from 79.0 percent in the first three months of 2020.

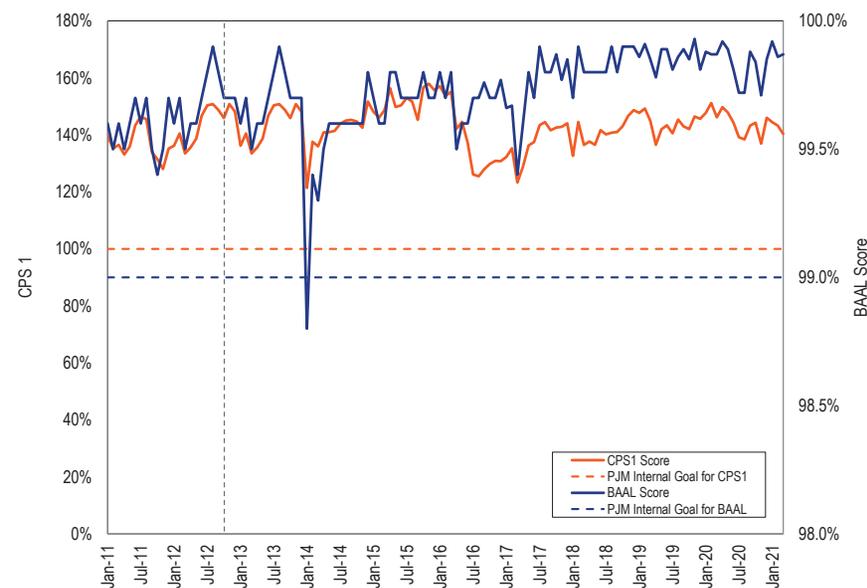
Table 10-47 Comparison of average price and cost for regulation: January through March, 2009 through 2021

Year (Jan-Mar)	Weighted Regulation Market Price	Weighted Regulation Market Cost	Regulation Price as Percent Cost
2009	\$22.25	\$11.81	188.4%
2010	\$17.97	\$13.27	135.4%
2011	\$11.52	\$13.51	85.3%
2012	\$12.62	\$4.13	305.3%
2013	\$33.91	\$39.36	86.2%
2014	\$92.97	\$112.30	82.8%
2015	\$47.91	\$58.23	82.3%
2016	\$15.55	\$17.92	86.8%
2017	\$13.89	\$18.47	75.2%
2018	\$40.33	\$49.60	81.3%
2019	\$14.05	\$18.49	76.0%
2020	\$10.99	\$13.91	79.0%
2021	\$17.18	\$21.01	81.8%

Performance Standards

PJM’s performance as measured by CPS1 and BAAL standards is shown in Figure 10-20 for every month from January 2011 through March 2021 with the dashed vertical line marking the date (October 1, 2012) of the implementation of the Performance Based Regulation Market design.⁹⁶ The horizontal dashed lines represent PJM internal goals for CPS1 and BAAL performance.

Figure 10-20 Monthly CPS1 and BAAL performance: January 2011 through March 2021



Black Start Service

Black start service is required for the reliable restoration of the grid following a blackout. Black start service is the ability of a generating unit to start without an outside electrical supply, or the demonstrated ability of a generating unit to automatically remain operating at reduced levels when disconnected from the grid (automatic load rejection or ALR).⁹⁷ Although PJM has raised the issue, there are no firm fuel requirements for black start units.

PJM does not have a market to provide black start service, but compensates black start resource owners on the basis of cost of service rates defined in the tariff.⁹⁸

⁹⁶ See 2019 State of the Market Report for PJM, Appendix F: Ancillary Services.

⁹⁷ OATT Schedule 1 § 1.3BB.

⁹⁸ See OATT Schedule 6A para. 18.

PJM defines required black start capability zonally, while recognizing that the most effective way to provide black start service may be across zones. Under the current rules PJM has substantial flexibility in procuring black start resources and is responsible for black start resource selection.

On April 7, 2021, PJM issued an incremental RFP for additional black start service in the BGE and PEPCO Zones. The RFP is a two stage process. Level one submissions are due May 10, 2021. Level two submissions have a target date of May 31, 2021. The expected award date is August 6, 2021. The planned in service date is April 1, 2023.⁹⁹

Total black start charges are the sum of black start revenue requirement charges and black start uplift (operating reserve) charges. Black start revenue requirements for black start units consist of fixed black start service costs, variable black start service costs, training costs, fuel storage costs, and an incentive factor applicable when CRF rates are not used. The tariff specifies how to calculate each component of the revenue requirement formula.¹⁰⁰ Black start resources can choose to recover fixed costs under a formula rate based on zonal Net CONE and unit ICAP rating, a cost recovery rate based on incremental black start NERC-CIP compliance capital costs, or a cost recovery rate based on FERC-approved rate plus capital costs for new investment. In addition, PJM applies a cost recovery rate based on incremental black start equipment capital costs.

Black start uplift (operating reserve) charges are paid to units committed in real time to provide black start service or for black start testing.¹⁰¹ Total black start charges are allocated monthly to PJM customers proportionally to their zone and nonzone peak transmission use and point to point transmission reservations.¹⁰² It is not clear why it is reasonable to have different charges for black start service across zones as the service is to ensure that PJM as a whole can recover from a large scale outage.

In the first three months of 2021, total black start charges were \$16.553 million, an increase of \$0.568 million (3.6 percent) from 2020. Uplift charges for black start service increased from \$0.041 million in the first three months of 2020 to \$0.069 million (70.7 percent) in the first three months of 2021. Table 10-48 shows total charges in the first three months of each year from 2010 through 2021.¹⁰³

Table 10-48 Black start revenue requirement charges: 2010 through 2021

Jan-Mar	Revenue Requirement		Total
	Charges	Uplift Charges	
2010	\$2,673,689	\$0	\$2,673,689
2011	\$2,793,709	\$0	\$2,793,709
2012	\$3,864,301	\$0	\$3,864,301
2013	\$5,412,855	\$22,210,646	\$27,623,501
2014	\$5,104,104	\$7,561,533	\$12,665,637
2015	\$10,276,712	\$4,699,965	\$14,976,676
2016	\$16,677,315	\$57,082	\$16,734,396
2017	\$17,731,836	\$63,384	\$17,795,220
2018	\$16,840,283	\$23,309	\$16,863,592
2019	\$15,938,101	\$36,188	\$15,974,289
2020	\$15,944,660	\$40,587	\$15,985,247
2021	\$16,483,797	\$69,278	\$16,553,075

⁹⁹ RFPs issued can be found on the PJM website. See PJM. <<http://www.pjm.com/markets-and-operations/ancillary-services.aspx>>.

¹⁰⁰ See OATT Schedule 6A para. 18.

¹⁰¹ There are no black start units currently using the ALR option.

¹⁰² OATT Schedule 6A (paras. 25, 26 and 27 outline how charges are to be applied).

¹⁰³ Starting December 1, 2012, PJM defined a separate black start uplift category. ALR units accounted for the high uplift charges in 2013 - 2015. All ALR units had been replaced by April 2015.

Black start zonal charges in the first three months of 2021 ranged from \$0.02 per MW-day in the BGE Zone (total charges were \$11,411) to \$4.10 per MW-day in the PE Zone (total charges were \$1,074,321). For each zone, Table 10-49 shows black start charges, the sum of monthly zonal peak loads multiplied by the number of days of the month in which the peak load occurred, and black start rates (calculated as charges per MW-day). Customers paid an average of \$1.15 per MW-day for black start service in the first three months of 2021.

Table 10-49 Black start zonal charges: January through March, 2020 and 2021¹⁰⁴

Zone	Jan-Mar 2020					Jan-Mar 2021				
	Revenue Requirement Charges	Uplift Charges	Total Charges	Peak Load (MW)	Black Start Rate (\$/MW-day)	Revenue Requirement Charges	Uplift Charges	Total Charges	Peak Load (MW)	Black Start Rate (\$/MW-day)
ACEC	\$644,998	\$0	\$644,998	2,737	\$2.59	\$644,881	\$9,456	\$654,336	2,635	\$2.76
AEP	\$4,341,276	\$647	\$4,341,924	22,498	\$2.12	\$4,906,023	\$1,111	\$4,907,134	21,615	\$2.52
APS	\$970,382	\$0	\$970,382	9,596	\$1.11	\$950,490	\$0	\$950,490	8,638	\$1.22
ATSI	\$1,401,494	\$0	\$1,401,494	12,567	\$1.23	\$1,395,106	\$0	\$1,395,106	12,465	\$1.24
BGE	\$68,961	\$0	\$68,961	6,706	\$0.11	\$11,441	\$0	\$11,441	6,700	\$0.02
COMED	\$945,794	\$1,660	\$947,454	20,949	\$0.50	\$2,287,254	\$2,530	\$2,289,785	20,220	\$1.26
DAY	\$54,930	\$14,120	\$69,050	1,086	\$0.70	\$54,514	\$13,958	\$68,472	3,309	\$0.23
DUKE	\$88,680	\$0	\$88,680	5,052	\$0.19	\$90,184	\$12,598	\$102,782	4,975	\$0.23
DUQ	\$11,116	\$0	\$11,116	2,662	\$0.05	\$10,750	\$0	\$10,750	2,668	\$0.04
DOM	\$891,955	\$14,765	\$906,719	19,931	\$0.50	\$1,301,989	\$23,582	\$1,325,571	20,061	\$0.73
DPL	\$554,748	\$6,132	\$560,880	4,098	\$1.50	\$530,324	\$2,016	\$532,340	4,086	\$1.45
EKPC	\$85,022	\$0	\$85,022	3,074	\$0.30	\$78,559	\$0	\$78,559	2,720	\$0.32
JCPLC	\$1,686,300	\$0	\$1,686,300	6,057	\$3.06	\$193,927	\$0	\$193,927	5,903	\$0.37
MEC	\$110,184	\$0	\$110,184	2,986	\$0.41	\$93,318	\$0	\$93,318	2,976	\$0.35
OVEC	\$0	\$0	\$0	NA	NA	\$0	\$0	\$0	NA	NA
PECO	\$339,350	\$831	\$340,181	8,428	\$0.44	\$357,215	\$1,203	\$358,418	8,148	\$0.49
PE	\$1,099,663	\$0	\$1,099,663	3,015	\$4.01	\$1,074,321	\$0	\$1,074,321	2,911	\$4.10
PEPCO	\$618,196	\$625	\$618,820	6,191	\$1.10	\$74,288	\$0	\$74,288	5,887	\$0.14
PPL	\$276,730	\$161	\$276,891	7,939	\$0.38	\$1,216,203	\$0	\$1,216,203	7,260	\$1.86
PSEG	\$1,048,666	\$0	\$1,048,666	9,753	\$0.29	\$415,941	\$0	\$415,941	9,557	\$0.48
REC	\$0	\$0	\$0	NA	NA	\$0	\$0	\$0	NA	NA
(Imp/Exp/Wheels)	\$706,215	\$1,646	\$707,861	7,325	\$1.06	\$797,070	\$2,824	\$799,894	7,697	\$1.15
Total	\$15,944,660	\$40,587	\$15,985,247	162,648	\$1.08	\$16,483,797	\$69,278	\$16,553,075	160,429	\$1.15

¹⁰⁴ Peak load for each zone is used to calculate the black start rate per MW day.

Table 10-50 provides a revenue requirement estimate by zone for the 2020/2021, 2021/2022 and 2022/2023 Delivery Years.¹⁰⁵ Revenue requirement values are rounded up to the nearest \$50,000 to reflect uncertainty about future black start revenue requirement costs. These values are illustrative only. The estimates are based on the best available data including current black start unit revenue requirements, expected black start unit termination and in service dates, changes in recovery rates, and owner provided cost estimates of incoming black start units at the time of publication and may change significantly.

Table 10-50 Black start zonal revenue requirement estimate: 2020/2021 through 2022/2023 Delivery Years

Zone	2020 / 2021 Revenue Requirement	2021 / 2022 Revenue Requirement	2022 / 2023 Revenue Requirement
ACEC	\$2,750,000	\$2,150,000	\$2,100,000
AEP	\$20,700,000	\$21,650,000	\$21,450,000
APS	\$5,050,000	\$10,300,000	\$10,300,000
ATSI	\$5,900,000	\$5,900,000	\$5,900,000
BGE	\$50,000	\$100,000	\$100,000
COMED	\$9,800,000	\$9,950,000	\$9,300,000
DAY	\$250,000	\$300,000	\$250,000
DUKE	\$400,000	\$450,000	\$350,000
DUQ	\$400,000	\$2,100,000	\$2,100,000
DOM	\$5,650,000	\$5,750,000	\$5,500,000
DPL	\$2,250,000	\$1,350,000	\$1,250,000
EKPC	\$350,000	\$400,000	\$300,000
JCPLC	\$850,000	\$900,000	\$800,000
MEC	\$400,000	\$550,000	\$450,000
OVEC	\$0	\$0	\$0
PECO	\$1,550,000	\$1,700,000	\$1,450,000
PE	\$4,550,000	\$4,650,000	\$4,550,000
PEPCO	\$700,000	\$350,000	\$350,000
PPL	\$4,750,000	\$5,250,000	\$5,200,000
PSEG	\$1,750,000	\$1,850,000	\$1,750,000
REC	\$0	\$0	\$0
Total	\$68,100,000	\$75,650,000	\$73,450,000

¹⁰⁵ The System Restoration Strategy Task Force requested that the MMU provide estimated black start revenue requirements.

CRF Issues

The capital recovery factor (CRF) defines the revenue requirement of black start units when new equipment is added to provide black start capability.¹⁰⁶ The CRF is a rate, which when multiplied by the investment, provides for a return on and of capital over a defined time period. CRFs are calculated using a formula or a standard financial model that accounts for the weighted average cost of capital and its components, including depreciation and taxes. The PJM CRF table was created in 2007 as part of the new RPM capacity market design and incorporated in Attachment DD to the PJM OATT (Table 10-51). The CRF table provided for the accelerated return of incremental investment in capacity resources based on concerns about the fact that some old coal units would be making substantial investments related to pollution control. The CRF values were later added to the black start rules.¹⁰⁷ The CRF table includes assumptions about tax rates that are no longer correct. The CRF values are significantly too high as a result. The PJM tariff tables including CRF values should have been changed for both black start and the capacity market when the tax laws changed in 2017.

Table 10-51 Existing CRF table for black start units

Age of Black Start Unit (Years)	Term of Black Start Unit Commitment (Years)	Levelized CRF
1 to 5	20	0.125
6 to 10	15	0.146
11 to 15	10	0.198
16+	5	0.363

The existing CRF table includes the column header, term of black start unit commitment, which is misleading and incorrect. The column is simply the cost recovery period. Accelerated recovery reduces risk to black start units and should not be the basis for a shorter commitment. Full payment of all costs of black start investment on an accelerated basis should not be a reason for a shortened commitment period. Regardless of the recovery period, payment of the full costs of the black start investment should require commitment for

¹⁰⁶ See OATT Schedule 6A para. 18.

¹⁰⁷ *Id.*

the life of the unit.¹⁰⁸ There is no need for such short recovery periods for black start investment costs. Two periods, based on unit age, are more than adequate.

The U.S. Internal Revenue Code changed significantly in December 2017. The PJM CRF table did not change to reflect these changes. As a result, CRF values have overcompensated black start units since the changes to the tax code. The new depreciation rules allow for a more accelerated depreciation and therefore lower taxes. The tax code also reduced the corporate tax rate to 21 percent which also reduces taxes.

Updated CRF rates, incorporating the tax code changes, should be implemented immediately. The updated CRF rates should apply to all black start units because the actual tax payments for all black start units were reduced by the tax law changes. Without this change, black start units are receiving and will continue to receive an unexpected windfall.

Table 10-52 includes updated CRF values based on the new tax code. The second column is the cost recovery period and not the commitment period.

Table 10-52 Updated CRF table for black start units

Age of Black Start Unit (Years)	Black Start Cost Recovery Period (Years)	Updated Levelized CRF
1 to 5	20	0.101
6 to 10	15	0.116
11 to 15	10	0.147
16+	5	0.246

Overcompensation amounts vary with the project investment and the CRF recovery period (Table 10-53). For a new black start unit with an investment cost of \$21 million, the overcompensation is \$12,180,000 over the 20 year recovery period. For a new black start unit with an investment of \$21 million, the overcompensation is \$12,285,000 over the five year recovery period.

¹⁰⁸ PJM's recent filing to revise Schedule 6A includes a required commitment to provide black start service for the life of the unit. See FERC Docket No. ER21-1635.

Table 10-53 Lifetime recovery of black start units with old and updated CRF

Example	Old CRF Rate	Updated CRF Rate	Project Investment	Old CRF Lifetime Recovery	Updated CRF Lifetime Recovery	Updated Lifetime Difference
1	0.125	0.101	\$9,000,000	\$22,500,000	\$18,180,000	\$4,320,000
2	0.125	0.101	\$15,000,000	\$37,500,000	\$30,300,000	\$7,200,000
3	0.125	0.101	\$21,000,000	\$52,500,000	\$42,420,000	\$10,080,000
1	0.146	0.116	\$9,000,000	\$19,710,000	\$15,660,000	\$4,050,000
2	0.146	0.116	\$15,000,000	\$32,850,000	\$26,100,000	\$6,750,000
3	0.146	0.116	\$21,000,000	\$45,990,000	\$36,540,000	\$9,450,000
1	0.198	0.147	\$9,000,000	\$17,820,000	\$13,230,000	\$4,590,000
2	0.198	0.147	\$15,000,000	\$29,700,000	\$22,050,000	\$7,650,000
3	0.198	0.147	\$21,000,000	\$41,580,000	\$30,870,000	\$10,710,000
1	0.363	0.246	\$9,000,000	\$16,335,000	\$11,070,000	\$5,265,000
2	0.363	0.246	\$15,000,000	\$27,225,000	\$18,450,000	\$8,775,000
3	0.363	0.246	\$21,000,000	\$38,115,000	\$25,830,000	\$12,285,000

Table 10-54 shows the total excess payments to black start units that will result if the CRF issue is not addressed. The table includes the excess payments for units in service prior to the 2017 tax law change and excess payments for units in service after the 2017 tax law change. For the pre 2017 units, the updated CRF rates were changed to reflect only the change in the tax rate, and for the post 2017 units, the updated CRF rates were changed to reflect both the change in the tax rate and the change in the tax depreciation treatment.

Table 10-54 Lifetime difference of black start units with updated CRF

Years	Existing Annual Revenue Requirement Total	Updated Annual Revenue Requirement Total	Difference Per Year Total	Updated Lifetime Difference Total
Pre 2017 units	\$53,402,977	\$46,637,692	\$6,765,285	\$38,078,930
Post 2017 Units	\$28,217,475	\$19,902,490	\$8,314,985	\$58,811,154
Total	\$81,620,451	\$66,540,182	\$15,080,269	\$96,890,084

For the future, the CRF should be updated and posted at least annually to reflect changes in federal or state taxes, including depreciation treatment and tax rates. The tariff should include an explicit statement of the formula and define the components of the formula. Existing black start resources constructed prior to the new tax law and to which the new tax law depreciation rules did not apply should use a CRF calculated using the depreciation rules applicable to the investment in the resources, the current tax rate and the current interest rate.

The MMU recommends that new CRF rates for black start units, incorporating current tax code changes, be implemented immediately. The new CRF rates should apply to all black start units, including those that are currently in service and those not yet in service. The CRF rates for units going into service since the change in the tax code should incorporate applicable changes to depreciation treatment and tax rates. The CRF rates for units constructed prior to the new tax law and to which the new tax law depreciation rules did not apply should incorporate only the applicable changes to the tax rate. The black start units should be required to commit to providing black start service for the life of the unit.

On April 7, 2021, PJM filed with FERC to replace the CRF values with a description of the components of the CRF formula.¹⁰⁹ Rather than fix the inaccurate CRF values used for existing black units, PJM's filing would make the use of inaccurate values permanent. PJM should instead apply the filed formula, including rebilling those units that have been overpaid. The tariff needs to include the CRF formula in addition to the components of CRF so that the tariff includes the complete filed rate. The MMU filed a protest to the April 7th filing on April 28, 2021.¹¹⁰

NERC – CIP

Currently, no black start units have requested new or additional black start NERC – CIP Capital Costs.¹¹¹

Minimum Tank Suction Level (MTSL)

Some units that participate in the PJM energy market have oil tanks. All oil tanks at PJM units have a MTSL regardless of whether the units provide black start service (unless they use direct current pumps). The MTSL is the amount of fuel at the bottom of a tank which cannot be recovered for use.

PJM has required that customers pay black start unit owners carrying cost recovery for one hundred percent of the MTSL for tanks which are shared with units in the energy market. These tanks were sized to meet the needs of the generating units, which use significantly more fuel than the black start units. In some instances the MTSL is greater than the total amount of fuel that the black start unit needs to operate to meet its black start obligations. When a black start diesel is added at the site of an oil fired generating unit, the additional MTSL is zero.

Figure 10-21 illustrates that the size of the oil tank does not change with the addition of the black start unit. Figure 10-22 shows how the MTSL could be proportionally divided between the generator and the black start unit. The tank is 4,000,000 gallons with an MTSL of 800,000 gallons leaving 3,200,000 gallons of usable fuel. The black start unit running 16 hours using 12,000 gallons per hour would need a total of 192,000 gallons, or six percent of the total usable fuel. Assigning six percent of the MTSL (800,000 gallons) would yield 48,000 gallons which could be assigned to the black start proportion for the MTSL.

The MMU recommends that for oil tanks which are shared with other resources that only a proportionate share of the MTSL be allocated for black start units. The MMU further recommends that the PJM tariff be updated to clearly state how the MTSL will be calculated for black start units sharing oil tanks. PJM has filed to correct the rules consistent with the Market Monitor's recommendation.¹¹²

¹⁰⁹ See Docket No. ER21-1635-000.

¹¹⁰ See Comments of the Independent Market Monitor for PJM, FERC Docket No. ER21-1635-000, which can be accessed at http://www.monitoringanalytics.com/filings/2021/IMM_Comments_Docket_No_ER21-1635_20210428.pdf.

¹¹¹ OATT Schedule 6A para. 21. "The Market Monitoring Unit shall include a Black Start Service summary in its annual State of the Market report which will set forth a descriptive summary of the new or additional Black Start NERC-CIP Capital costs requested by Black Start Units, and include a list of the types of capital costs requested and the overall cost of such capital improvements on an aggregate basis such that no data is attributable to an individual Black Start Unit."

¹¹² See FERC Docket No. ER21-1635-000.

Figure 10-21 Oil tank MTSL not changed from addition of black start generator

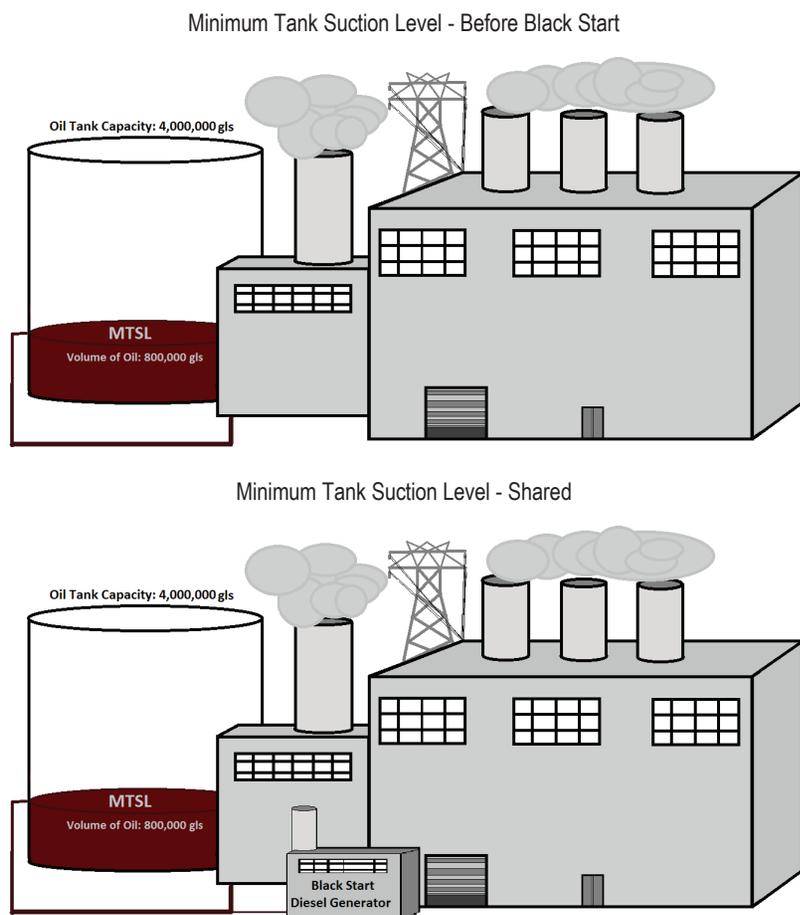
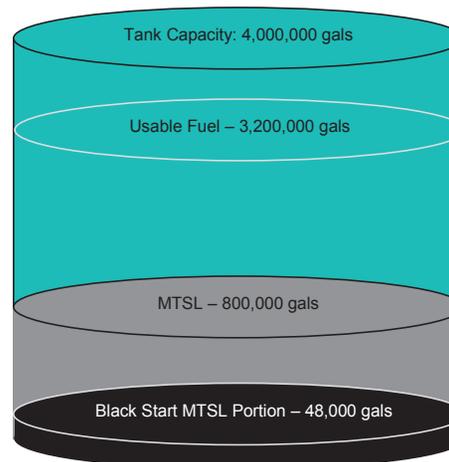


Figure 10-22 Oil tank black start MTSL portion



Reactive Power Service and Capability

Suppliers of reactive power are compensated separately for reactive power service and reactive capability. Compensation for reactive power service is determined based on real-time lost opportunity costs. Compensation for reactive capability is approved separately for each resource or resource group by FERC per Schedule 2 of the OATT. Resources may obtain FERC approval to recover a share of resources' fixed costs by calculating a reactive revenue requirement, the reactive capability rate, and to collect such rates from PJM transmission customers.¹¹³

Any reactive service provided operationally that involves a MW reduction outside of its normal operating range or a startup for reactive power will be logged by PJM operators and paid uplift based on lost opportunity costs.

Reactive Service, Reactive Supply and Voltage Control are provided by generation and other sources of reactive power (such as static VAR

¹¹³ See "PJM Manual 27: Open Access Transmission Tariff Accounting," § 3.2 Reactive Supply and Voltage Control Credits, Rev. 93, (Aug. 31, 2020).

compensators and capacitor banks).¹¹⁴ PJM in its role as the independent RTO and transmission provider determines the reactive capability it needs from all sources in order to reliably operate the grid. PJM, as part of its Interconnection Agreement, requires that all resources over 20 MW be able to operate at a power factor of 0.90 lagging to 0.95 leading throughout their entire operating range. This requirement ensures that even under extreme conditions every generator will be able to operate within the voltage schedule assigned to them by PJM. Reactive power helps maintain appropriate voltages on the transmission system and must be sourced locally.

Total reactive capability charges are the sum of FERC approved reactive supply revenue requirements which are posted monthly on the PJM website.¹¹⁵ Zonal reactive supply revenue requirement charges are allocated monthly to PJM customers proportionally to their zone and to any nonzone (i.e. outside of the PJM Region) peak transmission use and daily average point to point transmission reservations.^{116 117}

In 2016, FERC began to reexamine its policies on reactive compensation.¹¹⁸ Changes in the default capabilities of generators, disparities between nameplate values and tested values and questions about the way the allocation factors have been calculated have called continued reliance on the *AEP* method into question.¹¹⁹ The continued use of fleet rates rather than unit specific rates is also an issue.

Recommended Market Approach to Reactive Costs

The best approach for recovering reactive capability costs is through markets where markets are available as they are in PJM. The best approach for recovering reactive capability costs in PJM is through the capacity market. The capacity market already incorporates reactive costs and reactive revenues. The treatment of reactive costs in the PJM market needs to be modified so

¹¹⁴ OATT Schedule 2.

¹¹⁵ See PJM. Markets & Operations: Billing, Settlements & Credit, "Reactive Revenue Requirements," <<http://www.pjm.com/~media/markets-ops/settlements/reactive-revenue-requirements-table-may-2016.ashx>> (June 8, 2016).

¹¹⁶ OATT Schedule 2.

¹¹⁷ See "PJM Manual 27: Open Access Transmission Tariff Accounting," § 3.3 Reactive Supply and Voltage Control Charges, Rev. 93 (Aug. 31, 2020).

¹¹⁸ See *Reactive Supply Compensation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. AD16-17-000 (March 17, 2016) (Notice of Workshop).

¹¹⁹ See 88 FERC ¶ 61,141 (1999).

that the capacity market incorporates reactive costs and revenues in a more efficient manner.

Reactive capability is an integral part of all generating units; no generating unit is built without reactive capability.¹²⁰ There is no reason that the fixed costs of reactive capability either can be or should be separated from the total fixed costs of a generating unit. There is no reason that reactive capability should be compensated outside the markets when the units participate in organized markets. Reactive capability is a precondition for participating in organized markets. Resources must invest in the equipment needed to have minimum reactive capability as a condition of receiving interconnection service from PJM and other markets.¹²¹ The Commission has recently extended the interconnection service requirement to have reactive capability to wind and solar units, which had previously been exempt.¹²² Reactive capability is a requirement for participating in organized markets and is therefore appropriately treated as part of the gross cost of new entry in organized markets.

The current FERC review provides an excellent opportunity to discard an anachronistic cost of service approach that has not been working well and that is inconsistent with markets and is unnecessary in organized markets. Increased reliance on markets for the recovery of reactive capability costs would promote efficiency and consistency. Customers, market administrators and regulators would be better served by a simpler and more effective competition based approach. The MMU recommends that separate payments for reactive capability be eliminated and the cost of reactive capability be recovered in the capacity market.

¹²⁰ See Order No. 827, 155 FERC ¶ 61,277 at P 9 (2016) ("[T]he equipment needed for a wind generator to provide reactive power has become more commercially available and less costly, such that the cost of installing equipment that is capable of providing reactive power is comparable to the costs of a traditional generator.").

¹²¹ See 18 CFR § 35.28(f)(1); Order No. 2003, FERC Stats. & Regs. ¶ 31,146, Appendix G (Large Generator Interconnection Agreement (LGIA)), *order on reh'g*, Order No. 2003-A, FERC Stats. & Regs. ¶ 31,160, *order on reh'g*, Order No. 2003-B, FERC Stats. & Regs. ¶ 31,171 (2004), *order on reh'g*, Order No. 2003-C, FERC Stats. & Regs. ¶ 31,190 (2005), *aff'd sub nom. Nat'l Ass'n of Regulatory Util. Comm'rs v. FERC*, 475 F.3d 1277 (D.C. Cir. 2007), *cert. denied*, 552 U.S. 1230 (2008); Order No. 2006, FERC Stats. & Regs. ¶ 31,180, Attachment F (Small Generator Interconnection Agreement), *order on reh'g*, Order No. 2006-A, FERC Stats. & Regs. ¶ 31,196 (2005), *order granting clarification*, Order No. 2006-B, FERC Stats. & Regs. ¶ 31,221 (2006).

¹²² Order No. 827, 155 FERC ¶ 61,277 (2016); see also 151 FERC ¶ 61,097 at P 28 (2015).

Improvements to Current Approach

Reactive compensation must be integrated into PJM's competitive market design. Reactive capability rates recover through cost of service rates exactly the same investment that capacity markets price at market based rates.

If OATT Schedule 2 reactive capability payments are not eliminated, then the MMU recommends, at a minimum, that steps be taken to ensure that payments only go to the generating units that specifically support PJM grid operations and are fully subject to PJM dispatch, are based on capability that PJM needs to maintain system stability and do not constitute double recovery.

FERC has initiated a number of investigations into the basis for reactive rates, and the MMU has intervened in and is participating in those proceedings.¹²³ The only FERC proceeding that has provided an opportunity for the MMU to raise its concerns at hearing has been *Panda Stonewall LLC*.¹²⁴ The initial decision issued in that case sidesteps the issues identified by the MMU, and the error is repeated in the order on the initial decision.¹²⁵ The MMU's request for rehearing is pending. These issues must be squarely addressed for PJM to have an even minimally satisfactory market design related to compensating investment in reactive capability that cannot be differentiated from investment in capacity.

Power Factor Capped at PJM Determined Level of Need

Under the *AEP* method, units must establish their MVAR rating based on "the capability of the generators to produce VARs."¹²⁶ Typically this has meant reliance on manufacturers' specified nameplate power factor.¹²⁷ More recently, the Commission has, in the *Wabash* Orders, required that "reactive power revenue requirement filings must include reactive power test reports."¹²⁸ Noting a difference between tested reactive MVAR ratings and nameplate

MVAR ratings, the Commission has, in a number of cases, set the issue of MVAR rating degradation for hearing.¹²⁹

The Commission has identified a significant issue. The MVAR rating has a significant influence on the level of the requirements and should accurately reflect the MVAR capability actually available to maintain reliability. However, power ratings, whether based on nameplate or testing, do not establish MVAR capability that is properly relevant to reactive capability rates in PJM. PJM determines the level of reactive capability it needs in its role as the independent RTO and transmission provider. Generation owners should not be permitted through uncoordinated reactive capability rates to substitute their assessment for PJM's.

The most fundamental point about power factors is that PJM requires that all generating units have a 0.90 power factor throughout their full operating range in order to obtain interconnection service.¹³⁰ There is no reason to pay any provider of reactive capability based on a power factor exceeding the 0.90 power factor that PJM has determined is necessary.

The PJM required power factor value is the only value reasonably included in reactive capability rates because that is what PJM has determined it needs from each generator. Generators should not be permitted to make investment decisions that unnecessarily increase the cost of reactive capability. Individual owners have a conflict of interest concerning such decisions and are not authorized under the OATT to change PJM's determinations on the required power factor.

Reactive capability rates should not be confused with compensation for operating to provide reactive power at PJM's direction. Reactive service is supplied during normal operation as needed and directed by PJM dispatchers. Most reactive service is provided with no impact to operational dispatch. When a need for reactive service requires that a unit's MW output be reduced **outside of its normal operational range, or when a unit is started to provide**

¹²³ See e.g., FERC Dockets Nos. EL16-32, EL16-44, EL16-51, EL16-54, EL16-65, EL16-66, EL16-79, EL16-89, EL16-90, EL16-98, EL16-100, EL16-103, EL16-118, EL16-1004, ER16-1456, ER16-2217, EL17-19, EL17-38, EL17-39, EL17-49, ER17-259 and ER17-801.

¹²⁴ See Docket No. EL17-1821.

¹²⁵ 167 FERC ¶ 63,010 (2019), *order on initial decision*, 174 FERC ¶ 61,266 (2021).

¹²⁶ *AEP mimeo* at 31.

¹²⁷ See, e.g., *id.*

¹²⁸ 154 FERC ¶ 61,246 at P 28 (2016); see also 154 FERC ¶ 61,246 at P 29 (*Wabash* Orders).

¹²⁹ See, e.g., 154 FERC ¶ 61,087 at P 10 (2016) ("The Informational Filing contains information that raises concerns about the justness and reasonableness of Ironwood's reactive power rate, including, but not limited to, the degradation of the Facility's current MVAR capability as compared with the MVAR capability that was originally used to calculate the revenue requirement for Reactive Service included in Ironwood's reactive power rate.")

¹³⁰ See *supra* footnote 27.

reactive power, it is logged by PJM dispatchers and will be paid reactive service credits in the zone or zones where the reactive service was provided.

Offset Cap on Reactive Capability Rates

In addition to effectively capping the appropriate level of the power factor, the PJM market rules also effectively cap the appropriate level of reactive capability rates overall.

Under the current capacity market rules, the gross costs of the entire plant, including any reactive costs, are included in the gross Cost of New Entry (CONE) and the revenues from reactive service capability rates are an offset to the gross CONE. The result is that, conceptually, the cost of reactive included in the offset is not part of net CONE.¹³¹ This is logically consistent with the separate collection of reactive costs through a cost of service rate in that there is no double counting if the revenue offset is done accurately. Under this approach there is a separate collection of reactive capability costs. This approach also requires that any capacity resource calculating unit specific net revenues must include the cost of service reactive revenues in the calculation.

The revenue offset is defined as a fixed number in the OATT and is currently set equal at \$2,199/MW-year.¹³² This is the average annual reactive capability revenue for combustion turbines from 2005 through 2007, based on the actual costs reported to the Commission in reactive service filings.

The PJM market rules explicitly account for recovery of reactive revenues of \$2,199 per MW-year. Reactive capability rates up to that level do not result in double recovery. Reactive capability rates above that level do result in double recovery because costs that would support a rate exceeding \$2,199 per MW-year continue to be recoverable in the PJM Capacity Market.

The \$2,199 offset is a simple rule that established a just and reasonable reconciliation of different regulatory approaches in the same market design. The offset assumes a defined level of revenues are received under cost of service rates and nets them from the parameters used in the capacity market.

¹³¹ See OATT Attachment DD § 5.10(a)(iv).

¹³² See OATT Attachment DD § 5.10(a)(v).

Those parameters define the operation of the market so that just and reasonable capacity prices are established. Reactive rates cannot be just and reasonable if they do not account for the market design in which PJM units operate.

To the extent that the Commission decides that PJM and other markets should continue to rely on a cost of service method to compensate reactive capability, the rules should be modified to improve the accuracy of the calculations of reactive capability cost. Double compensation should not be permitted as a combined result of market based capacity prices and cost of service rates. No recovery above the \$2,199 per MW-year level should be provided as direct compensation for reactive capability under the current approach.

Reactive capability rate schedules must be accurate, and they must also coordinate properly with the PJM market rules. Revenues received for reactive capability are revenues for ancillary services that should be netted against avoidable costs whenever avoidable cost rate offers are submitted in RPM capacity market auctions.¹³³ Participants have not been properly including reactive revenues in capacity market offers, and the MMU has notified participants of its compliance concerns. The identification of revenues for reactive capability on a unit specific basis is necessary for the calculation of accurate avoidable cost rate offers and is needed to avoid disputes that could interfere with the orderly administration of RPM auctions. The MMU has sought to address these issues through participation in proceedings at FERC concerning reactive capability rates for PJM units.¹³⁴

Losses

The estimated capability costs also include estimated heating losses relative to MVAR output.¹³⁵ Heating losses are variable costs and not fixed costs and should not be included in the definition of reactive capability costs.¹³⁶ Heating losses can be accurately calculated for each hour of operation if each unit had

¹³³ See OATT Attachment DD §§ 6.4, 6.8(d).

¹³⁴ The MMUs has to date participated in nearly 150 reactive matters. See, e.g., FERC Dockets Nos. EL16-44 et al.; ER16-1456; EL16-57 et al.; EL16-51 et al.; ER16-1004; EL16-32; EL16-72; EL16-66; EL16-65; EL16-54; EL16-90 et al.; EL16-103 et al.; EL16-89 et al.; EL16-98 et al.; EL16-79 et al.; EL16-80 et al.; EL16-81 et al.; EL16-82 et al.; EL16-83 et al.; ER16-2217 et al.; EL17-19; EL16-118.

¹³⁵ See, e.g., *id.* at P 10 n12, citing *PPL Energy Plus, LLC*, Letter Order, Docket No. ER08-1462-000 (Sept. 24, 2008); 125 FERC ¶ 61,280 at P 35 (2008).

¹³⁶ See Transcript, *Reactive Supply Compensation in Markets Operated by Regional Transmission System Operators Workshop*, AD16-17-000 (June 30, 2016) at 26:21–27:23.

an accurate, recent D-curve test. Heating losses are variable costs and should not be included in the cost of reactive capability. The production of reactive power slightly reduces the MWh output of the generator as the generator follows its D-curve. The value of this heating loss component is generally estimated based on estimated operation and associated estimated losses and estimated market prices, treated as a fixed cost, and included in the cost of reactive capability. Losses are minimal and occur during normal operations and should not be treated as a fixed cost. Losses can be better and more accurately accounted for as a variable cost based on actual unit operations and market conditions.

Fleet Rates

Cost of service rates are established under Schedule 2 of the OATT and may cover rates for single units or a fleet of units.¹³⁷ Until the Commission took corrective action, fleet rates remained in place in PJM even when the actual units in the fleet changed as a result of unit retirements or sales of units.¹³⁸ New rules require unit owners to give notice of fleet changes in an informational filing or to file a new rate based on the remaining units, but do not yet require unit specific reactive rates.¹³⁹

Fleet rates create confusion about what revenue is properly attributable to each unit in the fleet. Reactive rates should be stated separately for each unit, even if multiple plants or units are considered in a single proceeding. The MMU filed with the Commission to require unit specific rates when PJM proposed limited reforms that could have corrected the oversight and compliance problems posed by fleet rates.¹⁴⁰ But PJM rules require fleet owners only to submit informational filings when a reactive unit is transferred or deactivated.¹⁴¹ The current rules do not require a rate filing, which would place the burden of proof on the company and allow for cost review.¹⁴²

¹³⁷ See, e.g., OATT Schedule 2; 114 FERC ¶ 61,318 (2006).

¹³⁸ See 149 FERC ¶ 61,132 (2014); 151 FERC ¶ 61,224 (2015); OATT Schedule 2.

¹³⁹ *Id.*

¹⁴⁰ 151 FERC ¶ 61,224 at P 29 (2015).

¹⁴¹ OATT Schedule 2.

¹⁴² *Id.*

The MMU also raised issues related to fleet rates in a settlement establishing a fleet rate without specifying the actual portion of the fleet rate attributable to each unit in the fleet.¹⁴³ The approach could prevent or inhibit an appropriate adjustment of the fleet requirement if a unit receiving an unspecified portion of such requirement is deactivated or transferred because third parties without access to cost information would bear the burden of proof in a complaint proceeding.¹⁴⁴ The MMU also explained that the approach makes it impossible to calculate cost-based offers from such units in the PJM Capacity Market. The settlement was approved over the MMU's objection on the grounds that the tariff does not prohibit fleet rates.¹⁴⁵

The MMU recommends that fleet rates be eliminated and that compensation be based on unit specific costs and rates and that rates be appropriately reduced when units with reactive payments retire.

Reactive Costs

In the first three months of 2021, total reactive charges were \$92.7 million, a 5.99 percent increase from the \$87.5 million for first three months of 2020. Reactive capability charges increased from \$87.5 million in the first three months of 2020 to \$92.0 million in 2021 and reactive service charges increased from \$0.046 million in the first three months of 2020 to \$0.706 million in 2021. All \$0.706 million in 2021 were paid for reactive service provided by 5 units in 296 hours.

Table 10-55 shows reactive service charges in the first three months of 2020 and 2021, reactive capability charges and total charges. Reactive service charges show charges to each zone for reactive service provided and not credits to plants in each zone. Reactive capability charges show charges to each zone for reactive capability.

¹⁴³ See Letter Opposing Settlement, Docket No ER06-554 et al. (June 14, 2017).

¹⁴⁴ *Id.*

¹⁴⁵ 162 FERC ¶ 61,029 (2018).

Table 10-55 Reactive service charges and reactive capability charges by zone: January through March, 2020 and 2021

Zone	Jan-Mar 2020			Jan-Mar 2021		
	Reactive Service Charges	Reactive Capability Charges	Total Charges	Reactive Service Charges	Reactive Capability Charges	Total Charges
ACEC	\$0	\$1,077,706	\$1,077,706	\$0	\$1,073,108	\$1,073,108
AEP	\$0	\$12,324,025	\$12,324,025	\$0	\$12,501,401	\$12,501,401
APS	\$0	\$4,371,669	\$4,371,669	\$0	\$4,869,514	\$4,869,514
ATSI	\$0	\$6,049,033	\$6,049,033	\$0	\$6,330,567	\$6,330,567
BGE	\$0	\$1,783,154	\$1,783,154	\$0	\$1,659,929	\$1,659,929
COMED	\$0	\$9,438,609	\$9,438,609	\$0	\$10,416,653	\$10,416,653
DAY	\$0	\$706,978	\$706,978	\$0	\$703,962	\$703,962
DUKE	\$0	\$2,394,949	\$2,394,949	\$0	\$2,620,095	\$2,620,095
DOM	\$0	\$10,081,536	\$10,081,536	\$0	\$12,092,090	\$12,092,090
DPL	\$10,508	\$2,548,824	\$2,559,332	\$0	\$2,702,811	\$2,702,811
DUQ	\$0	\$143,276	\$143,276	\$0	\$142,664	\$142,664
EKPC	\$0	\$547,368	\$547,368	\$0	\$545,033	\$545,033
JCPLC	\$35,237	\$1,881,974	\$1,917,211	\$0	\$1,884,257	\$1,884,257
MEC	\$0	\$1,539,867	\$1,539,867	\$0	\$1,533,298	\$1,533,298
OVEC	\$0	\$0	\$0	\$0	\$0	\$0
PECO	\$0	\$5,284,186	\$5,284,186	\$0	\$5,232,522	\$5,232,522
PE	\$0	\$4,620,475	\$4,620,475	\$0	\$4,291,436	\$4,291,436
PEPCO	\$0	\$2,795,713	\$2,795,713	\$0	\$2,598,556	\$2,598,556
PPL	\$0	\$8,738,991	\$8,738,991	\$705,618	\$9,152,382	\$9,858,000
PSEG	\$0	\$6,997,345	\$6,997,345	\$0	\$6,964,548	\$6,964,548
REC	\$0	\$0	\$0	\$0	\$0	\$0
(Imp/Exp/Wheels)	\$0	\$4,135,230	\$4,135,230	\$0	\$4,725,344	\$4,725,344
Total	\$45,745	\$87,460,909	\$87,506,654	\$705,618	\$92,040,170	\$92,745,788

Table 10-56 shows the units which have received reactive service credits for the first three months of 2021.

Table 10-56 Reactive service credits by plant: January through March, 2021

Zone	Plant	Reactive Service Credits
PPL	PL HAZELTON 1 CT	\$65,744
PPL	PL HAZELTON 2 CT	\$265,634
PPL	PL HAZELTON 3 CT	\$197,731
PPL	PL HAZELTON 4 CT	\$160,478
PPL	PL HARWOOD 1-2 CT	\$16,031
Total		\$705,618

Frequency Response

On February 15, 2018, the Commission issued Order No. 842, which modified the pro forma large and small generator interconnection agreements and procedures to require newly interconnecting generating facilities, both synchronous and nonsynchronous, to include equipment for primary frequency response capability as a condition to receive interconnection service.¹⁴⁶ Such equipment must include a governor or equivalent controls with the capability of operating at a maximum 5 percent droop and ± 0.036 Hz deadband (or the equivalent or better).

PJM filed revisions in compliance with Order No. 842 that substantively incorporated the pro forma agreements into its market rules.¹⁴⁷

The MMU recommends that the same capability be required of both new and existing resources. The MMU agrees with Order No. 842 that RTOs not be required to provide additional compensation specifically for frequency response. The current PJM market design provides compensation for all capacity costs, including these, in the capacity market. The current market design provides compensation, through heat rate adjusted energy offers, for any costs associated with providing frequency response. Because the PJM market design already compensates resources for frequency response capability and any costs associated with providing frequency response, any separate filings submitted on behalf of resources for compensation under section 205 of the Federal Power Act should be rejected as double recovery.

Frequency Control Definition

There are four distinct types of frequency control, distinguished by response timeframe and operational nature: Inertial Response, Primary Frequency Response, Secondary Frequency Control, and Tertiary Frequency Control.

- **Inertial Response.** Inertial response to frequency excursion is the natural resistance of rotating mass turbine generators to change in their stored kinetic energy. This response is immediate and resists short term changes

¹⁴⁶ 157 FERC ¶ 61,122 (2016).

¹⁴⁷ See 164 FERC ¶ 61,224 (2018).

to ACE from the instant of the disturbance up to twenty seconds after the disturbance.

- **Primary Frequency Response.** Primary frequency response is a response to a disturbance based on a local detection of frequency and local operational control settings. Primary frequency response begins within a few seconds and extends up to a minute. The purpose of primary frequency response is to arrest and stabilize the system until other measures (secondary and tertiary frequency response) become active.
- **Secondary Frequency Control.** Secondary frequency control is called regulation. In PJM it begins taking effect within 10 to 15 seconds and can maintain itself for several minutes up to an hour in some cases. It is controlled by PJM which detects the grid frequency, calculates a counterbalancing signal, and transmits that signal to all regulating resources.
- **Tertiary Frequency Control.** Tertiary frequency control and imbalance control lasting 10 minutes to an hour is available in PJM as Primary Reserve. It is initiated by an all call from the PJM control center.

VACAR Reserve Sharing Agreement

The VACAR Reserve Sharing Agreement (VRSA) is a combination of agreements among the entities in the VACAR subregion including Dominion.¹⁴⁸ VACAR is a subregion of the SERC Reliability Corporation (SERC) region. The agreement remained in effect in 2020. The agreement requires that each entity maintain primary reserves to meet the VACAR contingency reserve commitment (VACAR reserves) and deploy such reserves in the case of an emergency (e.g. loss of a unit in VACAR).¹⁴⁹ Dominion is the only party to the VRSA that is also a transmission owner and a generation owner in PJM. The VRSA is not a public agreement. PJM is not a party to the VRSA. However, as the reliability coordinator for Dominion Virginia Power, PJM is responsible for scheduling Dominion's required reserves in the SERC region as described in the PJM manuals.¹⁵⁰

¹⁴⁸ VRSA entities: Dominion, Duke Energy Progress, Duke Energy Carolinas, South Carolina Electric & Gas Company, South Carolina Public Service Authority and Cube Hydro Carolinas.

¹⁴⁹ See SERC Regional Criteria, Contingency Reserve Policy, NERC Reliability Standard BAL-002 at 10-11.

¹⁵⁰ See PJM, "Manual 13: Emergency Operations," Rev. 78 (Jan. 27, 2021).

PJM procures synchronized reserves and primary reserves for the PJM region, including Dominion. The synchronized reserve and primary reserve requirements are equal to the largest single contingency and 150 percent of the largest contingency. The requirement is procured separately for the RTO and the MidAtlantic Dominion area (MAD) when the largest contingency is located outside of MAD. All units in PJM that meet the synchronized or primary reserve operating parameter requirements are eligible to meet the synchronized and primary requirements as long as PJM does not deselect them.

PJM procures Day-Ahead Scheduling Reserves (DASR) for the PJM region, including Dominion, as Secondary Reserves. The DASR requirement is calculated daily and is equal to the peak load forecast for the ReliabilityFirst region (RFC) and EKPC times the sum of the forced outage rate and the load forecast error, plus Dominion's share of the VACAR contingency reserve commitment. All units in PJM that meet the DASR operating parameter requirements are eligible to meet the DASR requirement.¹⁵¹ There is no requirement that a specific amount of DASR be located in Dominion. Equation 10-1 shows the DASR requirement calculation.¹⁵²

Equation 10-1: DASR Requirement Formula

$$\text{DASR Requirement} = (\text{RFC and EKPC Peak}) \times (\text{FOR} + \text{LFE}) + \text{DOM VACAR}$$

Issues

PJM is expected to implement its ORDC proposal on May 1, 2022. Under the ORDC, it will not be possible for Dominion to hold reserves to meet its obligations under the VRSA without double counting the reserves Dominion has in PJM or withholding such reserves from PJM. Under the ORDC proposal, it will not be possible for Dominion to meet both the VRSA and the PJM reserve rules.

¹⁵¹ DASR can be provided by units that do not clear the Day-Ahead Energy Market and can start within 30 minutes or by units that clear the Day-Ahead Energy Market and can ramp up within 30 minutes.

¹⁵² During cold weather alerts and hot weather alerts, the DASR requirement is increased to procure additional reserves.

Recommendations

The Market Monitor recommends that the details of VACAR Reserve Sharing Agreement (VRSA) be made public, including any responsibilities assigned to PJM and including the amount of reserves that Dominion commits to meet its obligations under the VRSA.

The Market Monitor recommends that the VRSA be terminated and, if necessary, replaced by a reserve sharing agreement between PJM and VACAR South, similar to agreements between PJM and other bordering areas.

Congestion and Marginal Losses

When there are binding transmission constraints and locational price differences, load pays more for energy than generation is paid to produce that energy.¹ The difference is congestion.² As a result, congestion belongs to load and should be returned to load. Congestion is not the difference in CLMP between nodes. Congestion is not the billing line item labeled congestion.³

The locational marginal price (LMP) is the incremental price of energy at a bus. The LMP at a bus can be divided into three components: the system marginal price (SMP) or energy component, the congestion component (CLMP), and the marginal loss component (MLMP). SMP, MLMP and CLMP are the simultaneous products of the least cost, security constrained dispatch of system resources to meet system load and the use of a load-weighted reference bus. The relative values of SMP and CLMP are arbitrary and depend on the reference bus.

SMP is defined as the incremental price of energy for the system, given the current dispatch, at the load-weighted reference bus, or LMP net of losses and congestion. SMP is the LMP at the load-weighted reference bus. The load-weighted reference bus is not a fixed location but varies with the distribution of load at system load buses. For SMP, energy means the component of LMP not associated with a binding transmission constraint. All other locational prices that result from the least cost, security constrained market solution are higher or lower than this reference point price (SMP) as a result of binding constraints. The reference bus is a point of reference. For a given market solution, changing the reference bus does not change the LMP for any node on the system, but changes only the elements of the nodal prices that are positive or negative due to the binding constraints in that solution. CLMP is defined as the incremental price of meeting load at each bus when a transmission constraint is binding, based on the shadow price associated with the relief of a binding transmission constraint in the security constrained optimization. (There can be multiple binding transmission constraints.) CLMPs are positive or negative depending on location relative to binding constraints and relative to the load-weighted reference bus. In an unconstrained system CLMPs will be

¹ Load is generically referred to as withdrawals and generation is generically referred to as injections, unless specified otherwise.

² The difference in losses is not part of congestion.

³ PJM billing examples can be found in *2020 State of the Market Report for PJM*, Appendix F: Congestion and Marginal Losses.

zero. This means that CLMP at a bus is not congestion. The difference between CLMPs at buses is not congestion, it is just the absolute LMP difference between the two buses caused by transmission constraints. CLMP is the portion of the LMP at a bus that indicates whether the LMP at that bus is higher or lower than the marginal price of energy SMP at the selected reference bus due to binding transmission constraints. The relative values of SMP and CLMP are arbitrary and depend on the reference bus.

MLMP is defined as the incremental price of losses at a bus, based on marginal loss factors in the security constrained optimization. Losses refer to energy lost to physical resistance in the transmission network as power is moved from generation to load.

Total losses refer to total system wide transmission losses as a result of moving power from injections to withdrawals on the system. Marginal losses are the incremental change in system losses caused by changes in load and generation.

Congestion is neither good nor bad, but is a direct measure of the extent to which there are multiple marginal generating units with different offers dispatched to serve load as a result of transmission constraints. Congestion occurs when available, least-cost energy cannot be delivered to all load because transmission facilities are not adequate to deliver that energy to one or more areas, and higher cost units in the constrained area(s) must be dispatched to meet the load.⁴ The result is that the price of energy in the constrained area(s) is higher than in the unconstrained area. Load in the constrained area pays the single higher price for all the energy used, including energy from low cost and energy from high cost generation, while generators are each paid the price at their individual bus. Congestion is the difference between what load pays based on the single higher price at load buses and what generators receive based on the lower prices at the individual generator buses due to binding transmission constraints.

⁴ This is referred to as dispatching units out of economic merit order. Economic merit order is the order of all generator offers from lowest to highest cost. Congestion occurs when loadings on transmission facilities mean the next unit in merit order cannot be used and a higher cost unit must be used in its place. Dispatch within the constrained area follows merit order for the units available to relieve the constraint.

The energy, marginal losses and congestion metrics must be interpreted carefully.

In PJM accounting, the term total congestion refers to net implicit CLMP charges plus net explicit CLMP charges plus net inadvertent CLMP charges. The net implicit CLMP charges are the implicit withdrawal CLMP charges less implicit injection CLMP credits.

As with congestion, total system energy costs are more precisely termed net system energy costs and total marginal loss costs are more precisely termed net marginal loss costs. Ignoring interchange, total generation MWh must be greater than total load MWh in any hour in order to provide for losses. Since the hourly integrated energy component of LMP is the same for every bus within every hour, the net energy bill is negative (ignoring net interchange), with more generation credits than load payments in every hour.⁵

While PJM accounting focuses on CLMPS, the individual CLMP values at any bus are irrelevant to the calculation of congestion, as CLMPs are just an artificial deconstruction of LMP based on a selected reference bus. Holding aside the marginal loss component of LMP, differences in the LMPs are caused by binding constraints in the least cost security constrained dispatch market solution and total congestion is the net surplus revenue that remains after all sources and sinks are credited or charged their LMPs. Changing the components of LMP by electing a different reference bus does not change the LMPs or the difference between LMPs for a given market solution, it merely changes the components of the LMP.

Local congestion is the congestion paid by load at a specific bus or set of buses and is calculated on a constraint specific basis. For a given market solution, a change in the elected reference bus does not change the LMP at any bus and does not change total congestion paid by load and does not change the local congestion paid by load at a specific location. Holding aside the marginal loss component of LMP, local congestion is the sum of the total LMP charges to load at the defined set of buses minus the sum of the total LMP credits

⁵ The total congestion and marginal losses for the first three months of 2021 were calculated as of April 12, 2021, and are subject to change, based on continued PJM billing updates.

received by all generation that supplied that load, given the set of all binding transmission constraints, regardless of location.. Local congestion reflects the underlying characteristics of the complete power system as it affects the defined area, including the nature and capability of transmission facilities, the offers and geographic distribution of generation facilities, the level and geographic distribution of incremental bids and offers and the geographic and temporal distribution of load. Local congestion fully reflects the least cost security constrained system solution and the LMPs that result from that solution.

Overview

Congestion Cost

- **Total Congestion.** Total congestion costs increased by \$35.9 million or 42.2 percent, from \$85.1 million in the first three months of 2020 to \$121.0 million in the first three months of 2021.
- **Day-Ahead Congestion.** Day-ahead congestion costs increased by \$121.1 million or 117.2 percent, from \$103.3 million in the first three months of 2020 to \$224.5 million in the first three months of 2021.
- **Balancing Congestion.** Negative balancing congestion costs increased by \$85.2 million, from -\$18.2 million in the first three months of 2020 to -\$103.4 million in the first three months of 2021. Negative balancing explicit charges increased by \$22.7 million, from -\$14.2 million in the first three months of 2020 to -\$36.9 million in the first three months of 2021.
- **Real-Time Congestion.** Real-time congestion costs increased by \$220.2 million, from \$87.7 million in the first three months of 2020 to \$308.0 million in the first three months of 2021.
- **Monthly Congestion.** Monthly total congestion costs in the first three months of 2021 ranged from \$29.1 million in January to \$55.2 million in March.
- **Geographic Differences in CLMP.** Differences in CLMP among eastern, southern and western control zones in PJM were primarily a result of

congestion on the Vienna Transformer, the Bagley - Raphael Road Line, the Bagley - Graceton Line, the Conastone Transformer, and the Harwood - Susquehanna Line.

- **Congestion Frequency.** Congestion frequency continued to be significantly higher in the day-ahead energy market than in the real-time energy market in the first three months of 2021. The number of congestion event hours in the day-ahead energy market was about three times the number of congestion event hours in the real-time energy market.

Day-ahead congestion frequency decreased by 14.4 percent from 17,087 congestion event hours in the first three months of 2020 to 14,618 congestion event hours in the first three months of 2021.

Real-time congestion frequency decreased by 0.6 percent from 5,515 congestion event hours in the first three months of 2020 to 5,484 congestion event hours in the first three months of 2021.

- **Congested Facilities.** The monthly average of daily day-ahead congestion event hours decreased in November 2020 as a result of decreased UTC activity due to a FERC order issued effective November 1, 2020, directing PJM to charge uplift to up to congestion transactions.⁶ Day-ahead, congestion event hours decreased on all types of facilities except lines. The congestion event hours on the PA Central Interface decreased from 1,340 hours in the first three months of 2020 to 0 hours in the first three months of 2021.

The Vienna Transformer was the largest contributor to congestion costs in the first three months of 2021. With \$14.4 million in total congestion costs, it accounted for 11.9 percent of the total PJM congestion costs in the first three months of 2021.

- **CT Price Setting Logic and Closed Loop Interface Related Congestion.** CT Price Setting Logic caused -\$0.0 million of day-ahead congestion in the first three months of 2021 and -\$5.2 million of balancing congestion in the first three months of 2021. None of the closed loop interfaces was binding in the first three months of 2021 or 2020.

- **Zonal Congestion.** AEP had the highest zonal congestion costs among all control zones in the first three months of 2021. AEP had \$16.3 million in zonal congestion costs, comprised of \$31.8 million in day-ahead congestion costs and -\$15.6 million in balancing congestion costs.

Marginal Loss Cost

- **Total Marginal Loss Costs.** Total marginal loss costs increased by \$101.2 million or 93.2 percent, from \$108.5 million in the first three months of 2020 to \$209.7 million in the first three months of 2021. The loss MWh in PJM increased by 395.4 GWh or 10.9 percent, from 3,613.6 GWh in the first three months of 2020 to 4,009.0 GWh in the first three months of 2021. The loss component of real-time LMP in the first three months of 2021 was \$0.02, compared to \$0.01 in the first three months of 2020.
- **Day-Ahead Marginal Loss Costs.** Day-ahead marginal loss costs increased by \$98.6 million or 80.8 percent, from \$122.0 million in the first three months of 2020 to \$220.5 million in the first three months of 2021.
- **Balancing Marginal Loss Costs.** Negative balancing marginal loss costs decreased by \$2.6 million or 19.5 percent, from -\$13.4 million in the first three months of 2020 to -\$10.8 million in the first three months of 2021.
- **Total Marginal Loss Surplus.** The total marginal loss surplus increased by \$43.8 million or 131.9 percent, from \$33.2 million in the first three months of 2020, to \$77.1 million in the first three months of 2021.
- **Monthly Total Marginal Loss Costs.** Monthly total marginal loss costs in the first three months of 2021 ranged from \$47.2 million in March to \$102.7 million in February.

System Energy Cost

- **Total System Energy Costs.** Total system energy costs decreased by \$56.4 million or 74.8 percent, from -\$75.3 million in the first three months of 2020 to -\$131.7 million in the first three months of 2021.
- **Day-Ahead System Energy Costs.** Day-ahead system energy costs decreased by \$55.7 million or 57.8 percent, from -\$96.3 million in the first three months of 2020 to -\$152.0 million in the first three months of 2021.

⁶ 172 FERC ¶ 61,046 (2020).

- **Balancing System Energy Costs.** Balancing system energy costs decreased by \$1.7 million or 8.1 percent, from \$21.4 million in the first three months of 2020 to \$19.7 million in the first three months of 2021.
- **Monthly Total System Energy Costs.** Monthly total system energy costs in the first three months of 2021 ranged from -\$63.1 million in February to -\$30.8 million in March.

Conclusion

Congestion is defined as the total payments by load in excess of the total payments to generation, excluding marginal losses. The level and distribution of congestion reflects the underlying characteristics of the power system, including the nature and capability of transmission facilities, the offers and geographic distribution of generation facilities, the level and geographic distribution of incremental bids and offers and the geographic and temporal distribution of load.

Total congestion costs increased by \$35.9 million or 42.2 percent, from \$85.1 million in the first three months of 2020 to \$121.0 million in the first three months of 2021. The total day-ahead congestion costs and negative balancing congestion costs increased significantly compared to the first three months of 2020. This was the combined result of higher demand and higher prices, cold weather in February of 2021, CT pricing logic, and transmission facility outages in March.

The monthly total congestion costs ranged from \$29.1 million in January to \$55.2 million in March in the first three months of 2021.

The current ARR/FTR design does not serve as an efficient way to ensure that load receives the rights to all congestion revenues. The congestion offset for the first ten months of the 2020/2021 planning period was 45.8 percent. The cumulative offset of congestion by ARRs for the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period, using the rules effective for each planning period, was 74.1 percent. Load has been underpaid by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period.

Issues

Closed Loop Interfaces and CT Pricing Logic

PJM uses closed loop interfaces and CT pricing logic to force otherwise uneconomic resources to be marginal and set price in the day-ahead or real-time market solution. PJM uses CT pricing logic to create an artificial constraint with a variable flow limit, paired with an artificial override of the inflexible resource's economic minimum, to make the resource marginal in PJM's LMP security constrained pricing logic.

Through the assumption of artificial flexibility of the affected unit and artificially creating a constraint for which the otherwise inflexible resource can be marginal, PJM's use of CT pricing logic attempts to force the affected resource bus LMP to match the marginal offer of the resource. PJM does this by adjusting the constraint limit based on the output of the resource. Sometimes the constraint limit does not match the flows on the constraint, and the constraint violates instead of binding, resulting in prices set by the transmission constraint penalty factor. In the case of a closed loop interface, all buses within the interface are modeled with a distribution factor (dfax) of 1.0 to the constraint and therefore with the same constraint related congestion component of price at the marginal resource's bus. In the CT pricing logic case, the constraint affects the CLMP of downstream (constrained side) buses in proportion to their dfax to that constraint.⁷ One objective of making inflexible resources marginal is to artificially minimize the uplift costs associated with the inflexible resources that PJM commits for system security reasons.

The use of closed loop interfaces and CT pricing logic can be a source of modeling differences between the day-ahead and real-time markets. If closed loop interfaces and CT pricing logic are not included in the day-ahead market in exactly the same way as in the real-time market, including specific constraints and limits, the differences between the day-ahead and real-time market model will result in positive or negative balancing congestion.

Failure to model the same constraints in the day-ahead and real-time markets will result in pricing and congestion settlement differences between the day-

⁷ The constrained side means the higher priced side with a positive CLMP created by the constraint.

ahead and real-time market. Any modeling differences create false arbitrage opportunities for virtual bids and contribute to negative balancing congestion. PJM attempts to incorporate its real-time use of closed loop interfaces and CT pricing logic in the day-ahead market, although the matching is necessarily imperfect and with a lag.

Use of closed loop interfaces and CT price setting logic requires manipulation of the economic dispatch model. Closed loop interfaces and CT price setting logic force higher cost inflexible units to be marginal. Unlike constraints that restrict the use of lower cost resources in the system solution, the closed loop interface and CT price setting logic constraints are forcing the use of higher cost resources. The sign of the shadow price of this artificial constraint in the optimization solution, unlike normal security constraints in a least cost dispatch optimization, is therefore positive because relaxing this constraint will cause system costs to go up, not down. Increasing the limit (relaxing) for a closed loop interface or CT price setting logic constraint requires an increase in the output from the high cost unit from within the artificially constrained area, and a decrease in output from low price generation from outside the artificially constrained area. This means that increasing the limit of a closed loop interface or CT price setting logic constraint causes a net increase in incremental cost for any increase in the flow limit of the constraint and a positive, rather than the usual negative, shadow price for the modeled transmission constraint.

The nature of the closed loop interface or CT price setting logic constraint is that more power is produced in the artificial closed loop or constrained area than would result without the closed loop. This means that there are more high CLMP generation credits than high CLMP load charges associated with the constrained area within the closed loop interface or CT price setting logic constraint. The rest of the system receives power from the closed loop/constrained area, the lower cost generators outside the closed loop/constrained area are backed down and prices are lower outside the loop than they would have been without the closed loop. While all of the generation within the artificially constrained area is paid the higher CLMP in the form of generation credits, a smaller amount of load (in some cases no load) pays this higher

CLMP in the form of load charges within the loop. The residual energy is delivered and paid for at a lower CLMP outside the closed loop/constrained area. The result is that PJM pays out more to generators in the closed loop than it collects from load. The result of using closed loops and CT price setting logic is that uneconomic generation costs that would otherwise be collected as uplift are being realized as negative congestion. In the day-ahead market this reduces the total congestion dollars that are available to FTR holders. In the balancing market these costs are allocated directly to load as negative balancing rather than to deviations as uplift charges.

Balancing Congestion Cost Calculation Logic Change

Effective April 1, 2018, PJM made a significant change to the calculation and allocation of balancing congestion costs.⁸

Prior to April 1, 2018, balancing implicit CLMP charges calculated at the zonal and aggregate level were determined by bus specific deviations between day-ahead and real-time MWh priced at the bus specific congestion price in the real-time energy market.

As of April 1, 2018, at the time of the introduction of five minute settlements, PJM modified the calculation so that zonal and aggregate balancing implicit CLMP charges are determined by netting the bus specific hourly deviations across every bus in a zone or subzonal aggregate and pricing the resulting deviation in zonal or aggregate total deviations at the zonal or aggregate congestion price in the real-time energy market. As a result, the allocation of balancing implicit congestion was reduced for MW deviations associated with load and virtual bids that settle at zones and aggregates.

Another result of the change in rules was to increase negative balancing charges billed to load on a load ratio basis. While total load deviations and associated balancing charges at load aggregates were reduced by netting, the rules for determining balancing CLMP credits and charges to all other balancing MW deviations at all other bus or aggregates did not change. This means that the change in rules resulted in a decrease in total balancing

⁸ See PJM, "Manual 28: Operating Agreement Accounting," Rev. 84 (Dec.17, 2020).

implicit charges while having no effect on the calculation of total balancing implicit credits. The net result has been an increase in negative balancing congestion costs, which is the difference between balancing CLMP charges from deviations at aggregates and zones (reduced due to the rule change) and bus specific balancing CLMP credits (not affected by the rule change). This has caused an increase in total negative balancing charges.

The netting of zonal and aggregate deviations decreased the allocation of balancing charges to load deviations and increased total negative balancing congestion. Negative balancing congestion is assigned to load and exports on a load ratio share basis as the result of a FERC order.

Table 11-1 shows the total balancing implicit CLMP charges that would have resulted from applying the pre and post April 1, 2018, settlement rules for the first three months of 2017 through 2021. Table 11-1 also shows the actual total balancing implicit CLMP charges for the first three months of 2017 through 2021 based on the methods in place at the time. Table 11-1 shows that the April 1, 2018, settlement rule, if applied to the first three months of 2017 through 2021 except the first three months of 2020, would have caused negative balancing congestion costs to increase. Table 11-1 shows that the post April 1, 2018, settlement rule caused negative total balancing implicit charges to increase by \$4.6 million (7.5 percent) in the first three months of 2021.

Table 11-1 Total balancing implicit CLMP charge (Dollars (Millions)) (old method and new method): January through March, 2017 through 2021

Balancing Implicit CLMP Charges (\$ Million)										
Old Method		New Method			Method Used			Change Between New and Old		
(Jan - Mar)	Withdrawal Charges	Injection Credits	Total	Withdrawal Charges	Injection Credits	Total	Withdrawal Charges	Injection Credits	Total	
2017	(\$0.3)	\$7.5	(\$7.8)	(\$1.8)	\$7.4	(\$9.2)	(\$0.3)	\$7.5	(\$7.8)	(\$1.3)
2018	\$12.8	\$23.6	(\$10.8)	\$1.4	\$21.3	(\$19.9)	\$12.8	\$23.6	(\$10.8)	(\$9.1)
2019	(\$1.1)	\$20.1	(\$21.2)	(\$1.8)	\$20.1	(\$21.9)	(\$1.8)	\$20.1	(\$21.9)	(\$0.6)
2020	(\$0.3)	\$3.8	(\$4.1)	(\$0.2)	\$3.8	(\$4.0)	(\$0.2)	\$3.8	(\$4.0)	\$0.1
2021	(\$21.6)	\$40.3	(\$61.9)	(\$26.7)	\$39.9	(\$66.6)	(\$26.7)	\$39.9	(\$66.6)	(\$4.6)

The differences in results between the old method and the new method result from the use of zonal CLMP and zonal net deviations in place of the use of bus specific CLMPs and bus specific deviations.

When the total day-ahead factor weighted real-time bus CLMP is lower than real-time zonal CLMP, the balancing implicit CLMP charges will be lower using the new method. When the total day-ahead factor weighted real-time bus CLMP is higher than real-time zonal CLMP, the balancing implicit CLMP charges will be higher using the new method. Table 11-2 presents three cases to explain the calculation. The day-ahead load factor or real-time load factor for an aggregate equals the load at each bus divided by the total aggregate load.

Case 1 (Table 11-2) shows the case in which the total day-ahead factor weighted real-time bus CLMP (\$1.1) is less than the real-time zonal CLMP (\$1.6). The total balancing implicit CLMP charges using the new method (-\$4.2) are lower than under the old method (\$1.8).

Case 2 (Table 11-2) shows the case in which the total day-ahead factor weighted real-time bus CLMP (\$1.9) is larger than the real-time zonal CLMP (\$1.5). The total balancing implicit CLMP charges using the new method (\$2.0) are higher than under the old method (-\$1.2).

Case 3 (Table 11-2) shows that the total day-ahead factor weighted real-time bus CLMP (\$1.6) is equal to the real-time zonal CLMP (\$1.6). The total balancing implicit CLMP charges using the new method (-\$4.2) are equal under the old method (-\$4.2).

Table 11-2 Example of balancing implicit CLMP charge calculation (old method and new method)

										Balancing Implicit Withdrawal Charges	
	Real-Time CLMP	Real-Time Load	Real-Time Load Factor	Real-Time CLMP * Real-Time Load Factor	Day-Ahead Load Factor	Real-Time CLMP * Day-Ahead Load Factor	Day-Ahead Load	Balancing Load		Old Method	New Method
Case 1											
Bus A	\$1.0	4.0	0.4	\$0.4	0.9	\$0.9	10.8	(6.8)		\$6.80	
Bus B	\$2.0	6.0	0.6	\$1.2	0.1	\$0.2	1.2	4.8		\$9.60	
Zonal		10.0		\$1.6		\$1.1	12.0			\$2.8	(\$3.20)
Balancing Implicit Injection Credits										\$1.0	\$1.0
Balancing Implicit Congestion Charges										\$1.8	(\$4.2)
Case 2											
Bus A	\$1.0	5.0	0.5	\$0.5	0.1	\$0.1	0.8	4.2		\$4.20	
Bus B	\$2.0	5.0	0.5	\$1.0	0.9	\$1.8	7.2	(2.2)		(\$4.40)	
Zonal		10.0		\$1.5		\$1.9	8.0			(\$0.2)	\$3.00
Balancing Implicit Injection Credits										\$1.0	\$1.0
Balancing Implicit Congestion Charges										(\$1.2)	\$2.0
Case 3											
Bus A	\$1.0	4.0	0.4	\$0.4	0.4	\$0.4	4.8	(0.8)		(\$0.80)	
Bus B	\$2.0	6.0	0.6	\$1.2	0.6	\$1.2	7.2	(1.2)		(\$2.40)	
Zonal		10.0		\$1.6		\$1.6	12.0			(\$3.2)	(\$3.20)
Balancing Implicit Injection Credits										\$1.0	\$1.0
Balancing Implicit Congestion Charges										(\$4.2)	(\$4.2)

Locational Marginal Price (LMP)

Components

On June 1, 2007, PJM changed from a single node reference bus to a distributed load reference bus. While the use of a single node reference bus or a distributed load reference bus has no effect on the total LMP, the use of a single node reference bus or a distributed load reference bus does affect the components of LMP. With a distributed load reference bus, the energy component of LMP is a load-weighted system price. No congestion or losses are included in the load-weighted reference bus price.

LMP at a bus reflects the incremental price of energy at that bus. LMP at any bus can be disaggregated into three components: the system marginal price (SMP), marginal loss component (MLMP), and congestion component (CLMP).

SMP, MLMP and CLMP are a product of the least cost, security constrained dispatch of system resources to meet system load. SMP is the incremental cost of system energy, given the current dispatch and given the choice of reference bus. SMP is LMP net of losses and congestion. Losses refer to energy lost to physical resistance in the transmission and distribution network as power is moved from generation to load. Marginal losses are the incremental change in system power losses caused by changes in the system load and generation patterns.⁹ The first derivative of total losses with respect to the power flow is marginal losses. Congestion cost reflects the incremental cost of relieving transmission constraints while maintaining system power balance. Congestion occurs

⁹ For additional information, see the *MMU Technical Reference for PJM Markets*, at "Marginal Losses," <http://www.monitoringanalytics.com/reports/Technical_References/references.shtml>.

when available, least-cost energy cannot be delivered to all loads because transmission facilities are not adequate to deliver that energy. When the least-cost available energy cannot be delivered to load in a transmission constrained area, higher cost units in the constrained area must be dispatched to meet that load.¹⁰ The result is that the price of energy in the constrained area is higher than in the unconstrained area because of the combination of transmission limitations and the cost of local generation. Load in the constrained area pays the higher price for all energy including energy from low cost generation and energy from high cost generation. Congestion is the difference between the total cost of energy paid by load in the transmission constrained area and the total revenue received by generation to meet the load in the transmission constrained area, net of losses. Congestion equals the sum of day-ahead and balancing congestion.

Table 11-3 shows the PJM real-time, load-weighted, average LMP components for January through March, 2008 through 2021.¹¹

The real-time, load-weighted, average LMP increased \$10.99 or 55.3 percent from \$19.85 in the first three months of 2020 to \$30.84 in the first three months of 2021. The real-time, load-weighted, average congestion component was \$0.01 in the first three months of 2020 and \$0.03 in the first three months of 2021. Using a load-weighted reference bus, the real-time, load-weighted, average congestion component of LMP should be zero. PJM's load-weighted reference bus congestion component is zero at the time that LMPs are set based on state estimator data. Metering updates during the settlement process change the load weights after the fact, but the reference bus price (SMP) is not updated with these changes over time. As a result, the average congestion and loss component used in real-time settlement is not zero, although this

¹⁰ This is referred to as dispatching units out of economic merit order. Economic merit order is the order of all generator offers from lowest to highest cost. Congestion occurs when loadings on transmission facilities mean the next unit in merit order cannot be used and a higher cost unit must be used in its place.

¹¹ The PJM real-time, load-weighted price is weighted by accounting load, which differs from the state-estimated load used in determination of the energy component (SMP). In the real-time energy market, the distributed load reference bus is weighted by state-estimated load in real time. When the LMP is calculated in real time, the energy component equals the system load-weighted price. But real-time bus-specific loads are adjusted, after the fact, based on updated load information from meters. This meter adjusted load is accounting load that is used in settlements and is used to calculate reported PJM load-weighted prices. This after the fact adjustment means that the real-time energy market energy component of LMP (SMP) and the PJM real-time, load-weighted LMP are not equal. The difference between the real-time energy component of LMP and the PJM wide real-time, load-weighted, average LMP is a result of the difference between state-estimated and metered loads used to weight the load-weighted reference bus and the load-weighted LMP. Without these adjustments, the congestion component of system average LMP would be zero.

component is not fully accurate. The real-time, load-weighted, average loss component in the first three months of 2021 was \$0.02 compared to \$0.01 in the first three months of 2020. The real-time, load-weighted, average system energy component increased by \$10.96 or 55.3 percent from \$19.83 in the first three months of 2020 to \$30.79 in the first three months of 2021.

Table 11-3 Real-time, load-weighted, average LMP components (Dollars per MWh): January through March, 2008 through 2021¹²

(Jan - Mar)	Real-Time LMP	Energy Component	Congestion Component	Loss Component
2008	\$69.35	\$69.27	\$0.04	\$0.04
2009	\$49.60	\$49.51	\$0.05	\$0.04
2010	\$45.92	\$45.81	\$0.06	\$0.05
2011	\$46.35	\$46.30	\$0.03	\$0.03
2012	\$31.21	\$31.18	\$0.02	\$0.00
2013	\$37.41	\$37.37	\$0.02	\$0.02
2014	\$92.98	\$93.08	(\$0.13)	\$0.03
2015	\$50.91	\$50.89	(\$0.00)	\$0.03
2016	\$26.80	\$26.75	\$0.03	\$0.01
2017	\$30.28	\$30.25	\$0.02	\$0.02
2018	\$49.45	\$49.39	\$0.03	\$0.03
2019	\$30.16	\$30.12	\$0.02	\$0.02
2020	\$19.85	\$19.83	\$0.01	\$0.01
2021	\$30.84	\$30.79	\$0.03	\$0.02

Table 11-4 shows the PJM day-ahead, load-weighted, average LMP components for the first three months of 2008 through 2021.¹³ The day-ahead, load-weighted, average LMP increased \$11.46, or 57.0 percent, from \$20.12 in the first three months of 2020 to \$31.58 in the first three months of 2021. The day-ahead, load-weighted, average congestion component increased \$0.20 from -\$0.01 in the first three months of 2020 to \$0.19 in the first three months of 2021. The day-ahead, load-weighted, average loss component was -\$0.01 in the first three months of 2020 and \$0.05 in the first three months of 2021. The day-ahead, load-weighted, average energy component increased \$11.20,

¹² Calculated values shown in Section 11, "Congestion and Marginal Losses," are based on unrounded, underlying data and may differ from calculations based on the rounded values in the tables.

¹³ In the real-time energy market, the energy component (SMP) equals the system load-weighted price, with the caveat about state-estimated versus metered load. However, in the day-ahead energy market the day-ahead energy component of LMP (SMP) and the PJM day-ahead, load-weighted LMP are not equal. The difference between the day-ahead energy component of LMP and the PJM day-ahead, load-weighted LMP is a result of the difference in the types of load used to weight the load-weighted reference bus and the load-weighted LMP. In the day-ahead energy market, the distributed load reference bus is weighted by fixed-demand bids only and the day-ahead SMP is, therefore, a system fixed demand weighted price. The day-ahead, load-weighted LMP calculation uses all types of demand, including fixed, price-sensitive and decrement bids.

or 55.6 percent, from \$20.14 in the first three months of 2020 to \$31.34 in the first three months of 2021. Using a load-weighted reference bus, the day-ahead, load-weighted, average congestion component of LMP should be zero. PJM's load-weighted reference bus congestion component is zero based on day-ahead firm load weights. Total billing however, includes price sensitive demand and virtual load congestion related charges, which makes the total load weights in accounting different than the load weights used to determine the SMP at the load-weighted reference bus. The resulting load-weighted average price from settlement for congestion and marginal losses components of price in day ahead is therefore not zero, although this component is not fully accurate.

Table 11-4 Day-ahead, load-weighted, average LMP components (Dollars per MWh): January through March, 2008 through 2021

(Jan - Mar)	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component
2008	\$68.00	\$68.14	\$0.05	(\$0.20)
2009	\$49.44	\$49.75	(\$0.18)	(\$0.13)
2010	\$47.77	\$47.74	\$0.01	\$0.02
2011	\$47.14	\$47.36	(\$0.11)	(\$0.11)
2012	\$31.51	\$31.45	\$0.08	(\$0.03)
2013	\$37.26	\$37.19	\$0.07	\$0.01
2014	\$94.96	\$94.52	\$0.43	\$0.00
2015	\$52.02	\$51.55	\$0.48	(\$0.02)
2016	\$27.94	\$27.80	\$0.15	(\$0.00)
2017	\$30.40	\$30.39	\$0.03	(\$0.02)
2018	\$47.55	\$47.36	\$0.20	(\$0.01)
2019	\$30.76	\$30.66	\$0.11	(\$0.01)
2020	\$20.12	\$20.14	(\$0.01)	(\$0.01)
2021	\$31.58	\$31.34	\$0.19	\$0.05

Table 11-5 shows the PJM real-time, load-weighted, average LMP by constrained and unconstrained hours.

Table 11-5 Real-time, load-weighted, average LMP by constrained and unconstrained hours (Dollars per MWh): January 2020 through March 2021

	2020		2021	
	Constrained Hours	Unconstrained Hours	Constrained Hours	Unconstrained Hours
Jan	\$22.30	\$15.73	\$25.96	\$21.31
Feb	\$19.56	\$17.12	\$45.23	\$23.19
Mar	\$18.28	\$16.13	\$26.57	\$19.67
Apr	\$17.63	\$17.39		
May	\$18.81	\$12.20		
Jun	\$21.64	\$14.18		
Jul	\$28.58	\$15.77		
Aug	\$26.01	\$17.43		
Sep	\$19.94	\$12.31		
Oct	\$22.19	\$22.78		
Nov	\$20.86	\$26.31		
Dec	\$27.28	\$21.27		
Avg	\$22.29	\$17.59	\$32.09	\$22.14

Zonal Components

The real-time components of LMP for each control zone are presented in Table 11-6 for the first three months of 2020 and 2021. In the first three months of 2021, DPL had the highest real-time congestion component of all control zones, \$8.25, and JCPLC had the lowest real-time congestion component, -\$4.76.

Table 11-6 Zonal and PJM real-time, load-weighted, average LMP components (Dollars per MWh): January through March, 2020 and 2021

	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Real-Time LMP	Energy Component	Congestion Component	Loss Component	Real-Time LMP	Energy Component	Congestion Component	Loss Component
ACEC	\$19.23	\$19.84	(\$0.54)	(\$0.08)	\$27.35	\$30.82	(\$3.82)	\$0.35
AEP	\$20.23	\$19.80	\$0.30	\$0.12	\$31.07	\$30.71	\$0.46	(\$0.11)
APS	\$20.09	\$19.84	\$0.25	\$0.00	\$30.16	\$30.78	(\$0.49)	(\$0.13)
ATSI	\$20.36	\$19.78	\$0.31	\$0.27	\$28.76	\$30.60	(\$1.68)	(\$0.16)
BGE	\$21.30	\$19.91	\$0.89	\$0.50	\$35.61	\$31.01	\$3.75	\$0.86
COMED	\$18.80	\$19.73	(\$0.50)	(\$0.43)	\$29.52	\$30.71	(\$0.32)	(\$0.86)
DAY	\$21.29	\$19.86	\$0.45	\$0.98	\$32.85	\$30.90	\$0.75	\$1.19
DOM	\$20.29	\$19.87	\$0.38	\$0.04	\$33.04	\$30.93	\$1.72	\$0.39
DPL	\$19.54	\$19.91	(\$0.62)	\$0.25	\$40.22	\$31.02	\$8.25	\$0.95
DUKE	\$20.42	\$19.82	\$0.40	\$0.20	\$32.09	\$30.98	\$1.06	\$0.06
DUQ	\$20.22	\$19.77	\$0.47	(\$0.02)	\$28.54	\$30.56	(\$1.29)	(\$0.73)
EKPC	\$20.46	\$19.94	\$0.37	\$0.15	\$33.06	\$31.56	\$1.36	\$0.13
JCPLC	\$19.34	\$19.87	(\$0.49)	(\$0.04)	\$26.44	\$30.76	(\$4.76)	\$0.43
MEC	\$19.45	\$19.88	(\$0.21)	(\$0.22)	\$28.37	\$30.67	(\$2.34)	\$0.05
OVEC	\$19.64	\$19.52	\$0.37	(\$0.25)	\$29.61	\$30.19	\$0.20	(\$0.78)
PE	\$19.46	\$19.81	(\$0.16)	(\$0.19)	\$29.13	\$30.54	(\$1.01)	(\$0.40)
PECO	\$18.92	\$19.84	(\$0.67)	(\$0.26)	\$26.84	\$30.71	(\$3.88)	\$0.00
PEPCO	\$20.86	\$19.94	\$0.65	\$0.26	\$33.06	\$31.12	\$1.38	\$0.56
PPL	\$18.14	\$19.86	(\$1.35)	(\$0.38)	\$27.01	\$30.69	(\$3.38)	(\$0.30)
PSEG	\$19.34	\$19.80	(\$0.36)	(\$0.10)	\$32.43	\$30.60	\$1.47	\$0.36
REC	\$19.32	\$19.86	(\$0.44)	(\$0.10)	\$38.14	\$30.48	\$7.36	\$0.30
PJM	\$19.85	\$19.83	\$0.01	\$0.01	\$30.84	\$30.79	\$0.03	\$0.02

The day-ahead components of LMP for each control zone are presented in Table 11-7 for the first three months of 2020 and 2021. In the first three months of 2021, DPL had the highest day-ahead congestion component of all control zones, \$3.85, and JCPLC had the lowest day-ahead congestion component, -\$3.34.

Table 11-7 Zonal and PJM day-ahead, load-weighted, average LMP components (Dollars per MWh): January through March, 2020 and 2021

	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component
ACEC	\$18.95	\$20.11	(\$1.03)	(\$0.13)	\$28.36	\$31.05	(\$2.99)	\$0.31
AEP	\$20.56	\$20.09	\$0.37	\$0.10	\$31.72	\$31.36	\$0.44	(\$0.09)
APS	\$20.45	\$20.17	\$0.29	(\$0.01)	\$31.17	\$31.23	\$0.06	(\$0.12)
ATSI	\$20.81	\$20.11	\$0.34	\$0.36	\$30.99	\$31.04	(\$0.09)	\$0.04
BGE	\$22.18	\$20.27	\$1.51	\$0.40	\$35.61	\$31.27	\$3.47	\$0.88
COMED	\$19.10	\$20.02	(\$0.57)	(\$0.36)	\$29.99	\$31.33	(\$0.58)	(\$0.76)
DAY	\$21.67	\$20.16	\$0.60	\$0.90	\$34.00	\$31.54	\$0.98	\$1.49
DOM	\$20.73	\$20.19	\$0.59	(\$0.04)	\$33.03	\$31.31	\$1.43	\$0.29
DPL	\$19.40	\$20.26	(\$1.00)	\$0.15	\$36.10	\$31.17	\$3.85	\$1.09
DUKE	\$20.83	\$20.13	\$0.58	\$0.13	\$32.92	\$31.44	\$1.34	\$0.15
DUQ	\$20.73	\$20.11	\$0.58	\$0.04	\$30.09	\$30.93	(\$0.14)	(\$0.70)
EKPC	\$20.87	\$20.35	\$0.53	(\$0.02)	\$33.21	\$32.44	\$0.91	(\$0.14)
JCPLC	\$19.12	\$20.22	(\$1.04)	(\$0.06)	\$28.09	\$31.01	(\$3.34)	\$0.42
MEC	\$19.41	\$20.18	(\$0.48)	(\$0.29)	\$29.59	\$30.96	(\$1.35)	(\$0.03)
OVEC	\$20.40	\$20.14	\$0.56	(\$0.30)	\$32.03	\$32.94	(\$0.08)	(\$0.83)
PE	\$20.00	\$20.24	(\$0.26)	\$0.02	\$30.96	\$31.38	(\$0.33)	(\$0.09)
PECO	\$18.57	\$20.15	(\$1.27)	(\$0.31)	\$27.87	\$30.97	(\$3.05)	(\$0.05)
PEPCO	\$21.57	\$20.30	\$1.04	\$0.23	\$33.88	\$31.47	\$1.80	\$0.61
PPL	\$18.23	\$20.17	(\$1.47)	(\$0.47)	\$28.23	\$30.88	(\$2.22)	(\$0.43)
PSEG	\$19.12	\$20.12	(\$0.89)	(\$0.11)	\$30.82	\$30.91	(\$0.53)	\$0.45
REC	\$19.52	\$20.24	(\$0.62)	(\$0.10)	\$35.57	\$31.74	\$3.31	\$0.53
PJM	\$20.12	\$20.14	(\$0.01)	(\$0.01)	\$31.58	\$31.34	\$0.19	\$0.05

Hub Components

The real-time components of LMP for each hub are presented in Table 11-8 for the first three months of 2020 and 2021.¹⁴

Table 11-8 Hub real-time, average LMP components (Dollars per MWh): January through March, 2020 and 2021

	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Real-Time LMP	Energy Component	Congestion Component	Loss Component	Real-Time LMP	Energy Component	Congestion Component	Loss Component
AEP Gen Hub	\$19.39	\$19.39	\$0.33	(\$0.33)	\$27.86	\$29.73	(\$0.89)	(\$0.98)
AEP-DAY Hub	\$19.77	\$19.39	\$0.27	\$0.11	\$29.83	\$29.73	\$0.32	(\$0.22)
ATSI Gen Hub	\$19.70	\$19.39	\$0.29	\$0.01	\$27.73	\$29.73	(\$1.39)	(\$0.61)
Chicago Gen Hub	\$18.13	\$19.39	(\$0.61)	(\$0.65)	\$27.74	\$29.73	(\$0.78)	(\$1.21)
Chicago Hub	\$18.47	\$19.39	(\$0.54)	(\$0.38)	\$28.37	\$29.73	(\$0.52)	(\$0.84)
Dominion Hub	\$19.52	\$19.39	\$0.27	(\$0.14)	\$31.68	\$29.73	\$1.82	\$0.13
Eastern Hub	\$18.98	\$19.39	(\$0.60)	\$0.19	\$37.95	\$29.73	\$7.44	\$0.78
N Illinois Hub	\$18.38	\$19.39	(\$0.53)	(\$0.48)	\$28.24	\$29.73	(\$0.51)	(\$0.98)
New Jersey Hub	\$18.84	\$19.39	(\$0.45)	(\$0.10)	\$28.56	\$29.73	(\$1.50)	\$0.32
Ohio Hub	\$19.78	\$19.39	\$0.25	\$0.14	\$30.03	\$29.73	\$0.47	(\$0.17)
West Interface Hub	\$19.61	\$19.39	\$0.35	(\$0.14)	\$28.90	\$29.73	(\$0.32)	(\$0.51)
Western Hub	\$19.72	\$19.39	\$0.46	(\$0.14)	\$29.83	\$29.73	\$0.35	(\$0.25)

The day-ahead components of LMP for each hub are presented in Table 11-9 for the first three months of 2020 and 2021.

Table 11-9 Hub day-ahead, average LMP components (Dollars per MWh): January through March, 2020 and 2021

	2020 (Jan - Mar)				2021 (Jan - Mar)			
	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component
AEP Gen Hub	\$19.72	\$19.69	\$0.36	(\$0.33)	\$29.13	\$30.07	\$0.01	(\$0.94)
AEP-DAY Hub	\$20.14	\$19.69	\$0.36	\$0.09	\$30.33	\$30.07	\$0.40	(\$0.13)
ATSI Gen Hub	\$20.15	\$19.69	\$0.37	\$0.09	\$29.60	\$30.07	(\$0.07)	(\$0.39)
Chicago Gen Hub	\$18.40	\$19.69	(\$0.72)	(\$0.57)	\$28.03	\$30.07	(\$0.92)	(\$1.11)
Chicago Hub	\$18.81	\$19.69	(\$0.59)	(\$0.29)	\$28.70	\$30.07	(\$0.66)	(\$0.71)
Dominion Hub	\$19.90	\$19.69	\$0.43	(\$0.21)	\$31.36	\$30.07	\$1.27	\$0.02
Eastern Hub	\$18.82	\$19.69	(\$0.98)	\$0.12	\$34.03	\$30.07	\$3.04	\$0.93
N Illinois Hub	\$18.68	\$19.69	(\$0.59)	(\$0.42)	\$28.47	\$30.07	(\$0.70)	(\$0.89)
New Jersey Hub	\$18.62	\$19.69	(\$0.95)	(\$0.12)	\$28.59	\$30.07	(\$1.84)	\$0.36
Ohio Hub	\$20.16	\$19.69	\$0.36	\$0.11	\$30.39	\$30.07	\$0.41	(\$0.08)
West Interface Hub	\$20.01	\$19.69	\$0.43	(\$0.10)	\$30.06	\$30.07	\$0.42	(\$0.42)
Western Hub	\$20.19	\$19.69	\$0.55	(\$0.05)	\$30.60	\$30.07	\$0.64	(\$0.11)

¹⁴ The real-time components of LMP are the simple average of the hourly components for each hub. Some hubs include only generation buses and do not include load buses. The real-time components of LMP were previously reported as the real-time, load-weighted, average of the hourly components of LMP.

Congestion

Congestion Accounting

In PJM accounting, total congestion costs equal net implicit CLMP charges, plus net explicit CLMP charges, plus net inadvertent CLMP charges. Implicit CLMP charges equal implicit withdrawal charges less implicit injection credits. Explicit CLMP charges are the net CLMP charges associated with the injection credits and withdrawal charges for point to point energy transactions. Inadvertent CLMP charges are not directly attributable to specific participants that are distributed on a load ratio basis. Each of these categories of congestion costs is comprised of day-ahead and balancing congestion costs.

While PJM accounting focuses on CLMPS, the individual CLMP values at any bus are irrelevant to the calculation of congestion, as CLMPs are just an artificial deconstruction of LMP based on a selected reference bus. Holding aside the marginal loss component of LMP, differences in the LMPs are caused by binding constraints in the least cost security constrained dispatch market solution and total congestion is the net surplus revenue that remains after all sources and sinks are credited or charged their LMPs. Changing the components of LMP by electing a different reference bus does not change the LMPs or the difference between LMPs for a given market solution or actual congestion, it merely changes the components of the LMP.

Congestion occurs in the day-ahead and real-time energy markets.¹⁵ Day-ahead congestion costs are based on day-ahead MWh while balancing congestion costs are based on deviations between day-ahead and real-time MWh priced at the congestion price in the real-time energy market.

Implicit CLMP charges are the CLMP charges calculated for energy injected or withdrawn at a location. The explicit CLMP charges are the CLMP charges calculated for transactions with a defined source and a sink. For example, implicit CLMP charges are calculated for network load and explicit CLMP charges are calculated for up to congestion transactions (UTCs). Inadvertent CLMP charges are CLMP charges resulting from the differences between the

¹⁵ When the term *congestion charge* is used in documents by PJM's Market Settlement Operations, it has the same meaning as the term *congestion costs* as used here.

net actual energy flow and the net scheduled energy flow into or out of the PJM control area each hour.

CLMP charges and CLMP credits are calculated for both the day-ahead and balancing energy markets.

- **Day-Ahead Implicit Load CLMP Charges.** Day-ahead implicit withdrawal charges are calculated for all cleared demand, decrement bids and day-ahead energy market sale transactions. Day-ahead implicit withdrawal charges are calculated using MW and the load bus CLMP, the decrement bid CLMP or the CLMP at the source of the sale transaction.
- **Day-Ahead Implicit Generation CLMP Credits.** Day-ahead implicit injection credits are calculated for all cleared generation, increment offers and day-ahead energy market purchase transactions.¹⁶ Day-ahead implicit injection credits are calculated using MW and the generator bus CLMP, the increment offer's CLMP or the CLMP at the sink of the purchase transaction.
- **Balancing Implicit Load CLMP Charges.** Balancing implicit withdrawal charges are calculated for all deviations between a PJM member's real-time load and energy sale transactions and their day-ahead cleared demand, decrement bids and energy sale transactions. Balancing implicit withdrawal charges are calculated using MW deviations and the real-time CLMP for each aggregate where a deviation exists.
- **Balancing Implicit Generation CLMP Credits.** Balancing implicit injection credits are calculated for all deviations between a PJM member's real-time generation and energy purchase transactions and the day-ahead cleared generation, increment offers and energy purchase transactions. Balancing implicit injection credits are calculated using MW deviations and the real-time CLMP for each aggregate where a deviation exists.

¹⁶ Internal bilateral transactions are included in the tariff definitions of Market Participant Energy Injections and Market Participant Energy Withdrawals. The purchase part of an internal bilateral transaction is an injection to the buyer and the sale part of an internal bilateral transaction is a withdrawal to the seller. The tariff (Attachment K) also says market participants will be charged implicit CLMP charges for all Market Participant Energy Withdrawals and will be credited implicit CLMP credits for all Market Participant Energy Injections. The seller of an internal bilateral transaction will be charged implicit CLMP charges at the source and the buyer of an internal bilateral transaction will be credited implicit CLMP credits at the sink. Internal bilateral transaction CLMP credits and charges sum to zero, as the IBT is merely a transfer of ownership injection and withdrawal MW and associated charges and credits between participants, meaning that the sum of all MW and all credits and all charges with and without IBTs are the same.

- **Explicit CLMP Charges.** Explicit CLMP charges are the net CLMP costs associated with point to point energy transactions. Day-ahead explicit CLMP charges equal the product of the transacted MW and CLMP differences between sources (origins) and sinks (destinations) in the day-ahead energy market. Balancing explicit CLMP charges equal the product of the deviations between the real-time and day-ahead transacted MW and the differences between the real-time CLMP at the transactions' sources and sinks. Explicit CLMP charges are calculated for internal purchase, import and export transaction, and up to congestion transactions (UTCs.)
- **Inadvertent CLMP Charges.** Inadvertent CLMP charges are charges resulting from the differences between the net actual energy flow and the net scheduled energy flow into or out of the PJM control area each hour. This inadvertent interchange of energy may be positive or negative, where positive interchange typically results in a charge while negative interchange typically results in a credit. Inadvertent CLMP charges are common costs, not directly attributable to specific participants that are distributed on a load ratio basis.¹⁷

The congestion accounting calculation equations are in Table 11-10.

Table 11-10 Congestion accounting calculations

Congestion Category	Calculation
Day-Ahead Implicit Withdrawal CLMP Charges	Day-Ahead Demand MWh * Day-Ahead CLMP
Day-Ahead Implicit Injection CLMP Credits	Day-Ahead Supply MWh * Day-Ahead CLMP
Day-Ahead Explicit CLMP Charges	Day-Ahead Transaction MW * (Day-Ahead Sink CLMP - Day-Ahead Source CLMP)
Day-Ahead Total Congestion Costs	Day-Ahead Implicit Withdrawal CLMP Charges - Day-Ahead Implicit Injection CLMP Credits + Day-Ahead Explicit CLMP Charges
Balancing Implicit Withdrawal CLMP Charges	Balancing Demand MWh * Real-Time CLMP
Balancing Implicit Injection CLMP Credits	Balancing Supply MWh * Real-Time CLMP
Balancing Explicit CLMP Costs	Balancing Transaction MW * (Real-Time Sink CLMP - Real-Time Source CLMP)
Balancing Total Congestion Costs	Balancing Implicit Withdrawal CLMP Charges - Balancing Implicit Injection CLMP Credits + Balancing Explicit CLMP Costs
Total Congestion Costs	Day-Ahead Total Congestion Costs + Balancing Total Congestion Costs

MWh Category	Definition
Day-Ahead Demand MWh	Cleared Demand, Decrement Bids, Energy Sale Transactions
Day-Ahead Supply MWh	Cleared Generation, Increment Bids, Energy Purchase Transactions
Real-Time Demand MWh	Load and Energy Sale Transactions
Real-Time Supply MWh	Generation and Energy Purchase Transactions
Balancing Demand MWh	Real-Time Demand MWh - Day-Ahead Demand MWh
Balancing Supply MWh	Real-Time Supply MWh - Day-Ahead Supply MWh

¹⁷ PJM Operating Agreement Schedule 1 §3.7.

PJM billing items include Day-Ahead Transmission Congestion Charges, Day-Ahead Transmission Congestion Credits, Balancing Transmission Congestion Charges, and Balancing Transmission Congestion Credits. Those line items are calculated for each PJM member. The congestion bill shows the CLMP charges or credits collected from the PJM market participants. However, the sum of an individual customer's CLMP credits or charges on the customer's bill is not a measure of the congestion paid by that customer.

The congestion paid by a customer is the difference between what the customer paid for energy and what all network sources of that energy were paid to serve that customer. A load customer's congestion bill, in contrast, merely indicates whether the LMP they paid for their withdrawals is higher or lower than the system energy price due to transmission constraints. The customer's bill is correct, but the bill does not measure congestion paid by the customer, only how much the customer was charged and credited for their MW positions. The congestion costs associated with specific constraints are the sum of the total day-ahead and balancing congestion costs associated with those constraints. Zonal congestion is calculated on a constraint by constraint basis. The congestion calculations are the total difference between

what the zonal load pays in CLMP charges and what the generation that serves that load is paid, regardless of whether the zone is a net importer or a net exporter of generation. Congestion costs can be both positive and negative and CLMP charges and CLMP credits can be both positive and negative. CLMP charges, positive or negative, are paid by withdrawals and CLMP credits, positive or negative, are paid to injections. Total congestion costs (the sum of charges and credits), when positive, measure the net congestion payment by a participant group and when negative, measure the net congestion credit paid to a participant group. Explicit CLMP charges, when positive, measure the congestion payment to a PJM member and when negative, measure the congestion credit paid to a PJM member. Explicit CLMP charges are calculated for up to congestion transactions (UTCs).

The congestion accounting definitions can be misleading. Load pays congestion. Congestion is the difference between what load pays for energy and what generation is paid for energy due to binding transmission constraints. Generation does not pay congestion. Some generation receives a price lower than SMP and some generation receives a price greater than SMP but that does not mean that generation is paying congestion. It means only that generation is being paid an LMP that is higher or lower than the system load-weighted average LMP.

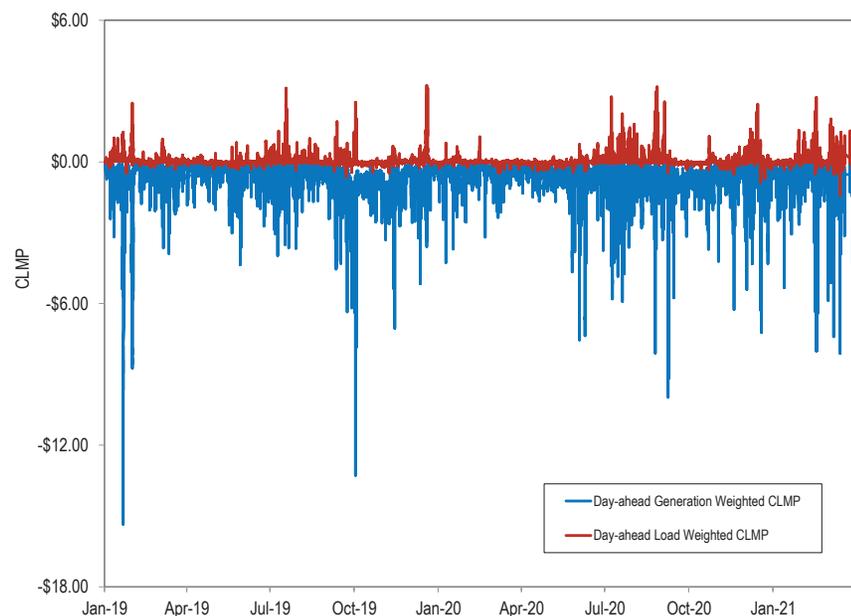
The CLMP is calculated with respect to the LMP at the system reference bus, also called the system marginal price (SMP). When a transmission constraint occurs, the resulting CLMP is positive on one side of the constraint and negative on the other side of the constraint and the corresponding congestion costs are positive or negative. For each transmission constraint, the CLMP reflects the cost of a constraint at a pricing node and is equal to the product of the constraint shadow price and the distribution factor from the constraint to the pricing node. The total CLMP at a pricing node is the sum of all constraint contributions to LMP and is equal to the difference between the actual LMP that results from transmission constraints, excluding losses, and the SMP. If an area experiences lower prices because of a constraint, the CLMP in that area is negative.¹⁸

¹⁸ For an example of the congestion accounting methods used in this section, see *MMU Technical Reference for PJM Markets*, at "FTRs and ARRs," <http://www.monitoringanalytics.com/reports/Technical_References/docs/2010-som-pjm-technical-reference.pdf>.

Load-weighted LMP components are calculated relative to a load-weighted, average LMP. At the load-weighted reference bus, which represents the load center of the system, the LMP includes no congestion or loss components, by definition. The load weighted, average CLMP across all load buses, calculated relative to that reference bus, is equal to, or very close to, zero, with non-zero results caused by state estimator error and after the fact meter updates. The sum of load related CLMP charges is logically zero and the small reported differences are the result of accounting issues. A positive CLMP at a load bus indicates that the load at that bus has a total energy price higher than the average LMP, due to transmission constraints. A negative CLMP at a load bus indicates that the load at that bus has a total energy price lower than the average LMP, due to transmission constraints. The LMPs at the load buses are a function of marginal generation bus LMPs determined through the least cost security constrained economic dispatch which accounts for transmission constraints and marginal losses. Due to transmission constraints, the average generation weighted CLMP for generation resources is lower than the LMP at the load-weighted reference bus price. Calculated relative to the load reference bus which has a CLMP of zero, this means that the average of the generation bus CLMPs is negative. This means that total generation CLMP credits are negative.

Figure 11-1 shows the weighted average CLMPs of generation and load in the day-ahead market. Figure 11-1 shows that in January 2019 through March 2021, day-ahead generation weighted CLMPs were generally negative and day-ahead, load weighted CLMPs were generally positive, indicating that load was charged a higher weighted average LMP for energy as a result of transmission constraints than the weighted average LMP generation was paid to provide that energy. This means that total CLMP load payments are higher than total CLMP generation credits. The difference in load payments and generation credits (load charges minus generation credits) is congestion (Table 11-13 and Table 11-14). This result is a product of the least cost, security constrained dispatch and the use of a load-weighted reference bus that is used for the determination of the components of LMP. More generally, in a least cost, security constrained market solution the weighted average LMP at load buses is higher than the weighted average price at generation buses.

Figure 11-1 Day-ahead generation weighted CLMPs and day-ahead load-weighted CLMPs: January 2019 through March 2021



Total Congestion

Total congestion costs in PJM in the first three months of 2021 were \$121.0 million, comprised of implicit withdrawal charges of \$55.6 million, explicit charges of -\$18.2 million and implicit injection credits of -\$83.6 million. Total congestion is the difference between what load pays for energy and what generation is paid for energy, due to binding transmission constraints.

Table 11-11 shows total congestion for the first three months of 2008 through 2021. Total congestion costs in Table 11-11 include congestion associated with PJM facilities and those associated with reciprocal, coordinated flowgates in MISO and in NYISO.^{19 20}

¹⁹ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, LLC," (December 11, 2008) Section 6.1, Effective Date: May 30, 2016. <<http://www.pjm.com/documents/agreements.aspx>>.

²⁰ See "NYISO Tariffs New York Independent System Operator, Inc.," (June 21, 2017) 35.12.1, Effective Date: May 1, 2017. <<http://www.pjm.com/documents/agreements.aspx>>.

Table 11-11 Total congestion costs (Dollars (Millions)): January through March, 2008 through 2021

(Jan - Mar)	Congestion Costs (Millions)			Percent of PJM	
	Congestion Cost	Percent Change	Total PJM Billing	Billing	
2008	\$486	NA	\$7,718	6.3%	
2009	\$307	(36.8%)	\$7,515	4.1%	
2010	\$345	12.4%	\$8,415	4.1%	
2011	\$360	4.3%	\$9,584	3.8%	
2012	\$122	(66.0%)	\$6,938	1.8%	
2013	\$186	51.9%	\$7,762	2.4%	
2014	\$1,236	564.8%	\$21,070	5.9%	
2015	\$632	(48.9%)	\$14,040	4.5%	
2016	\$292	(53.7%)	\$9,500	3.1%	
2017	\$158	(45.9%)	\$9,710	1.6%	
2018	\$661	318.4%	\$14,520	4.6%	
2019	\$164	(75.2%)	\$10,980	1.5%	
2020	\$85	(48.1%)	\$8,110	1.0%	
2021	\$121	42.2%	\$10,400	1.2%	

CLMP charges and credits are not congestion. CLMP charges and credits reflect marginal energy price differences caused by binding system constraints. Congestion is the sum of all congestion related charges and credits. In a two settlement system all virtual bids have net zero MW after their day-ahead and balancing positions are cleared, which means that virtual bids are fully settled in terms of CLMP credits and charges at the close of the market for any particular day, with either a net loss or profit due to differences between day-ahead and real-time prices. Net payouts (negative credits) to virtual bids appear as negative adjustments to either day-ahead or balancing congestion and net charges to virtual bids appear as positive adjustments to either day-ahead or balancing congestion.

Table 11-12 shows total congestion by day-ahead and balancing component for the first three months of 2008 through 2021.

Table 11-12 Total CLMP credits and charges by accounting category (Dollars (Millions)): January through March, 2008 through 2021

(Jan - Mar)	CLMP Credits and Charges (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Congestion Costs
2008	\$332.4	(\$220.0)	\$39.9	\$592.3	(\$46.0)	\$29.5	(\$31.2)	(\$106.7)	\$0.0	\$485.6
2009	\$120.2	(\$221.3)	\$47.9	\$389.5	(\$14.2)	(\$6.0)	(\$74.4)	(\$82.6)	(\$0.0)	\$306.9
2010	\$85.9	(\$293.1)	\$12.9	\$391.9	(\$5.7)	\$12.1	(\$29.1)	(\$47.0)	(\$0.0)	\$344.9
2011	\$176.5	(\$226.7)	\$4.1	\$407.3	\$21.6	\$27.8	(\$41.2)	(\$47.4)	\$0.0	\$359.9
2012	\$21.9	(\$131.4)	\$27.5	\$180.9	(\$5.1)	\$11.3	(\$42.0)	(\$58.4)	\$0.0	\$122.4
2013	\$85.0	(\$199.1)	\$47.8	\$331.9	(\$6.6)	\$73.3	(\$66.0)	(\$145.9)	\$0.0	\$185.9
2014	\$333.7	(\$1,193.9)	(\$94.3)	\$1,433.3	\$73.0	\$208.9	(\$61.3)	(\$197.2)	\$0.0	\$1,236.1
2015	\$327.0	(\$457.9)	(\$11.0)	\$773.9	\$5.4	\$69.6	(\$78.0)	(\$142.2)	(\$0.0)	\$631.7
2016	\$120.2	(\$193.5)	\$9.2	\$322.9	(\$1.1)	\$11.9	(\$17.7)	(\$30.8)	\$0.0	\$292.2
2017	\$24.2	(\$137.7)	\$3.0	\$164.9	(\$0.3)	\$7.5	\$0.9	(\$6.9)	(\$0.0)	\$158.0
2018	\$130.9	(\$557.5)	(\$46.7)	\$641.7	\$12.8	\$23.6	\$30.1	\$19.3	\$0.0	\$661.0
2019	\$53.3	(\$137.7)	\$11.2	\$202.2	(\$1.8)	\$20.1	(\$16.4)	(\$38.3)	\$0.0	\$163.9
2020	\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	(\$0.0)	\$85.1
2021	\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$0.0	\$121.0

Charges and Credits versus Congestion: Virtual Transactions, Load and Generation

In PJM's two settlement system, there is a day-ahead market and a real-time, balancing market, that make up a market day.

In a two settlement system all virtual bids have net zero MW after their day-ahead and balancing positions are cleared, which means that virtual bids are fully settled in terms of CLMP credits and charges at the close of each market day, with either a net loss or profit due to differences between day-ahead and real-time prices. Net payouts (negative credits) to virtual bids appear as negative adjustments to either day-ahead or balancing congestion and net charges to virtual bids appear as positive adjustments to either day-ahead or balancing congestion.

Unlike virtual bids, physical load and generation have net MW at the close of a market day's day-ahead and balancing settlement.

Generation does not pay congestion. Some generation receives a price lower than SMP and some generation receives a price greater than SMP but that does not mean that generation is paying congestion. It means that generation is being paid an LMP that is higher or lower than the system load-weighted, average LMP.

The residual difference between total load charges (day-ahead and balancing) and generation credits (day-ahead and balancing) after virtual bids have settled their day-ahead and balancing positions is congestion. That is, congestion is the difference between what withdrawals (load) are paying for energy and what injections (generation) are being paid for energy due to binding transmission constraints, after virtual bids are settled at the end of the market day. Load is the source of the net surplus after generation is paid and virtuals are settled at the end of the market day. Load pays congestion.

Table 11-13 and Table 11-14 show the total CLMP charges and credits for each transaction type in the first three months of 2021 and 2020. Table 11-13 shows that in the first three months of 2021 DECs paid \$21.5 million in CLMP charges in the day-ahead market, were paid \$40.4 million in CLMP credits in the balancing energy market, resulting in a net payment of \$18.9 million in total CLMP credits. In the first three months of 2021, INCs paid \$5.1 million in CLMP charges in the day-ahead market, were paid \$12.3 million in CLMP credits in the balancing energy market resulting in a net payment of \$7.2 million in total CLMP credits. In the first three months of 2021, up to congestion (UTCs) paid \$16.8 million in CLMP charges in the day-ahead market, were paid \$36.9 million in CLMP credits in the balancing market resulting in a total payment of \$20.1 million in total CLMP credits.

Table 11-13 Total CLMP credits and charges by transaction type (Dollars (Millions)): January through March, 2021

Transaction Type	CLMP Credits and Charges (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Grand Total
DEC	\$21.5	\$0.0	\$0.0	\$21.5	(\$40.4)	\$0.0	\$0.0	(\$40.4)	\$0.0	(\$18.9)
Demand	\$16.4	\$0.0	\$0.0	\$16.4	\$3.1	\$0.0	\$0.0	\$3.1	\$0.0	\$19.5
Demand Response	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0
Explicit Congestion Only	\$0.0	\$0.0	\$1.3	\$1.3	\$0.0	\$0.0	(\$0.1)	(\$0.1)	\$0.0	\$1.2
Explicit Congestion and Loss Only	\$0.0	\$0.0	(\$0.2)	(\$0.2)	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	(\$0.2)
Export	\$4.1	\$0.0	(\$0.1)	\$4.0	\$10.3	\$0.0	\$0.1	\$10.4	\$0.0	\$14.5
Generation	\$0.0	(\$159.4)	\$0.0	\$159.4	\$0.0	\$21.7	\$0.0	(\$21.7)	\$0.0	\$137.7
Import	\$0.0	(\$0.1)	\$0.0	\$0.1	\$0.0	\$5.6	\$0.0	(\$5.6)	\$0.0	(\$5.5)
INC	\$0.0	(\$5.1)	\$0.0	\$5.1	\$0.0	\$12.3	\$0.0	(\$12.3)	\$0.0	(\$7.2)
Internal Bilateral	\$40.2	\$41.0	\$0.8	\$0.0	(\$0.4)	(\$0.4)	\$0.0	\$0.0	\$0.0	\$0.0
Up to Congestion	\$0.0	\$0.0	\$16.8	\$16.8	\$0.0	\$0.0	(\$36.9)	(\$36.9)	\$0.0	(\$20.1)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.8	\$0.1	(\$0.6)	\$0.0	(\$0.6)
Wheel Out	\$0.0	\$0.0	\$0.0	\$0.0	\$0.8	\$0.0	\$0.0	\$0.8	\$0.0	\$0.8
Total	\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$0.0	\$121.0

Table 11-14 Total CLMP credits and charges by transaction type (Dollars (Millions)): January through March, 2020

Transaction Type	CLMP Credits and Charges (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Grand Total
DEC	(\$0.4)	\$0.0	\$0.0	(\$0.4)	(\$0.9)	\$0.0	\$0.0	(\$0.9)	\$0.0	(\$1.4)
Demand	(\$1.7)	\$0.0	\$0.0	(\$1.7)	\$1.4	\$0.0	\$0.0	\$1.4	\$0.0	(\$0.3)
Demand Response	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)
Explicit Congestion Only	\$0.0	\$0.0	\$0.7	\$0.7	\$0.0	\$0.0	(\$0.3)	(\$0.3)	\$0.0	\$0.4
Explicit Congestion and Loss Only	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	\$0.0
Export	(\$6.0)	\$0.0	(\$0.0)	(\$6.0)	(\$0.5)	\$0.0	\$0.3	(\$0.1)	\$0.0	(\$6.2)
Generation	\$0.0	(\$93.5)	\$0.0	\$93.5	\$0.0	(\$0.9)	\$0.0	\$0.9	\$0.0	\$94.4
Import	\$0.0	(\$0.1)	\$0.0	\$0.1	\$0.0	\$0.1	(\$0.0)	(\$0.1)	\$0.0	(\$0.0)
INC	\$0.0	(\$4.0)	\$0.0	\$4.0	\$0.0	\$4.8	\$0.0	(\$4.8)	\$0.0	(\$0.8)
Internal Bilateral	\$21.6	\$21.8	\$0.2	(\$0.0)	(\$0.3)	(\$0.3)	\$0.0	(\$0.0)	\$0.0	(\$0.0)
Up to Congestion	\$0.0	\$0.0	\$13.3	\$13.3	\$0.0	\$0.0	(\$14.2)	(\$14.2)	\$0.0	(\$1.0)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.1	\$0.0	(\$0.1)	\$0.0	(\$0.1)
Wheel Out	\$0.0	\$0.0	\$0.0	\$0.0	\$0.1	\$0.0	\$0.0	\$0.1	\$0.0	\$0.1
Total	\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	\$0.0	\$85.1

Table 11-15 shows the change in total CLMP credits and charges incurred by transaction type from the first three months of 2020 to the first three months of 2021. Total negative CLMP credits incurred by generation increased by \$43.3 million, and total CLMP charges incurred by demand increased by \$19.8 million. The total CLMP credits to up to congestion transactions (UTCs) increased from \$1.0 million in the first three months of 2020 to \$20.1 million in the first three months of 2021. Total day-ahead CLMP charges to UTCs increased by \$3.6 million from \$13.3 million in the first three months of 2020 to \$16.8 million in the first three months of 2021. Over the same period balancing CLMP credits to UTCs increased by \$22.7 million, from \$14.2 million in the first three months of 2020 to \$36.9 million in the first three months of 2021.

take the form of negative balancing CLMP charges being allocated to UTC positions. In the first three months of 2021, 100.2 percent (-\$36.9 million out of -\$36.9 million) of negative balancing explicit CLMP charges was incurred by UTCs and -0.2 percent (\$0.1 out of -\$36.9 million) was incurred by Explicit Congestion Only, Export, Import and Wheel In transactions (Table 11-13). The vertical line at February 22, 2018, marks the date on which the FERC order that limited UTC trading to hubs, residual metered load, and interfaces was effective.²¹ The vertical line at November 1, 2020, marks the date on which the FERC order that required PJM to allocate uplift to up to congestion transactions was effective.²²

Table 11-15 Change in total CLMP credits and charges by transaction type (Dollars (Millions)): January through March, 2020 to 2021

Transaction Type	Change in CLMP Credits and Charges (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Grand Total
DEC	\$22.0	\$0.0	\$0.0	\$22.0	(\$39.5)	\$0.0	\$0.0	(\$39.5)	\$0.0	(\$17.5)
Demand	\$18.1	\$0.0	\$0.0	\$18.1	\$1.7	\$0.0	\$0.0	\$1.7	\$0.0	\$19.8
Demand Response	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0
Explicit Congestion Only	\$0.0	\$0.0	\$0.6	\$0.6	\$0.0	\$0.0	\$0.2	\$0.2	\$0.0	\$0.8
Explicit Congestion and Loss Only	\$0.0	\$0.0	(\$0.2)	(\$0.2)	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	(\$0.2)
Export	\$10.2	\$0.0	(\$0.1)	\$10.1	\$10.8	\$0.0	(\$0.3)	\$10.6	\$0.0	\$20.6
Generation	\$0.0	(\$65.9)	\$0.0	\$65.9	\$0.0	\$22.6	\$0.0	(\$22.6)	\$0.0	\$43.3
Import	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.0	\$5.5	\$0.0	(\$5.5)	\$0.0	(\$5.5)
INC	\$0.0	(\$1.1)	\$0.0	\$1.1	\$0.0	\$7.5	\$0.0	(\$7.5)	\$0.0	(\$6.4)
Internal Bilateral	\$18.6	\$19.2	\$0.6	\$0.0	(\$0.2)	(\$0.2)	\$0.0	\$0.0	\$0.0	\$0.0
Up to Congestion	\$0.0	\$0.0	\$3.6	\$3.6	\$0.0	\$0.0	(\$22.7)	(\$22.7)	\$0.0	(\$19.1)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.6	\$0.1	(\$0.5)	\$0.0	(\$0.5)
Wheel Out	\$0.0	\$0.0	\$0.0	\$0.0	\$0.6	\$0.0	\$0.0	\$0.6	\$0.0	\$0.6
Total	\$68.8	(\$47.8)	\$4.5	\$121.1	(\$26.5)	\$36.1	(\$22.7)	(\$85.2)	\$0.0	\$35.9

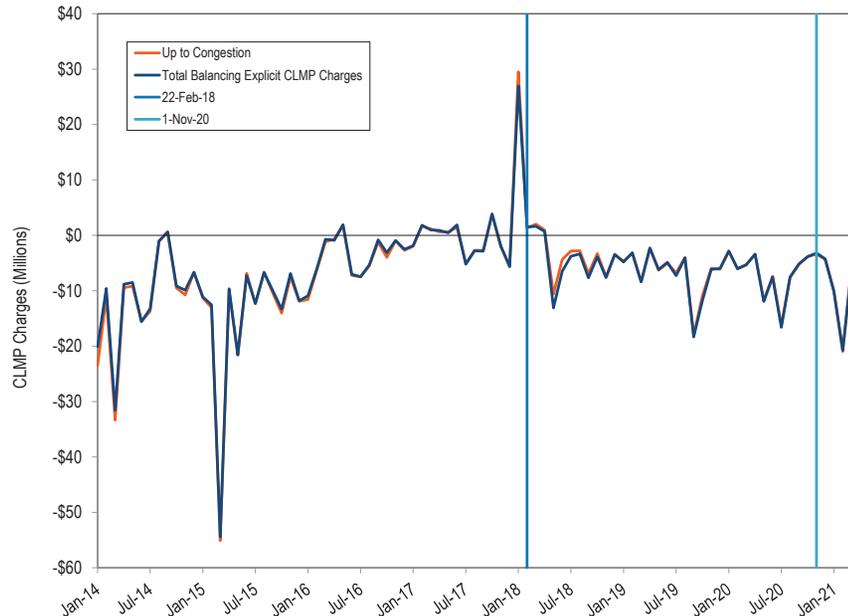
UTCs and Negative Balancing Explicit CLMP Charges

Figure 11-2 shows the change in up to congestion balancing explicit CLMP charges from January 2014 through March 2021. Figure 11-2 shows that UTCs account for almost all balancing explicit CLMP charges in PJM. As shown in Figure 11-2, UTCs are generally paid balancing CLMP credits, which

²¹ For additional information about the FERC order, see the *2020 State of the Market Report for PJM*, Appendix F: Congestion and Marginal Losses.

²² 172 FERC ¶ 61,046 (2020).

Figure 11-2 Monthly balancing explicit CLMP charges incurred by UTC: January 2014 through March 2021



Balancing congestion is caused by settling real-time deviations from day-ahead positions at real-time prices. Whether balancing congestion is positive or negative depends on the differences between the day-ahead and real-time market models including modeled constraints, the transfer capability (line limits) of the modeled constraints and the differences in deviations between day-ahead and real-time flows that result. The deviations are priced at the real-time LMPs.

For example, one source of negative balancing congestion is that the PJM system has less transmission transfer capability in the real-time market than is modeled in the day-ahead market. In order to reduce processing time in the presence of large number of virtual bids and offers, PJM only enforces or models a subset of its physical transmission limits in the day-ahead market. Transmission constraints not modeled in the day-ahead market have

unlimited transfer capability in the day-ahead market model. The inclusion of the actual, lower transmission capability in the real-time market requires the use of more high cost generation and the use of less low cost generation to serve load, which means a decrease in congestion.²³ The reduction in real-time congestion compared to day-ahead congestion creates negative balancing congestion.

As a day-ahead spread bid, UTCs can take advantage of and profit from LMP differences caused by modeling differences between the day-ahead and real-time market. UTCs clear between source and sink points with little or no price difference in the day-ahead market, and settle the resulting deviations at higher real-time price differences in the real-time market. The result is negative balancing congestion caused by and paid to UTCs in the form of CLMP credits. This is an example of false arbitrage because the UTCs cannot cause prices to converge and the profits to decrease. As a result of the FERC order requiring load to pay balancing congestion, load is responsible for paying the balancing congestion caused by UTCs.²⁴

Table 11-17 provides an example of how UTCs can profit from differences in day-ahead and real-time models and generate negative balancing congestion. In the example, Bus A and Bus B are linked by a transmission line. In the day-ahead market the transmission limit is modeled as 9,999 MW (no limit is enforced in the day-ahead market solution). In the real-time market the physical limit between bus A and bus B is 50 MW. Generation at A has a price of \$1.00 and Generation at B has a price of \$6. There is 100 MW of load at bus A and 100 MW of load at bus B. There is a UTC of 200 MW that will source at bus A and sink at bus B if the spread in the prices between A and B is less than \$1.

As a result of the fact that the transmission capability between A and B is unlimited in the day-ahead market, all of load at A and B can be met with the \$1 generation at bus A. The constraint between A and B does not bind in

²³ Although it seems counter intuitive, as the amount of low cost generation decreases and the amount of high cost generation increases, the difference between load payments to generation and the payments received by generators goes down. High cost generation receives what load pays.

²⁴ On September 15, 2016, FERC ordered PJM to allocate balancing congestion to load, rather than to FTRs, to modify PJM's Stage 1A ARR allocation process and to continue to use portfolio netting. 153 FERC ¶ 61,180.

day-ahead so the price at A and B is \$1. The price spread between bus A and bus B is zero, which is less than the UTC spread requirement of \$1, so the UTC clears. The UTC causes a 200 MW injection at A and 200 MW withdrawal at B, creating 200 MW of flow between bus A and bus B. The 300 MW of combined flow from generation at A and UTC injections at A to the load and UTC sink at B does not exceed the DA modeled limit between A and B. This means that all 200 MW of the UTC injection at A and 200 MW of withdrawal at B can clear without forcing a price spread between A and B. Total day-ahead congestion, which is the difference between CLMP charges and credits, is zero. There is no price difference between the two nodes and every MW of injection and every MW of withdrawal at bus A and bus B settles at the same price.

In the real-time market, the transmission line between bus A and bus B has a 50 MW limit. The UTC does not physically exist in the real-time market and therefore has deviations at Bus A (-200 MW) and at Bus B (+200 MW). The UTC must buy at bus A at the real-time price and sell at bus B at the real-time price to settle its deviations. The load at A (100 MW) and B (100 MW) does not change, so there are no load deviations. With only 50 MW of transmission capability between A and B, the generation at A cannot be used to meet total load on the system. Generation from A meets the load at A (100 MW) and can supply only 50 MW of the 100 MW of load at B. Due to the binding constraint between A and B, the remaining 50 MW of load at B must be met with local generation at B at a cost of \$6 and the price at A remains \$1.

The UTC must buy 200 MW at A at the real-time price of \$1 and sell 200 MW at B at the real-time price of \$6. The UTC pays \$200 at A and is paid \$1,200 at B. The result is a net payment to the UTC of \$1,000 in balancing credits.

Table 11-16 shows the balancing credits and charges associated with the real-time deviations in the example. Total congestion (day-ahead plus balancing congestion) in this example is negative \$1,250. Total CLMP credits (payments) to generation and the UTC exceed the total charges collected from load. The negative balancing congestion that results is paid by the load under the FERC order.²⁵

²⁵ 153 FERC ¶ 61,180.

The UTC did not and could not contribute to price convergence between the day-ahead and real-time market and did not and could not improve efficiency in system dispatch or commitment. The UTC took advantage of the modeling differences between the day-ahead and real-time markets. The UTC did significantly increase payments by load. Load was required to pay the UTC \$1,000 in negative balancing, over and above the costs of generation that was needed to meet real-time load. The differences in modeling would have resulted in only \$250 in negative balancing congestion if there had been no UTCs.

Table 11-16 Example of UTC causing and profiting from negative balancing congestion

Prices	Transfer Capability (Line Limit)		Bus B	
	Bus A	MW		
LMP DA	\$1.00	9,999	\$1.00	
LMP RT	\$1.00	50	\$6.00	
Day-Ahead MW	Bus A	Bus B	Total MW	
Day-Ahead Generation	200	0	200	
Day-Ahead Load	(100)	(100)	(200)	
Day-Ahead UTC (+/-)	200	(200)	0	
Total MW	300	(300)	0	
Day-Ahead Credits and Charges		Bus A	Bus B	Total Day-Ahead Congestion
Total DA Gen Credits		\$200.00	\$0.00	
Total DA Load Charges		\$100.00	\$100.00	
Total DA UTC Credits		\$200.00	(\$200.00)	
Total DA Credits		\$300.00	(\$300.00)	\$0.00
Total Day-Ahead Congestion (Charges - Credits)				\$0.00
Balancing Deviation MW		Bus A	Bus B	Total Deviations
RT GEN Deviations		(50)	50	
RT Load Deviations		0	0	
DA UTC (+/-)		(200)	200	
Total Deviations				(250) 250 0
Balancing Credits and Charges		Bus A	Bus B	Balancing Congestion Credits
Total BA Gen Credits		(\$50.00)	\$300.00	\$250.00
Total BA Load Charges		\$0.00	\$0.00	
Total BA UTC Credits		(\$200.00)	\$1,200.00	\$1,000.00
Total BA Credits		(\$250.00)	\$1,500.00	\$1,250.00
Total Balancing Congestion (Charges - Credits)				(\$1,250.00)

Zonal and Load Aggregate Congestion

Zonal, and load aggregate, congestion is calculated on a constraint specific basis for a specific location or set of load pricing nodes (a zone or an aggregate). Local congestion is the difference between what load pays for energy and what generation is paid for energy due to individual binding transmission constraints. Local congestion includes all energy charges or credits incurred to serve a specific load, zone or load aggregate. Local congestion calculations account for the total difference between what the specified load pays and what the generation that serves that load is paid, regardless of whether the zone is a net importer or a net exporter of generation.

Local congestion is calculated on a constraint specific basis. Congestion is the total congestion payments by load at the buses within a defined area minus total CLMP credits received by generation that supplied that load, given the transmission constraints. Congestion reflects the underlying characteristics of the entire power system as it affects the defined area, including the nature and capability of transmission facilities, the offers and geographic distribution of generation facilities, the level and geographic distribution of decremental bids and incremental offers and the geographic and temporal distribution of load.

On a system wide basis, congestion results from transmission constraints that prevent the lowest cost generation from serving some load that must be served by higher cost generation.

The total congestion caused by a constraint is equal to the product of the constraint shadow price times the net flow on the binding constraint. Total congestion caused by the constraint can also be calculated using the CLMPs caused by the constraint at every bus and the net MW injections or MW withdrawals at every affected bus. Congestion associated with a specific constraint is equal to load CLMP charges (CLMP of that specific constraint at each bus times load MW at each bus) caused by that constraint in excess of generation CLMP credits (CLMP of that specific constraint at each bus times generation MW at each bus) caused by that constraint.

Constraint specific CLMPs are determined relative to a reference bus, where there is no congestion and no losses. For purposes of calculating the congestion from an individual constraint, the reference bus for each constraint calculation is the point that is just upstream of the constraint (the bus with the greatest negative price effect from the constraint), allowing any positive price effects of the constraint to be reflected as a positive CLMP.

In order to define the load that is actually paying congestion, congestion is appropriately assigned to downstream (positive CLMP) load buses that paid the congestion caused by the constraint, in proportion to the CLMP charges collected from that load due to that constraint. The congestion collected from each load bus due to a constraint is equal to the CLMP caused by that constraint times the MW of load at that load bus. This calculation is done for both day-ahead congestion and balancing congestion.

Table 11-17 shows day-ahead and balancing congestion by zone for the first three months of 2021. AEP had the largest zonal congestion costs among all control zones in the first three months of 2021. AEP had \$16.3 million in zonal congestion costs, comprised of \$31.8 million in zonal day-ahead congestion costs and -\$15.6 million in zonal balancing congestion costs. The Cedar Grove Sub - William Line, the Conastone Transformer, the Bagley - Raphael Road Line, the Bagley - Graceton Line, and the East Lima - Haviland Line contributed \$4.9 million, or 30.1 percent of the AEP zonal congestion costs.²⁶

Table 11-18 shows the congestion costs by zone for the first three months of 2020.

²⁶ For additional information about the top 20 constraints that affected each zone, see the 2020 State of the Market Report for PJM, Appendix F: Congestion and Marginal Losses.

**Table 11-17 Day-ahead and balancing congestion by zone (Dollars (Millions)):
January through March, 2021**

Control Zone	CLMP Credits and Charges (Millions)								
	Day-Ahead				Balancing				Congestion Costs
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	
ACEC	\$0.6	(\$1.1)	\$0.2	\$1.8	(\$0.2)	\$0.4	(\$0.4)	(\$1.0)	\$0.9
AEP	\$7.8	(\$21.8)	\$2.3	\$31.8	(\$3.8)	\$6.0	(\$5.7)	(\$15.6)	\$16.3
APS	\$7.7	(\$7.8)	\$1.2	\$16.7	(\$1.5)	\$2.4	(\$2.2)	(\$6.1)	\$10.6
ATSI	\$4.1	(\$12.1)	\$1.3	\$17.6	(\$1.9)	\$2.9	(\$2.8)	(\$7.6)	\$10.0
BGE	\$2.8	(\$4.3)	\$0.7	\$7.7	(\$0.8)	\$1.5	(\$1.4)	(\$3.7)	\$4.0
COMED	\$8.6	(\$16.4)	\$2.5	\$27.6	(\$2.8)	\$4.6	(\$4.2)	(\$11.5)	\$16.1
DAY	\$0.6	(\$2.9)	\$0.3	\$3.8	(\$0.5)	\$0.8	(\$0.8)	(\$2.1)	\$1.7
DOM	\$8.6	(\$14.8)	\$2.0	\$25.4	(\$3.0)	\$5.0	(\$4.7)	(\$12.7)	\$12.7
DPL	\$13.2	(\$1.2)	\$0.7	\$15.1	(\$1.6)	\$0.6	(\$0.8)	(\$3.0)	\$12.2
DUKE	\$0.9	(\$4.9)	\$0.6	\$6.4	(\$0.8)	\$1.2	(\$1.2)	(\$3.2)	\$3.3
DUQ	\$0.3	(\$1.7)	\$0.1	\$2.1	(\$0.4)	\$0.6	(\$0.5)	(\$1.5)	\$0.7
EKPC	\$0.7	(\$2.5)	\$0.2	\$3.4	(\$0.4)	\$0.7	(\$0.7)	(\$1.9)	\$1.6
EXT	\$3.1	(\$3.3)	\$0.8	\$7.3	(\$2.7)	\$3.6	(\$2.5)	(\$8.9)	(\$1.5)
JCPLC	\$1.5	(\$2.7)	\$0.3	\$4.5	(\$0.5)	\$0.8	(\$0.7)	(\$2.0)	\$2.4
MEC	\$1.9	(\$2.3)	\$0.3	\$4.5	(\$0.4)	\$0.7	(\$0.6)	(\$1.7)	\$2.8
OVEC	\$0.1	(\$0.1)	\$0.0	\$0.2	(\$0.0)	\$0.1	(\$0.1)	(\$0.1)	\$0.1
PE	\$4.1	(\$2.2)	\$0.7	\$7.0	(\$0.7)	\$1.0	(\$1.0)	(\$2.7)	\$4.3
PECO	\$5.3	(\$4.7)	\$0.7	\$10.8	(\$1.0)	\$1.6	(\$1.5)	(\$4.1)	\$6.7
PEPCO	\$2.3	(\$3.8)	\$0.6	\$6.7	(\$0.8)	\$1.3	(\$1.2)	(\$3.3)	\$3.4
PPL	\$3.8	(\$6.9)	\$1.3	\$12.0	(\$1.1)	\$1.8	(\$1.7)	(\$4.5)	\$7.4
PSEG	\$3.6	(\$5.9)	\$1.1	\$10.6	(\$1.7)	\$2.2	(\$2.3)	(\$6.1)	\$4.5
REC	\$0.6	(\$0.2)	\$0.8	\$1.5	(\$0.1)	\$0.1	(\$0.1)	(\$0.3)	\$1.2
Total	\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$121.0

**Table 11-18 Day-ahead and balancing congestion by zone (Dollars (Millions)):
January through March, 2020**

Control Zone	CLMP Credits and Charges (Millions)								
	Day-Ahead				Balancing				Congestion Costs
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	
ACEC	\$0.2	(\$0.7)	\$0.2	\$1.1	(\$0.0)	\$0.0	(\$0.2)	(\$0.2)	\$0.9
AEP	(\$0.1)	(\$14.2)	\$2.1	\$16.2	(\$0.0)	\$0.6	(\$2.3)	(\$3.0)	\$13.2
APS	\$3.9	(\$2.7)	\$0.8	\$7.4	(\$0.0)	\$0.3	(\$0.9)	(\$1.2)	\$6.2
ATSI	\$2.1	(\$5.9)	\$1.1	\$9.2	(\$0.0)	\$0.3	(\$1.2)	(\$1.5)	\$7.7
BGE	\$0.7	(\$2.5)	\$0.4	\$3.6	(\$0.0)	\$0.2	(\$0.5)	(\$0.7)	\$2.9
COMED	(\$2.1)	(\$14.4)	\$2.9	\$15.1	\$0.0	\$0.4	(\$1.6)	(\$2.0)	\$13.2
DAY	(\$0.2)	(\$2.0)	\$0.3	\$2.1	(\$0.0)	\$0.1	(\$0.3)	(\$0.4)	\$1.7
DOM	\$1.0	(\$9.5)	\$1.4	\$11.9	(\$0.0)	\$0.4	(\$1.8)	(\$2.2)	\$9.7
DPL	\$1.5	(\$1.5)	\$0.5	\$3.5	(\$0.0)	\$0.1	(\$0.4)	(\$0.5)	\$3.0
DUKE	\$0.0	(\$2.5)	\$0.4	\$2.9	(\$0.0)	\$0.1	(\$0.5)	(\$0.6)	\$2.3
DUQ	(\$0.0)	(\$1.2)	\$0.2	\$1.4	(\$0.0)	\$0.1	(\$0.2)	(\$0.3)	\$1.1
EKPC	(\$0.0)	(\$1.4)	\$0.2	\$1.6	(\$0.0)	\$0.1	(\$0.3)	(\$0.3)	\$1.3
EXT	(\$0.1)	(\$2.0)	\$0.4	\$2.3	\$0.0	\$0.1	(\$0.5)	(\$0.6)	\$1.7
JCPLC	\$0.3	(\$1.9)	\$0.3	\$2.5	(\$0.0)	\$0.1	(\$0.4)	(\$0.5)	\$2.0
MEC	\$0.7	(\$1.2)	\$0.2	\$2.1	(\$0.0)	\$0.1	(\$0.3)	(\$0.4)	\$1.7
OVEC	\$0.0	(\$0.1)	\$0.1	\$0.3	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	\$0.2
PE	\$1.9	(\$0.4)	\$0.3	\$2.6	(\$0.0)	\$0.1	(\$0.3)	(\$0.4)	\$2.2
PECO	\$0.3	(\$3.4)	\$0.5	\$4.2	(\$0.0)	\$0.2	(\$0.7)	(\$0.9)	\$3.3
PEPCO	\$0.6	(\$2.3)	\$0.4	\$3.2	(\$0.0)	\$0.1	(\$0.5)	(\$0.6)	\$2.6
PPL	\$1.5	(\$3.0)	\$0.8	\$5.4	(\$0.0)	\$0.2	(\$0.7)	(\$0.9)	\$4.5
PSEG	\$1.1	(\$3.0)	\$0.6	\$4.6	(\$0.0)	\$0.2	(\$0.7)	(\$0.9)	\$3.7
REC	\$0.0	(\$0.1)	\$0.0	\$0.1	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	\$0.1
Total	\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	\$85.1

In cases where the constraint causes net negative congestion and/or there is no load bus on the constrained side of a binding constraint, the congestion of the constraint is handled as a special case. In the first three months of 2021, the total congestion costs associated with the special cases were -\$4.0 million or -3.3 percent of the total congestion costs. Table 11-17 and Table 11-18 include congestion allocations from these special case constraints.

There are five categories of constraint specific allocation special cases: congestion associated with constraints with no downstream load bus (no load bus); congestion associated with constraints with downstream load buses with zero value CLMPs (zero CLMP); congestion associated with closed loop

interfaces (closed loop interfaces); congestion associated with CT price setting logic; and congestion associated with nontransmission facility constraints in the day-ahead energy market and/or any unaccounted for difference between PJM billed CLMP charges and calculated congestion costs including rounding errors (unclassified).

Table 11-19 and Table 11-20 show total congestion by type of special case, CT congestion, and total congestion by zone. Closed loop interfaces and CT pricing logic generally result in negative congestion on a constraint specific basis. PJM’s use of both the closed loop interfaces and CT Pricing Logic forces the affected resource bus LMP to match the marginal offer of the resource. This causes higher CLMP payments to the affected generation than the CLMP load charges to any affected load, resulting in negative congestion associated with the constraint. None of the closed loop interfaces were binding in the first three months of 2021 and 2020.

Table 11-19 Day-ahead and total balancing congestion assigned by zone and special case logic (Dollars (Millions)): January through March, 2021

Control Zone	Congestion Costs (Millions)																Percent of Special Cases
	Day-Ahead							Balancing							Grand Total	Special Cases Total	
	Load Bus Zero CLMP	CT Price Setting Logic	Closed Loop Interfaces	No Load Buses	Unclassified	Contribution	Total	Load Bus Zero CLMP	CT Price Setting Logic	Closed Loop Interfaces	No Load Buses	Unclassified	Contribution	Total			
ACEC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$1.8	\$1.8	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$0.9)	(\$1.0)	\$0.9	(\$0.0)	(4.8%)
AEP	\$0.0	\$0.0	\$0.0	\$0.1	\$0.0	\$31.7	\$31.8	\$0.0	(\$0.4)	\$0.0	\$0.0	(\$0.2)	(\$15.0)	(\$15.6)	\$16.3	(\$0.5)	(2.9%)
APS	\$0.0	(\$0.0)	\$0.0	\$0.2	\$0.0	\$16.5	\$16.7	\$0.0	(\$0.2)	\$0.0	(\$0.0)	(\$0.1)	(\$5.8)	(\$6.1)	\$10.6	(\$0.1)	(1.0%)
ATSI	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$17.6	\$17.6	\$0.0	(\$0.2)	\$0.0	\$0.0	(\$0.1)	(\$7.3)	(\$7.6)	\$10.0	(\$0.3)	(3.0%)
BGE	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$7.7	\$7.7	\$0.0	(\$0.1)	\$0.0	(\$0.0)	(\$0.0)	(\$3.5)	(\$3.7)	\$4.0	(\$0.1)	(3.6%)
COMED	\$0.5	\$0.0	\$0.0	\$1.4	\$0.0	\$25.7	\$27.6	\$0.0	(\$0.3)	\$0.0	(\$0.0)	(\$0.1)	(\$11.1)	(\$11.5)	\$16.1	\$1.5	9.1%
DAY	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	\$3.8	\$3.8	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.0)	(\$2.0)	(\$2.1)	\$1.7	(\$0.1)	(4.8%)
DOM	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$25.4	\$25.4	\$0.0	(\$0.4)	\$0.0	\$0.0	(\$0.2)	(\$12.2)	(\$12.7)	\$12.7	(\$0.5)	(3.9%)
DPL	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$15.1	\$15.1	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.0)	(\$2.9)	(\$3.0)	\$12.2	(\$0.1)	(0.7%)
DUKE	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$6.4	\$6.4	(\$0.0)	(\$0.1)	\$0.0	(\$0.0)	(\$0.0)	(\$3.1)	(\$3.2)	\$3.3	(\$0.1)	(3.9%)
DUQ	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$2.1	\$2.1	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$1.4)	(\$1.5)	\$0.7	(\$0.1)	(8.7%)
EKPC	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$3.4	\$3.4	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.0)	(\$1.8)	(\$1.9)	\$1.6	(\$0.1)	(4.7%)
EXT	\$0.2	(\$0.0)	\$0.0	\$0.0	\$0.0	\$7.1	\$7.3	(\$0.0)	(\$2.7)	\$0.0	\$0.0	(\$0.0)	(\$6.1)	(\$8.9)	(\$1.5)	(\$2.5)	164.5%
JCPLC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$4.5	\$4.5	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.0)	(\$1.9)	(\$2.0)	\$2.4	(\$0.1)	(4.1%)
MEC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$4.5	\$4.5	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$1.6)	(\$1.7)	\$2.8	(\$0.0)	(1.6%)
OVEC	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2	\$0.2	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$0.1)	(\$0.1)	\$0.1	(\$0.0)	(7.4%)
PE	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$7.0	\$7.0	\$0.0	(\$0.1)	\$0.0	(\$0.0)	(\$0.0)	(\$2.6)	(\$2.7)	\$4.3	(\$0.1)	(2.4%)
PECO	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$10.8	\$10.8	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.1)	(\$3.9)	(\$4.1)	\$6.7	(\$0.2)	(2.7%)
PEPCO	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$6.7	\$6.7	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.0)	(\$3.1)	(\$3.3)	\$3.4	(\$0.1)	(4.0%)
PPL	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$12.0	\$12.0	(\$0.0)	(\$0.1)	\$0.0	\$0.0	(\$0.1)	(\$4.3)	(\$4.5)	\$7.4	(\$0.2)	(2.7%)
PSEG	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$10.6	\$10.6	\$0.0	(\$0.1)	\$0.0	\$0.0	(\$0.1)	(\$6.0)	(\$6.1)	\$4.5	(\$0.2)	(4.2%)
REC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$1.5	\$1.5	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$0.3)	(\$0.3)	\$1.2	(\$0.0)	(0.4%)
Total	\$0.6	(\$0.0)	\$0.0	\$1.8	\$0.0	\$222.0	\$224.5	(\$0.0)	(\$5.2)	\$0.0	(\$0.0)	(\$1.2)	(\$97.0)	(\$103.4)	\$121.0	(\$4.0)	(3.3%)

Table 11-20 Day-ahead and total balancing congestion assigned by zone and special case logic (Dollars (Millions)): January through March, 2020

Control Zone	Congestion Costs (Millions)																	Special Cases Total	Percent of Special Cases
	Day-Ahead							Balancing							Grand Total				
	Load Bus Zero CLMP	CT Price Setting Logic	Closed Loop Interfaces	No Load Buses	Unclassified	Contribution	Total	Load Bus Zero CLMP	CT Price Setting Logic	Closed Loop Interfaces	No Load Buses	Unclassified	Contribution	Total					
ACEC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$1.1	\$1.1	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.2)	(\$0.2)	\$0.9	(\$0.0)	(0.1%)	
AEP	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$16.1	\$16.2	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$2.9)	(\$3.0)	\$13.2	(\$0.0)	(0.0%)	
APS	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$7.4	\$7.4	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$1.2)	(\$1.2)	\$6.2	(\$0.0)	(0.0%)	
ATSI	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$9.2	\$9.2	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$1.5)	(\$1.5)	\$7.7	(\$0.0)	(0.1%)	
BGE	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$3.6	\$3.6	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.7)	(\$0.7)	\$2.9	(\$0.0)	(0.1%)	
COMED	\$0.2	(\$0.0)	\$0.0	\$0.7	\$0.0	\$14.2	\$15.1	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$2.0)	(\$2.0)	\$13.2	\$0.9	6.7%	
DAY	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$2.1	\$2.1	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.4)	(\$0.4)	\$1.7	(\$0.0)	(0.1%)	
DOM	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$11.9	\$11.9	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$2.2)	(\$2.2)	\$9.7	(\$0.0)	(0.1%)	
DPL	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$3.5	\$3.5	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.5)	(\$0.5)	\$3.0	(\$0.0)	(0.0%)	
DUKE	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$2.9	\$2.9	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.6)	(\$0.6)	\$2.3	(\$0.0)	(0.1%)	
DUQ	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$1.4	\$1.4	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.3)	(\$0.3)	\$1.1	(\$0.0)	(0.1%)	
EKPC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$1.6	\$1.6	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.3)	(\$0.3)	\$1.3	(\$0.0)	(0.1%)	
EXT	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$2.3	\$2.3	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.6)	(\$0.6)	\$1.7	\$0.0	0.2%	
JCPLC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$2.5	\$2.5	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.5)	(\$0.5)	\$2.0	(\$0.0)	(0.1%)	
MEC	\$0.0	(\$0.0)	\$0.0	\$0.1	\$0.0	\$2.0	\$2.1	(\$0.0)	(\$0.0)	\$0.0	(\$0.1)	(\$0.0)	(\$0.0)	(\$0.3)	(\$0.4)	\$1.7	\$0.0	0.5%	
OVEC	\$0.0	(\$0.0)	\$0.0	\$0.1	\$0.0	\$0.2	\$0.3	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.0)	\$0.2	\$0.1	43.6%	
PE	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$2.6	\$2.6	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.4)	(\$0.4)	\$2.2	(\$0.0)	(0.6%)	
PECO	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$0.0	\$4.2	\$4.2	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.9)	(\$0.9)	\$3.3	(\$0.0)	(0.1%)	
PEPCO	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$3.2	\$3.2	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.6)	(\$0.6)	\$2.6	(\$0.0)	(0.1%)	
PPL	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$5.4	\$5.4	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.9)	(\$0.9)	\$4.5	(\$0.0)	(0.1%)	
PSEG	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$4.6	\$4.6	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.9)	(\$0.9)	\$3.7	(\$0.0)	(0.2%)	
REC	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.1	\$0.1	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.0)	(\$0.0)	\$0.1	(\$0.0)	(0.2%)	
Total	\$0.2	(\$0.0)	\$0.0	\$0.9	\$0.1	\$102.2	\$103.3	(\$0.0)	(\$0.0)	\$0.0	(\$0.2)	(\$0.0)	(\$0.0)	(\$18.0)	(\$18.2)	\$85.1	\$0.9	1.1%	

Monthly Congestion

Table 11-21 shows day-ahead, balancing and inadvertent congestion costs by month for January 2020 through March 2021. Compared to the first three months of 2020, total congestion costs decreased in January, increased in February and increased in March. Total day-ahead congestion costs increased in January through March and total negative balancing congestion costs increased in January through March.

The top two constraints that contributed most to day-ahead and balancing congestion costs were the Cedar Grove Sub – William Line and the Vienna Transformer. The high shadow prices of Cedar Grove Sub – William Line were primarily a result of high prices due to cold weather. The high shadow prices of the Vienna Transformer were a result of a trip of generation units and a transmission outage in DPL in March.

CT pricing logic was also a factor that contributed to the high negative balancing congestion costs in the first three months of 2021. The top three constraints that contributed most to the negative balancing congestion costs resulting from CT pricing logic were the Terminal Transformer, the Coffeen North – Roxford Flowgate and the Bergenfield – Leonia Line.

Table 11-21 Monthly congestion costs by market (Dollars (Millions)): January 2020 through March 2021

Congestion Costs (Millions)								
	2020				2021			
	Day-Ahead	Balancing	Inadvertent Charges	Total	Day-Ahead	Balancing	Inadvertent Charges	Total
Jan	\$43.3	(\$5.6)	\$0.0	\$37.6	\$53.2	(\$24.1)	(\$0.0)	\$29.1
Feb	\$28.7	(\$7.0)	(\$0.0)	\$21.7	\$90.3	(\$53.5)	\$0.0	\$36.8
Mar	\$31.4	(\$5.6)	(\$0.0)	\$25.8	\$81.0	(\$25.8)	\$0.0	\$55.2
Apr	\$24.2	(\$8.2)	\$0.0	\$16.0				
May	\$46.1	(\$19.5)	\$0.0	\$26.6				
Jun	\$62.8	(\$10.7)	\$0.0	\$52.0				
Jul	\$105.6	(\$23.8)	\$0.0	\$81.7				
Aug	\$82.5	(\$14.0)	(\$0.0)	\$68.5				
Sep	\$78.1	(\$11.9)	\$0.0	\$66.1				
Oct	\$52.5	(\$9.3)	\$0.0	\$43.2				
Nov	\$41.3	(\$7.8)	\$0.0	\$33.5				
Dec	\$66.2	(\$10.5)	\$0.0	\$55.8				
Total	\$662.5	(\$133.9)	\$0.0	\$528.6	\$224.5	(\$103.4)	\$0.0	\$121.0

Figure 11-3 shows PJM monthly total congestion cost for the January 2008 through March 2021.

Figure 11-3 Monthly total congestion cost (Dollars (Millions)): January 2008 through March 2021

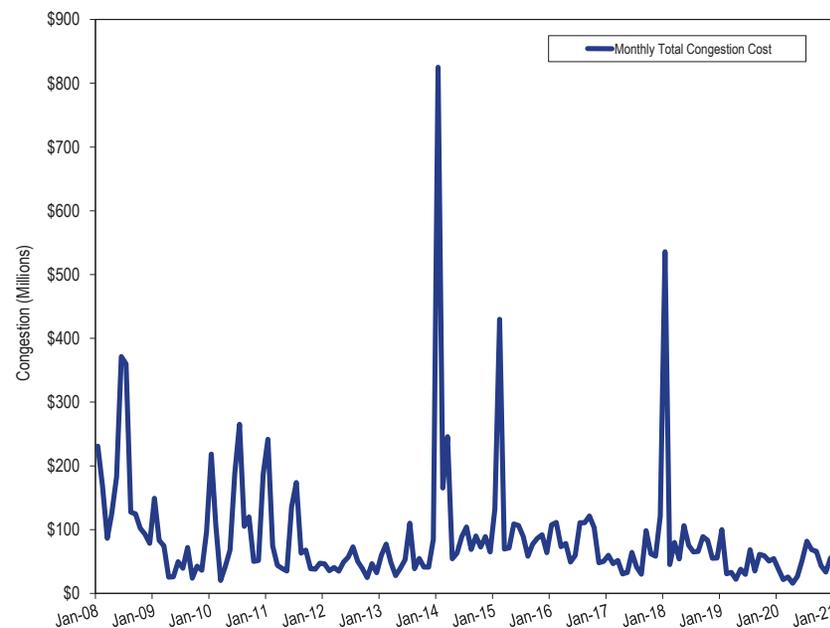


Table 11-22 shows monthly total CLMP credits and charges for each virtual transaction type in January 2020 through March 2021. Virtual transaction CLMP charges, when positive, are the total CLMP charges to the virtual transactions and when negative, are the total CLMP credits to the virtual transactions. The negative totals in Table 11-22 show that virtuals were paid, in net, CLMP credits in the first three months of 2021 and 2020. In the first three months of 2021, 43.5 percent of the total credits to virtuals went to UTCs, compared to 31.0 percent in the first three months of 2020.

Table 11-22 Monthly CLMP charges by virtual transaction type and by market (Dollars (Millions)): January 2020 through March 2021

CLMP Credits and Charges (Millions)											
Year		DEC			INC			Up to Congestion			Grand Total
		Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	
2020	Jan	\$0.2	(\$0.6)	(\$0.4)	\$1.4	(\$1.8)	(\$0.4)	\$3.7	(\$2.9)	\$0.8	(\$0.0)
	Feb	\$0.2	(\$0.2)	(\$0.1)	\$1.3	(\$1.5)	(\$0.1)	\$4.8	(\$6.1)	(\$1.3)	(\$1.5)
	Mar	(\$0.8)	(\$0.1)	(\$0.9)	\$1.3	(\$1.6)	(\$0.2)	\$4.8	(\$5.3)	(\$0.5)	(\$1.6)
	Apr	(\$0.6)	\$0.8	\$0.2	\$1.9	(\$5.0)	(\$3.0)	\$2.7	(\$3.4)	(\$0.7)	(\$3.5)
	May	\$0.6	(\$0.6)	\$0.0	\$2.7	(\$5.1)	(\$2.4)	\$7.3	(\$11.7)	(\$4.4)	(\$6.8)
	Jun	\$1.0	(\$1.6)	(\$0.6)	\$1.7	(\$2.8)	(\$1.2)	\$7.7	(\$7.4)	\$0.3	(\$1.5)
	Jul	\$5.1	(\$3.7)	\$1.4	\$0.9	(\$3.5)	(\$2.6)	\$9.1	(\$16.2)	(\$7.1)	(\$8.3)
	Aug	\$5.1	(\$7.4)	(\$2.4)	\$0.6	(\$1.9)	(\$1.3)	\$5.8	(\$7.6)	(\$1.8)	(\$5.5)
	Sep	\$2.5	(\$5.9)	(\$3.4)	\$1.7	(\$1.5)	\$0.1	\$6.9	(\$5.3)	\$1.6	(\$1.7)
	Oct	\$1.0	(\$2.0)	(\$1.0)	\$1.6	(\$3.2)	(\$1.6)	\$2.8	(\$3.8)	(\$1.1)	(\$3.7)
	Nov	(\$1.1)	\$1.4	\$0.3	\$3.0	(\$5.4)	(\$2.5)	\$2.7	(\$3.4)	(\$0.7)	(\$2.9)
	Dec	\$3.0	(\$6.2)	(\$3.2)	(\$1.0)	(\$1.3)	(\$2.4)	\$2.5	(\$4.3)	(\$1.8)	(\$7.4)
	Total	\$16.1	(\$26.2)	(\$10.1)	\$17.0	(\$34.6)	(\$17.6)	\$60.8	(\$77.5)	(\$16.7)	(\$44.4)
2021	Jan	\$3.0	(\$8.0)	(\$5.0)	\$0.5	(\$0.1)	\$0.4	\$4.0	(\$10.0)	(\$6.0)	(\$10.5)
	Feb	\$11.8	(\$24.7)	(\$12.9)	\$0.6	(\$4.0)	(\$3.5)	\$7.9	(\$20.9)	(\$13.0)	(\$29.4)
	Mar	\$6.7	(\$7.7)	(\$1.0)	\$4.0	(\$8.1)	(\$4.2)	\$4.9	(\$6.0)	(\$1.1)	(\$6.2)
	Total	\$21.5	(\$40.4)	(\$18.9)	\$5.1	(\$12.3)	(\$7.2)	\$16.8	(\$36.9)	(\$20.1)	(\$46.2)

Congested Facilities

A congestion event exists when a unit or units must be dispatched out of merit order to control for the potential impact of a contingency on a monitored facility or to control an actual overload. A congestion event hour exists when a specific facility is constrained for one or more five-minute intervals within an hour. A congestion event hour differs from a constrained hour, which is any hour during which one or more facilities are congested. If two facilities

are constrained during an hour the result is one constrained hour and two congestion event hours. Constraints are often simultaneous, so the number of congestion event hours usually exceeds the number of constrained hours and the number of congestion event hours usually exceeds the number of hours in a year.

In order to have a consistent metric for real-time and day-ahead congestion frequency, real-time congestion frequency is measured using the convention that an hour is constrained if any of its component five-minute intervals is constrained. This is consistent with the way in which PJM reports real-time congestion.

In the first three months of 2021, there were 14,618 day-ahead, congestion event hours compared to 17,087 day-ahead congestion event hours in the first three months of 2020. Of the day-ahead congestion event hours in the first three months of 2021, only 2,498 (17.1 percent) were also constrained in the real-time energy market (Table 11-25). In the first three months of 2021, there were 5,484 real-time, congestion event hours compared to 5,515 real-time, congestion event hours in the first three months of 2020. Of the real-time congestion event hours in the first three months of 2021, 2,505 (45.7 percent) were also constrained in the day-ahead energy market (Table 11-26).

The top five constraints by congestion costs contributed \$55.7 million, or 46.0 percent, of the total PJM congestion costs in the first three months of 2021. The top five constraints were the Vienna Transformer, the Bagley - Raphael Road Line, the Bagley - Graceton Line, the Conastone Transformer, and the Harwood - Susquehanna Line.

Several of the top constraints by congestion costs are located in the BGE Zone in the first three months of 2020 and 2021 (Figure 11-4).

Congestion by Facility Type and Voltage

Day-ahead, congestion event hours decreased on all types of facilities except lines. Interfaces decreased 1,360 congestion event hours from 1,385 day-ahead, congestion event hours in the first three months of 2020 to 25 day-ahead congestion event hours in the first three months of 2021. Of the 1,360 congestion event hours decrease, 98.5 percent of the decreased hours were on the PA Central Interface.

Real-time, congestion event hours increased on lines and transformers and decreased on flowgates and interfaces in the first three months of 2021. Interfaces decreased 1,106 congestion event hours from 1,129 real-time, congestion event hours in the first three months of 2020 to 23 real-time congestion event hours in the first three months of 2021. Of the 1,106 congestion event hours decrease, 101.8 percent of the decreased hours were on the PA Central Interface.

Day-ahead congestion costs increased on all types of facilities except interfaces in the first three months of 2021 compared to the first three months of 2020. The decrease of day-ahead congestion costs on interfaces was primarily a result of the decrease in day-ahead congestion event hours on the PA Central Interface.

Negative balancing congestion costs increased on all types of facilities except interfaces in the first three months of 2021 compared to the first three months of 2020 (Table 11-24). Table 11-23 provides congestion event hour subtotals and congestion cost subtotals comparing the first three months of 2021 results by facility type: line, transformer, interface, flowgate and unclassified facilities.^{27 28}

Table 11-23 Congestion summary (By facility type): January through March, 2021

Type	CLMP Credits and Charges (Millions)								Event Hours		
	Day-Ahead				Balancing				Congestion Costs	Day-Ahead	Real-Time
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total			
Flowgate	(\$1.8)	(\$26.5)	\$1.7	\$26.4	\$1.0	\$9.4	(\$4.6)	(\$13.1)	\$13.3	1,649	951
Interface	(\$0.0)	(\$1.5)	\$0.1	\$1.6	(\$0.0)	\$0.1	(\$0.1)	(\$0.3)	\$1.4	25	23
Line	\$58.2	(\$74.3)	\$14.6	\$147.1	(\$15.8)	\$27.1	(\$28.8)	(\$71.7)	\$75.4	10,879	3,673
Transformer	\$21.0	(\$20.3)	\$1.5	\$42.7	(\$13.3)	\$0.3	(\$1.3)	(\$14.9)	\$27.9	1,555	396
Other	\$5.0	(\$0.9)	\$0.7	\$6.7	\$1.7	\$2.5	(\$1.5)	(\$2.4)	\$4.3	510	441
Unclassified	\$0.0	\$0.0	(\$0.0)	\$0.0	(\$0.1)	\$0.6	(\$0.5)	(\$1.2)	(\$1.2)	NA	NA
Total	\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$121.0	14,618	5,484

²⁷ Unclassified are congestion costs related to nontransmission facility constraints in the day-ahead energy market and any unaccounted for difference between PJM billed CLMP charges and calculated congestion costs including rounding errors. Nontransmission facility constraints include day-ahead market only constraints such as constraints on virtual transactions and constraints associated with phase-angle regulators.

²⁸ The term flowgate refers to MISO reciprocal coordinated flowgates and NYISO M2M flowgates.

Table 11-24 Congestion summary (By facility type): January through March, 2020

Type	CLMP Credits and Charges (Millions)									Event Hours	
	Day-Ahead				Balancing				Congestion Costs	Day-Ahead	Real-Time
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total			
Flowgate	(\$7.7)	(\$21.0)	\$6.5	\$19.9	(\$0.4)	\$0.1	(\$9.4)	(\$9.9)	\$10.0	2,002	1,011
Interface	\$1.2	(\$12.7)	\$0.8	\$14.7	\$0.3	\$1.5	(\$1.2)	(\$2.4)	\$12.3	1,385	1,129
Line	\$13.1	(\$35.5)	\$4.5	\$53.2	(\$0.3)	\$1.5	(\$3.0)	(\$4.9)	\$48.3	9,935	2,730
Transformer	\$0.1	(\$5.5)	\$1.3	\$6.9	\$0.1	\$0.2	(\$0.1)	(\$0.2)	\$6.8	2,342	376
Other	\$6.6	(\$1.0)	\$0.9	\$8.5	\$0.2	\$0.5	(\$0.5)	(\$0.8)	\$7.7	1,423	269
Unclassified	\$0.0	(\$0.0)	\$0.0	\$0.1	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	\$0.1	NA	NA
Total	\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	\$85.1	17,087	5,515

Table 11-25 and Table 11-26 compare day-ahead and real-time congestion event hours. Among the hours for which a facility is constrained in the day-ahead energy market, the number of hours during which the facility is also constrained in the real-time energy market are presented in Table 11-25. In the first three months of 2021, there were 14,618 congestion event hours in the day-ahead energy market. Of those day-ahead congestion event hours, only 2,498 (17.1 percent) were also constrained in the real-time energy market. In the first three months of 2020, of the 17,087 day-ahead congestion event hours, only 3,142 (18.4 percent) were binding in the real-time energy market.²⁹

Among the hours for which a facility was constrained in the real-time energy market, the number of hours during which the facility was also constrained in the day-ahead energy market are presented in Table 11-26. In the first three months of 2021, of the 5,484 congestion event hours in the real-time energy market, 2,505 (45.7 percent) were also constrained in the day-ahead energy market. In the first three months of 2020, of the 5,515 real-time congestion event hours, 3,195 (57.9 percent) were also in the day-ahead energy market.

Congestion frequency continued to be significantly higher in the day-ahead energy market than in the real-time energy market in the first three months of 2021. The number of congestion event hours in the day-ahead energy market was about three times the number of congestion event hours in the real-time energy market.

In the real-time market, PJM has the ability to model and monitor almost all PJM transmission facilities. In the day-ahead market, PJM can model and monitor only a portion of PJM transmission facilities. This difference in modeling is the basis of false arbitrage and the source of significant virtual profits. While more constraints are modeled and monitored in the PJM real-time market than the day-ahead market, there is significantly more network flow in the day-ahead market than in the real-time market as a result of virtual bids and offers. Virtual bids and offers also contribute to day-ahead market flows that do not align with realized real-time physical flows. The number of congestion event hours in the day-ahead energy market was about three times the number of congestion event hours in the real-time energy market, despite the fact that only a portion of PJM transmission facilities are modeled in the day-ahead market.

²⁹ Constraints are mapped to transmission facilities. In the day-ahead energy market, within a given hour, a single facility may be associated with multiple constraints. In such situations, the same facility accounts for more than one constraint-hour for a given hour in the day-ahead energy market. Similarly in the real-time market a facility may account for more than one constraint-hour within a given hour.

Table 11-25 Congestion event hours (day-ahead against real-time): January through March, 2020 and 2021

Type	Congestion Event Hours					
	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Day-Ahead Constrained	Corresponding Real-Time Constrained	Percent	Day-Ahead Constrained	Corresponding Real-Time Constrained	Percent
Interface	1,385	942	68.0%	25	7	28.0%
Transformer	2,342	191	8.2%	1,555	268	17.2%
Flowgate	2,002	335	16.7%	1,649	231	14.0%
Line	9,935	1,514	15.2%	10,879	1,789	16.4%
Other	1,423	160	11.2%	510	203	39.8%
Total	17,087	3,142	18.4%	14,618	2,498	17.1%

Table 11-26 Congestion event hours (real-time against day-ahead): January through March, 2020 and 2021

Type	Congestion Event Hours					
	2020 (Jan - Mar)			2021 (Jan - Mar)		
	Real-Time Constrained	Corresponding Day-Ahead Constrained	Percent	Real-Time Constrained	Corresponding Day-Ahead Constrained	Percent
Interface	1,129	979	86.7%	23	7	30.4%
Transformer	376	191	50.8%	396	272	68.7%
Flowgate	1,011	337	33.3%	951	231	24.3%
Line	2,730	1,528	56.0%	3,673	1,792	48.8%
Other	269	160	59.5%	441	203	46.0%
Total	5,515	3,195	57.9%	5,484	2,505	45.7%

Table 11-27 shows congestion costs by facility voltage class for the first three months of 2021. Congestion costs in the first three months of 2021 increased for all facility voltage classes except 500 kV and 345 kV facilities compared to the first three months of 2020.

Table 11-27 Congestion summary (By facility voltage): January through March, 2021

Voltage (kV)	CLMP Credits and Charges (Millions)									Event Hours	
	Day-Ahead				Balancing				Congestion Costs	Day-Ahead	Real-Time
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Costs	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Costs	Total			
765	(\$0.3)	(\$1.2)	\$0.2	\$1.1	(\$0.5)	\$0.3	(\$0.4)	(\$1.2)	(\$0.1)	16	5
500	\$6.3	(\$9.1)	\$0.3	\$15.7	\$0.3	\$1.2	(\$0.6)	(\$1.5)	\$14.2	283	218
345	(\$1.8)	(\$15.6)	\$1.4	\$15.2	(\$4.1)	\$5.3	(\$3.2)	(\$12.6)	\$2.6	1,017	452
230	\$44.7	(\$37.5)	\$11.1	\$93.2	(\$20.7)	\$14.1	(\$18.9)	(\$53.7)	\$39.5	4,842	2,424
161	(\$2.0)	(\$6.4)	\$0.3	\$4.7	(\$0.1)	\$0.5	(\$0.9)	(\$1.4)	\$3.2	248	258
138	\$24.5	(\$50.3)	\$4.2	\$79.0	(\$0.9)	\$16.5	(\$11.8)	(\$29.2)	\$49.9	5,530	1,839
115	\$6.9	(\$3.2)	\$0.4	\$10.4	(\$0.5)	\$0.2	(\$0.2)	(\$0.9)	\$9.6	834	190
69	\$3.9	(\$0.2)	\$1.0	\$5.1	(\$0.1)	\$1.3	(\$0.4)	(\$1.7)	\$3.4	1,848	98
Unclassified	\$0.0	\$0.0	(\$0.0)	\$0.0	(\$0.1)	\$0.6	(\$0.5)	(\$1.2)	(\$1.2)	NA	NA
Total	\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$121.0	14,618	5,484

Table 11-28 Congestion summary (By facility voltage): January through March, 2020

Voltage (kV)	CLMP Credits and Charges (Millions)									Event Hours	
	Day-Ahead				Balancing				Congestion Costs	Day-Ahead	Real-Time
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total			
765	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	0	0
500	\$5.8	(\$16.1)	\$1.2	\$23.1	\$0.3	\$1.9	(\$1.4)	(\$3.1)	\$20.0	1,904	1,247
345	(\$2.4)	(\$6.3)	\$2.7	\$6.6	(\$0.1)	\$0.3	(\$1.9)	(\$2.4)	\$4.2	1,783	199
230	\$13.5	(\$15.8)	\$2.2	\$31.5	\$0.3	\$1.0	(\$1.5)	(\$2.2)	\$29.3	3,466	1,342
161	(\$1.9)	(\$5.1)	\$1.0	\$4.2	(\$0.1)	\$0.5	(\$1.6)	(\$2.2)	\$2.0	466	369
138	(\$11.5)	(\$34.0)	\$6.3	\$28.8	\$0.2	(\$0.4)	(\$7.6)	(\$7.0)	\$21.8	4,691	1,400
115	\$9.0	\$3.1	\$0.2	\$6.0	(\$0.8)	\$0.4	\$0.1	(\$1.1)	\$4.9	1,914	895
69	\$0.9	(\$1.6)	\$0.6	\$3.0	\$0.0	\$0.2	(\$0.1)	(\$0.3)	\$2.7	2,863	63
Unclassified	\$0.0	(\$0.0)	\$0.0	\$0.1	\$0.0	(\$0.0)	(\$0.0)	(\$0.0)	\$0.1	NA	NA
Total	\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	\$85.1	17,087	5,515

Constraint Frequency

Table 11-29 lists the constraints for the first three months of 2020 and 2021 that were most frequently binding and Table 11-30 shows the constraints which experienced the largest change in congestion event hours from the first three months of 2020 to the first three months of 2021. In Table 11-29, constraints are presented in descending order of total day-ahead event hours and real-time event hours for the first three months of 2021. In Table 11-30, the constraints are presented in descending order of absolute value of day-ahead event hour changes plus real-time event hour changes from the first three months of 2020 to the first three months of 2021.

Table 11-29 Top 25 constraints: January through March, 2020 and 2021

No.	Constraint	Type	Event Hours						Percent of Annual Hours					
			Day-Ahead			Real-Time			Day-Ahead			Real-Time		
			(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change
1	Cedar Grove Sub - William	Line	0	1,137	1,137	0	568	568	0.0%	53%	53%	0%	26%	26%
2	Bagley - Raphael Road	Line	0	606	606	0	424	424	0%	28%	28%	0%	20%	20%
3	Berwick - Koonsville	Line	50	842	792	0	1	1	2%	39%	37%	0%	0%	0%
4	East Lima - Haviland	Line	122	410	288	0	243	243	6%	19%	13%	0%	11%	11%
5	Bagley - Graceton	Line	569	371	(198)	179	275	96	26%	17%	(9%)	8%	13%	5%
6	Vienna	Transformer	0	499	499	0	139	139	0%	23%	23%	0%	6%	6%
7	Nottingham	Other	595	317	(278)	200	267	67	27%	15%	(13%)	9%	12%	3%
8	Essex - McCarter	Line	0	328	328	0	106	106	0%	15%	15%	0%	5%	5%
9	Harwood - Susquehanna	Line	199	277	78	128	147	19	9%	13%	4%	6%	7%	1%
10	Benton Harbor - Crystal	Line	0	290	290	0	97	97	0%	13%	13%	0%	4%	4%
11	Maple St - Chrysler	Flowgate	6	232	226	0	136	136	0%	11%	10%	0%	6%	6%
12	Gardners - Texas Eastern	Line	131	318	187	4	39	35	6%	15%	9%	0%	2%	2%
13	Ramapo (ConEd) - S Mahwah (RECO)	Line	0	349	349	0	0	0	0%	16%	16%	0%	0%	0%
14	Quad Cities	Transformer	285	328	43	0	0	0	13%	15%	2%	0%	0%	0%
15	Sub 85 - Sub 18	Flowgate	0	148	148	0	158	158	0%	7%	7%	0%	7%	7%
16	Cumberland - Juniata	Line	119	212	93	70	89	19	5%	10%	4%	3%	4%	1%
17	Bergen - Leonia	Line	7	294	287	0	0	0	0%	14%	13%	0%	0%	0%
18	College Corner - Collinsville	Line	12	179	167	0	101	101	1%	8%	8%	0%	5%	5%
19	All Dam - Kittanning	Line	184	250	66	46	13	(33)	8%	12%	3%	2%	1%	(2%)
20	Graceton - Safe Harbor	Line	96	184	88	28	77	49	4%	9%	4%	1%	4%	2%
21	Butler - Karns City	Line	41	247	206	0	13	13	2%	11%	10%	0%	1%	1%
22	Monroe - Vineland	Line	551	241	(310)	11	0	(11)	25%	11%	(14%)	1%	0%	(1%)
23	Sandburg	Flowgate	176	130	(46)	110	105	(5)	8%	6%	(2%)	5%	5%	(0%)
24	Haumesser Road - Steward	Line	266	68	(198)	197	161	(36)	12%	3%	(9%)	9%	7%	(2%)
25	East Side - North Delphos	Line	0	151	151	0	65	65	0%	7%	7%	0%	3%	3%

Table 11-30 Top 25 constraints with largest year to year change in occurrence: January through March, 2020 and 2021

No.	Constraint	Type	Event Hours						Percent of Annual Hours					
			Day-Ahead			Real-Time			Day-Ahead			Real-Time		
			(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change	(Jan - Mar)	(Jan - Mar)	Change
1	PA Central	Interface	1,340	0	(1,340)	1,126	0	(1,126)	61%	0%	(61%)	52%	0%	(52%)
2	Cedar Grove Sub - William	Line	0	1,137	1,137	0	568	568	0%	53%	53%	0%	26%	26%
3	Lenox - North Meshoppen	Line	968	44	(924)	782	49	(733)	44%	2%	(42%)	36%	2%	(34%)
4	Bagley - Raphael Road	Line	0	606	606	0	424	424	0%	28%	28%	0%	20%	20%
5	Berwick - Koonsville	Line	50	842	792	0	1	1	2%	39%	37%	0%	0%	0%
6	DoeX530	Transformer	691	7	(684)	0	0	0	32%	0%	(31%)	0%	0%	0%
7	Vienna	Transformer	0	499	499	0	139	139	0%	23%	23%	0%	6%	6%
8	Mountain	Transformer	558	10	(548)	0	0	0	26%	0%	(25%)	0%	0%	0%
9	East Lima - Haviland	Line	122	410	288	0	243	243	6%	19%	13%	0%	11%	11%
10	Logtown - North Delphos	Line	402	0	(402)	110	0	(110)	18%	0%	(18%)	5%	0%	(5%)
11	Prince George	Transformer	238	0	(238)	236	0	(236)	11%	0%	(11%)	11%	0%	(11%)
12	Face Rock	Other	610	118	(492)	41	65	24	28%	5%	(22%)	2%	3%	1%
13	Mohomet - ChampTP	Flowgate	336	0	(336)	104	1	(103)	15%	0%	(15%)	5%	0%	(5%)
14	Essex - McCarter	Line	0	328	328	0	106	106	0%	15%	15%	0%	5%	5%
15	Paradise - BR Tap	Flowgate	231	15	(216)	208	8	(200)	11%	1%	(10%)	10%	0%	(9%)
16	Easton - East Muni	Line	402	0	(402)	0	0	0	18%	0%	(18%)	0%	0%	0%
17	Benton Harbor - Crystal	Line	0	290	290	0	97	97	0%	13%	13%	0%	4%	4%
18	Sub 85 - Rock Island	Flowgate	218	0	(218)	154	0	(154)	10%	0%	(10%)	7%	0%	(7%)
19	Maple St - Chrysler	Flowgate	6	232	226	0	136	136	0%	11%	10%	0%	6%	6%
20	Butler - Sherman	Line	354	3	(351)	0	0	0	16%	0%	(16%)	0%	0%	0%
21	Ramapo (ConEd) - S Mahwah (RECO)	Line	0	349	349	0	0	0	0%	16%	16%	0%	0%	0%
22	Seward - Towanda	Line	368	30	(338)	0	0	0	17%	1%	(15%)	0%	0%	0%
23	Monroe - Vineland	Line	551	241	(310)	11	0	(11)	25%	11%	(14%)	1%	0%	(1%)
24	Powerton - Towerline	Flowgate	342	86	(256)	51	0	(51)	16%	4%	(12%)	2%	0%	(2%)
25	Sub 85 - Sub 18	Flowgate	0	148	148	0	158	158	0%	7%	7%	0%	7%	7%

Constraint Costs

Table 11-31 and Table 11-32 show the top constraints contributing to congestion costs by facility for the first three months of 2021 and 2020. The Vienna Transformer was the largest contributor to congestion costs in the first three months of 2021, with \$14.4 million in total congestion costs and 11.9 percent of the total PJM congestion costs in the first three months of 2021. The high shadow prices of the Vienna Transformer were a result of a trip of generation units and a transmission outage in DPL in March.

Table 11-31 Top 25 constraints affecting congestion costs (By facility): January through March, 2021³⁰

CLMP Credits and Charges (Millions)													
Day-Ahead												Balancing	
No.	Constraint	Type	Location	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Congestion Costs	Percent of Total PJM Congestion Costs
1	Vienna	Transformer	DPL	\$12.5	(\$8.3)	\$0.5	\$21.3	(\$9.6)	(\$2.2)	\$0.4	(\$6.9)	\$14.4	11.9%
2	Bagley - Raphael Road	Line	BGE	\$9.0	(\$1.3)	\$1.1	\$11.4	\$1.1	\$0.9	(\$1.0)	(\$0.8)	\$10.6	8.8%
3	Bagley - Graceton	Line	BGE	\$8.7	(\$1.6)	\$0.5	\$10.7	\$0.3	\$0.6	(\$0.0)	(\$0.4)	\$10.4	8.6%
4	Conastone	Transformer	500	\$5.7	(\$4.9)	\$0.1	\$10.7	\$0.2	\$0.4	(\$0.2)	(\$0.3)	\$10.4	8.6%
5	Harwood - Susquehanna	Line	PPL	\$3.1	(\$7.1)	\$0.2	\$10.3	\$0.1	\$0.4	(\$0.0)	(\$0.4)	\$10.0	8.2%
6	Cedar Grove Sub - William	Line	PSEG	\$8.7	(\$9.5)	\$5.2	\$23.3	(\$9.9)	\$8.9	(\$11.7)	(\$30.5)	(\$7.2)	(6.0%)
7	Cumberland - Juniata	Line	PPL	\$0.7	(\$5.7)	\$0.3	\$6.8	\$0.2	\$0.0	(\$0.2)	(\$0.0)	\$6.7	5.6%
8	Bergenfield - Leonia	Line	PSEG	\$0.0	\$0.0	\$0.0	\$0.0	(\$3.4)	\$1.1	(\$1.9)	(\$6.4)	(\$6.4)	(5.3%)
9	Terminal	Transformer	DEOK	(\$0.3)	(\$1.0)	\$0.2	\$0.9	(\$3.4)	\$1.8	(\$0.9)	(\$6.0)	(\$5.1)	(4.2%)
10	East Lima - Haviland	Line	AEP	(\$10.1)	(\$15.6)	\$0.4	\$5.9	(\$0.6)	\$0.2	(\$0.2)	(\$1.0)	\$4.9	4.1%
11	Nottingham	Other	PECO	\$4.9	\$0.7	\$0.6	\$4.8	\$0.0	\$0.0	\$0.0	\$0.0	\$4.8	3.9%
12	Krendale - Shanor Manor	Line	APS	(\$2.4)	(\$7.3)	(\$0.1)	\$4.8	\$0.0	\$0.0	\$0.0	\$0.0	\$4.8	3.9%
13	Five Forks - Rock Ridge Tap	Line	BGE	\$0.9	(\$2.9)	\$0.3	\$4.1	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$4.1	3.4%
14	Quad Cities - Rock Creek	Flowgate	MISO	\$0.1	(\$3.4)	\$0.4	\$3.9	\$0.3	\$0.1	(\$0.4)	(\$0.2)	\$3.7	3.0%
15	Lanesville - Interstate	Flowgate	MISO	\$0.7	(\$1.0)	\$0.0	\$1.7	\$0.4	\$5.2	(\$0.4)	(\$5.2)	(\$3.5)	(2.9%)
16	Benton Harbor - Chrystal	Flowgate	MISO	\$1.1	(\$2.0)	\$0.3	\$3.4	\$0.0	\$0.0	\$0.0	\$0.0	\$3.4	2.8%
17	Dauphin - Juniata	Line	PPL	(\$0.8)	(\$3.9)	\$0.3	\$3.4	\$0.0	\$0.0	\$0.0	\$0.0	\$3.4	2.8%
18	Benton Harbor - Crystal	Line	AEP	\$2.7	\$0.0	\$0.3	\$2.9	(\$2.2)	\$1.5	(\$2.6)	(\$6.3)	(\$3.3)	(2.7%)
19	Graceton - Safe Harbor	Line	BGE	\$2.5	(\$0.5)	\$0.3	\$3.3	\$0.4	\$0.4	(\$0.1)	(\$0.1)	\$3.2	2.6%
20	Will County - Goodings Grove	Line	ComEd	\$4.4	\$2.1	\$0.5	\$2.8	\$0.0	\$0.0	\$0.0	\$0.0	\$2.8	2.3%
21	Bergen - Leonia	Line	PSEG	\$2.1	\$0.1	\$0.8	\$2.8	\$0.0	\$0.0	\$0.0	\$0.0	\$2.8	2.3%
22	Sub 85 - Sub 18	Flowgate	MISO	(\$1.8)	(\$4.8)	\$0.3	\$3.4	\$0.3	\$0.7	(\$0.5)	(\$0.9)	\$2.5	2.0%
23	Gardners - Texas Eastern	Line	Met-Ed	\$0.3	(\$2.0)	(\$0.0)	\$2.3	(\$0.0)	\$0.1	\$0.0	(\$0.1)	\$2.2	1.8%
24	Tanners Creek - Miami Fort	Flowgate	MISO	(\$0.6)	(\$2.7)	\$0.2	\$2.2	\$0.0	\$0.0	\$0.0	\$0.0	\$2.2	1.8%
25	Cook - Olive	Line	AEP	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2	\$2.1	(\$0.2)	(\$2.1)	(\$2.1)	(1.7%)
Top 25 Total				\$52.0	(\$82.6)	\$12.4	\$147.0	(\$25.6)	\$22.2	(\$19.7)	(\$67.5)	\$79.5	65.6%
All Other Constraints				\$30.3	(\$40.9)	\$6.2	\$77.5	(\$1.0)	\$17.7	(\$17.2)	(\$35.9)	\$41.6	34.4%
Total				\$82.3	(\$123.5)	\$18.7	\$224.5	(\$26.7)	\$39.9	(\$36.9)	(\$103.4)	\$121.0	100.0%

³⁰ All flowgates are mapped to MISO as Location if they are flowgates coordinated by both PJM and MISO regardless of the location of the flowgates.

Table 11-32 Top 25 constraints affecting congestion costs (By facility): January through March, 2020³¹

CLMP Credits and Charges (Millions)													
No.	Constraint	Type	Location	Day-Ahead				Balancing				Percent of Total PJM Congestion Costs	
				Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total		
1	PA Central	Interface	500	\$1.1	(\$12.4)	\$0.8	\$14.3	\$0.3	\$1.5	(\$1.2)	(\$2.4)	\$11.9	14.0%
2	Bagley - Graceton	Line	BGE	\$5.8	(\$1.3)	\$0.4	\$7.6	\$0.1	\$0.1	(\$0.1)	(\$0.1)	\$7.6	8.9%
3	Harwood - Susquehanna	Line	PPL	\$1.0	(\$4.8)	\$0.0	\$5.9	(\$0.1)	\$0.4	(\$0.1)	(\$0.5)	\$5.3	6.3%
4	Conastone - Peach Bottom	Line	500	\$3.5	(\$1.5)	\$0.2	\$5.3	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$5.3	6.2%
5	Cumberland - Juniata	Line	PPL	(\$1.2)	(\$5.2)	\$0.3	\$4.3	\$0.0	(\$0.0)	(\$0.2)	(\$0.2)	\$4.1	4.8%
6	Mohomet - ChampIP	Flowgate	MISO	(\$0.5)	(\$3.7)	\$1.8	\$4.9	(\$0.1)	(\$0.4)	(\$1.6)	(\$1.3)	\$3.6	4.3%
7	Logtown - North Delphos	Line	AEP	(\$5.6)	(\$8.6)	\$0.7	\$3.7	\$0.1	\$0.4	(\$0.4)	(\$0.6)	\$3.1	3.7%
8	Quad Cities - Cordova	Flowgate	MISO	(\$1.9)	(\$3.8)	\$1.1	\$3.0	\$0.0	\$0.0	\$0.0	\$0.0	\$3.0	3.5%
9	Nottingham	Other	ATSI	\$3.3	\$0.8	\$0.4	\$2.9	\$0.2	\$0.0	(\$0.2)	\$0.0	\$2.9	3.4%
10	Nottingham	Other	PECO	\$2.8	\$0.7	\$0.2	\$2.3	\$0.0	\$0.0	\$0.0	\$0.0	\$2.3	2.7%
11	Lenox - North Meshoppen	Line	PENELEC	(\$0.5)	(\$3.1)	\$0.0	\$2.6	\$0.0	\$0.5	\$0.0	(\$0.5)	\$2.1	2.5%
12	Paradise - BR Tap	Flowgate	MISO	(\$1.5)	(\$3.5)	\$0.2	\$2.2	\$0.0	\$0.0	(\$0.2)	(\$0.2)	\$2.0	2.4%
13	Seward - Towanda	Line	PENELEC	\$8.5	\$6.8	\$0.1	\$1.9	\$0.0	\$0.0	\$0.0	\$0.0	\$1.9	2.2%
14	Face Rock	Other	PPL	\$0.0	(\$1.7)	\$0.2	\$1.9	\$0.0	\$0.2	\$0.0	(\$0.1)	\$1.8	2.1%
15	Westraver - Yukon	Line	APS	(\$0.8)	(\$2.5)	\$0.2	\$1.9	(\$0.0)	\$0.1	(\$0.1)	(\$0.2)	\$1.7	2.0%
16	Haumesser Road - Steward	Line	ComEd	(\$0.7)	(\$1.9)	\$0.2	\$1.4	\$0.1	(\$0.4)	(\$0.2)	\$0.3	\$1.7	2.0%
17	Powerton - Towerline	Flowgate	MISO	(\$1.0)	(\$1.7)	\$0.8	\$1.6	\$0.0	(\$0.0)	(\$0.0)	\$0.0	\$1.6	1.9%
18	Quad Cities - Cordova Energy	Line	ComEd	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.1)	\$0.4	(\$0.9)	(\$1.5)	(\$1.5)	(1.7)%
19	Danville - East Danville	Line	AEP	(\$0.8)	(\$2.2)	(\$0.0)	\$1.4	\$0.0	(\$0.0)	\$0.0	\$0.0	\$1.4	1.7%
20	Three Mile Island	Transformer	500	\$0.6	(\$0.7)	\$0.1	\$1.4	\$0.1	\$0.1	\$0.0	(\$0.0)	\$1.4	1.6%
21	Northeast - Raphael Road	Line	BGE	\$1.6	\$0.1	\$0.1	\$1.6	\$0.1	\$0.2	(\$0.1)	(\$0.2)	\$1.4	1.6%
22	Peters - Union Jet	Line	APS	(\$0.8)	(\$1.9)	\$0.1	\$1.2	\$0.1	\$0.0	(\$0.0)	(\$0.0)	\$1.2	1.4%
23	Blooming Grove - Paupack	Line	PPL	\$0.3	(\$0.7)	\$0.0	\$1.1	\$0.0	\$0.0	\$0.0	\$0.0	\$1.1	1.2%
24	Collins	Transformer	ComEd	(\$0.1)	(\$0.5)	\$0.6	\$1.0	\$0.0	\$0.0	\$0.0	\$0.0	\$1.0	1.2%
	Prince George	Transformer	Dominion	(\$0.6)	(\$1.4)	\$0.0	\$0.9	(\$0.0)	(\$0.1)	(\$0.0)	\$0.0	\$0.9	1.1%
	Top 25 Total			\$12.8	(\$54.8)	\$8.5	\$76.1	\$0.9	\$3.0	(\$5.2)	(\$7.3)	\$68.9	80.9%
	All Other Constraints			\$0.7	(\$20.9)	\$5.6	\$27.2	(\$1.0)	\$0.9	(\$9.0)	(\$10.9)	\$16.3	19.1%
	Total			\$13.5	(\$75.7)	\$14.1	\$103.3	(\$0.2)	\$3.8	(\$14.2)	(\$18.2)	\$85.1	100.0%

³¹ All flowgates are mapped to MISO as Location if they are flowgates coordinated by both PJM and MISO regardless the location of the flowgates.

Figure 11-4 shows the locations of the top 10 constraints by total congestion costs on a contour map of the real-time, load-weighted average CLMP in the first three months of 2021. Three of the top 10 constraints are located in the BGE Zone: the Bagley - Raphael Road Line, the Bagley - Graceton Line and the Conastone Transformer. Multiple constraints in the BGE Control Zone have been in the top 10 constraints by total congestion costs since 2016.

Figure 11-4 Location of the top 10 constraints by total congestion costs: January through March, 2021

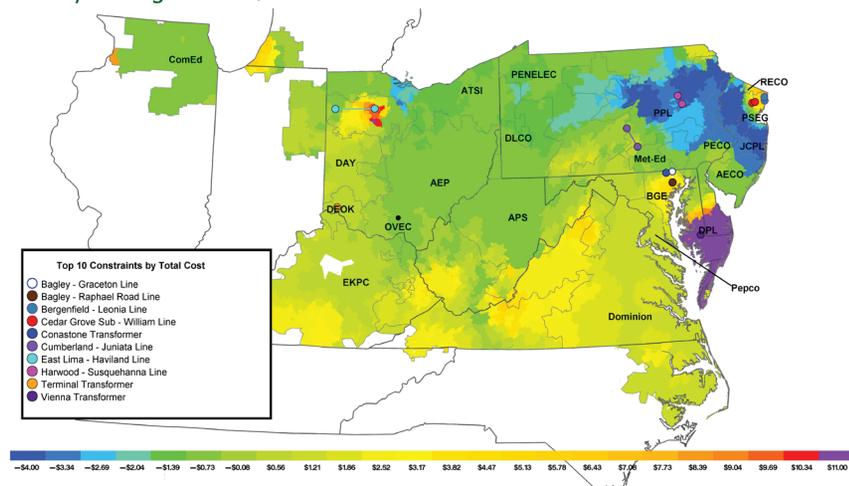


Figure 11-5 shows the locations of the top 10 constraints by balancing congestion costs on a contour map of the real-time, load-weighted, average CLMP in the first three months of 2021.

Figure 11-5 Location of top 10 constraints by balancing congestion costs: January through March, 2021

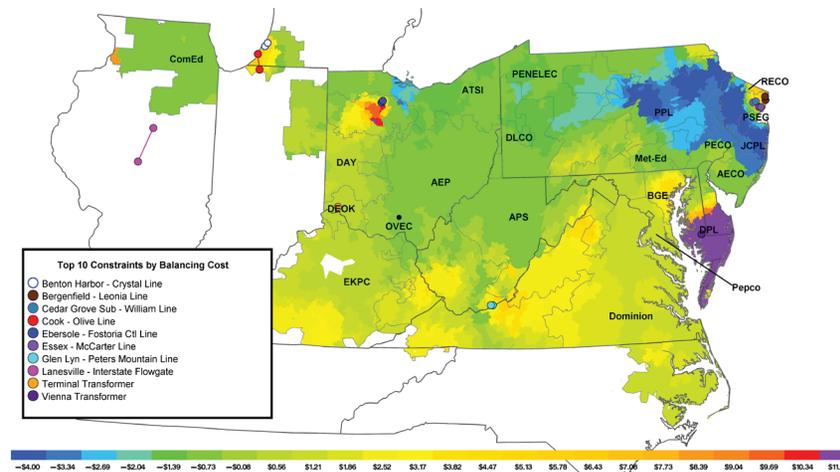
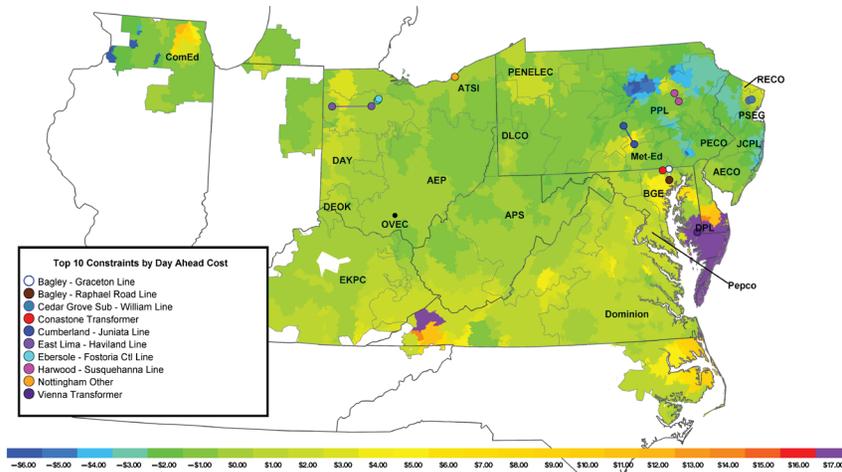


Figure 11-6 shows the locations of the top 10 constraints by day-ahead congestion costs on a contour map of the day-ahead, load-weighted, average CLMP in the first three months of 2021.

Figure 11-6 Location of the top 10 constraints by day-ahead congestion costs: January through March, 2021



Congestion Event Summary: Impact of Changes in UTC Volumes

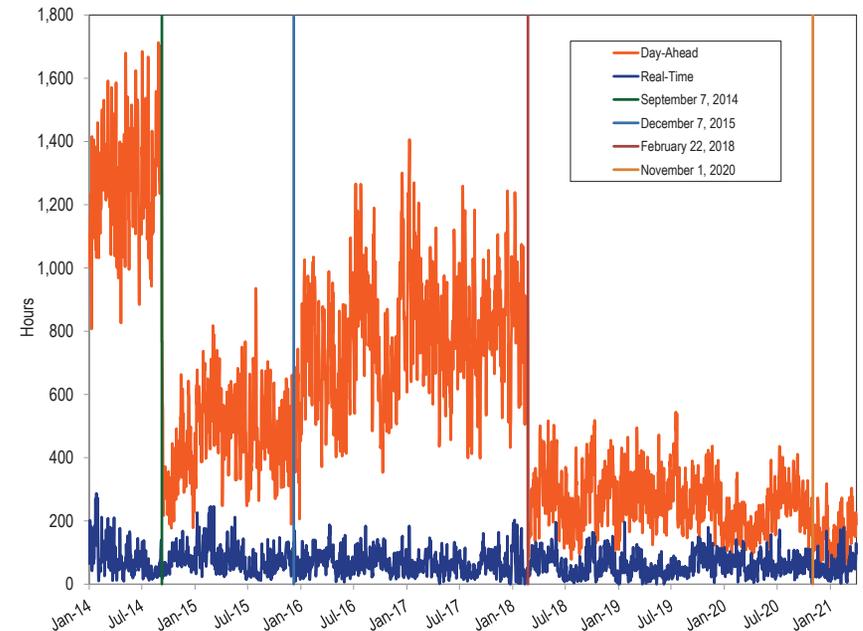
UTCs have a significant impact on congestion events in the day-ahead market and, as a result, contribute to differences between day-ahead and real-time congestion events. The greater the volume of UTCs, the greater the number of congestion events in the day-ahead market and the greater the differences between the day-ahead and real-time congestion events.³²

In the first three months of 2021, the average hourly cleared UTC MW decreased by 55.2 percent, compared to the first three months of 2020. Day-ahead congestion event hours decreased by 14.4 percent from 17,087

congestion event hours in the first three months of 2020 to 14,618 congestion event hours in the first three months of 2021 (Table 11-25).

Figure 11-7 shows the daily day-ahead and real-time congestion event hours for January 2014 through March 2021.

Figure 11-7 Daily congestion event hours: January 2014 through March 2021



³² A series of FERC orders has affected UTC activity which has in turn affected congestion events in the day-ahead market. See Appendix F: Congestion and Marginal Losses.

Marginal Losses

Marginal Loss Accounting

Marginal losses occur in the day-ahead and real-time energy markets. PJM calculates marginal loss costs for each PJM member. The loss cost is based on the applicable day-ahead and real-time marginal loss component of LMP (MLMP). Losses are the difference between what load (withdrawals) pay for energy and what generation (injections) are paid for energy, due to transmission line losses.

Losses increase with distance between sources and sinks and the amount of power moved. Total loss collected (loss surplus) increases with load, holding distance and resistance constant. Every incremental increase in load has to be met with a slightly larger increment of generation. The result is that the total energy losses increase as load increases.

Ignoring interchange, total generation MWh must be greater than total load MWh in any hour in order to provide for losses. Total marginal loss costs, analogous to total congestion costs, are equal to the net of the withdrawal loss charges minus injection loss credits, plus explicit loss charges, incurred in both the day-ahead energy market and the balancing energy market.

Total marginal loss costs can be more accurately thought of as net marginal loss costs. Total marginal loss costs equal implicit marginal loss charges plus explicit marginal loss charges plus net inadvertent loss charges. Implicit marginal loss charges equal withdrawal loss charges minus injection loss credits. Net explicit marginal loss costs are the net marginal loss costs associated with point to point energy transactions. Net inadvertent loss charges are the losses associated with the hourly difference between the net actual energy flow and the net scheduled energy flow into or out of the PJM control area.³³ Unlike the other categories of marginal loss accounting, inadvertent loss charges are costs not directly attributable to specific participants. Inadvertent loss charges are assigned to participants based on real-time load (excluding losses) ratio

³³ PJM Operating Agreement Schedule 1 §3.7.

share.³⁴ Each of these categories of marginal loss costs is comprised of day-ahead and balancing marginal loss costs.

The accounting definitions can be misleading. Load pays losses. Losses are the difference between what load pays for energy and what generation is paid for energy due to losses. Generation does not pay losses. Some generation receives a price lower than SMP and some generation receives a price greater than SMP due to the MLMP but that does not mean that generation is paying or being paid losses. It means that generation is being paid an LMP that is higher or lower than the system load-weighted, average LMP due to losses on the system.

While PJM accounting focuses on MLMPs, the individual MLMP values at any bus are irrelevant to the calculation of total losses. Total losses are the net surplus revenue that remains after all sources and sinks are credited or charged their LMPs. Changing the components of LMP by electing a different reference bus does not change the LMPs or the difference between LMPs for a given market solution or losses, it merely changes the components of the LMP.

The MLMP component of LMP is the marginal cost of energy, due to losses associated with serving load at the bus. The MLMP at the load weighted reference bus is the marginal cost of energy at the load weighted reference bus (holding the proportion of load at every bus constant). Due to losses, MLMP is non zero at the load reference bus. The LMP at the load reference bus is the system marginal price of energy (SMP) plus the marginal cost of energy due to losses at the reference bus.

Load-weighted LMP components are calculated relative to a load-weighted, average LMP. LMPs at specific load buses will reflect the fact that marginal generators must produce more (or less) energy due to losses to serve that bus than is needed to serve the load weighted reference bus. The LMP at any bus is a function of the SMP, losses and congestion. Relative to the system marginal price (SMP) at the load weighted reference bus, the loss factor can be either positive or negative.

³⁴ *Id.*

At the load-weighted reference bus, the LMP includes no congestion component, but does include a loss component. The load weighted, average MLMP across all load buses, calculated relative to that reference bus is positive. The LMPs at the load buses are a function of marginal generation bus LMPs determined through the least cost security constrained economic dispatch which accounts for transmission constraints and marginal losses.

Other than the effect on the optimal dispatch point, LMP at the marginal generator bus, and therefore the payment to the generator, is not affected by marginal losses. By paying for losses based on marginal instead of average losses at the load bus, a revenue over collection occurs.

The residual difference between total marginal loss related load charges (day-ahead and balancing) and marginal loss related generation credits (day-ahead and balancing) after virtual bids have settled their marginal loss related credits and charges for their day-ahead and balancing positions is total loss. That is, losses are the difference between what withdrawals (load) are paying for energy and what injections (generation) are being paid for energy due to losses, after virtual bids marginal loss related charges and credits are settled at the end of the market day. Load is the source of the net loss surplus after generation is paid and virtuals are settled at the end of the market day. Load pays losses. Generation does not pay losses.

Day-ahead marginal loss costs are based on day-ahead MWh priced at the marginal loss price component of LMP. Balancing marginal loss costs are based on the load or generation deviations between the day-ahead and real-time energy markets priced at the marginal loss price component of LMP in the real-time energy market. If a participant has real-time generation or load that is greater than its day-ahead generation or load then the deviation will be positive. If there is a positive load deviation at a bus where the real-time LMP has a positive marginal loss component, positive balancing marginal loss costs will result. Similarly, if there is a positive load deviation at a bus where real-time LMP has a negative marginal loss component, negative balancing marginal loss costs will result. If a participant has real-time generation or load that is less than its day-ahead generation or load then the deviation will be

negative. If there is a negative load deviation at a bus where real-time LMP has a positive marginal loss component, negative balancing marginal loss costs will result. Similarly, if there is a negative load deviation at a bus where real-time LMP has a negative marginal loss component, positive balancing marginal loss costs will result.

The total marginal loss surplus is the remaining loss amount from collection of marginal losses, after accounting for total system energy costs and net residual market adjustments. The marginal loss surplus is allocated to PJM market participants based on real-time load plus export ratio share as marginal loss credits.³⁵

Day-Ahead Implicit Load MLMP Charges

- **Day-Ahead Implicit Load MLMP Charges.** Day-ahead implicit load MLMP charges are calculated for all cleared demand, decrement bids and day-ahead energy market sale transactions. Day-ahead implicit load MLMP charges are calculated using MW and the load bus MLMP, the decrement bid MLMP or the MLMP at the source of the sale transaction.
- **Day-Ahead Implicit Generation MLMP Credits.** Day-ahead implicit generation MLMP credits are calculated for all cleared generation and increment offers and day-ahead energy market purchase transactions. Day-ahead implicit generation MLMP credits are calculated using MW and the generator bus MLMP, the increment offer MLMP or the MLMP at the sink of the purchase transaction.
- **Balancing Implicit Load MLMP Charges.** Balancing implicit load MLMP charges are calculated for all deviations between a PJM member's real-time load and energy sale transactions and their day-ahead cleared demand, decrement bids and energy sale transactions. Balancing implicit load MLMP charges are calculated using MW deviations and the real-time MLMP for each bus where a deviation exists.
- **Balancing Implicit Generation MLMP Credits.** Balancing implicit Generation MLMP credits are calculated for all deviations between a PJM member's real-time generation and energy purchase transactions and the day-ahead

³⁵ See PJM, "Manual 28: Operating Agreement Accounting," Rev. 84 (Dec. 17, 2020).

cleared generation, increment offers and energy purchase transactions. Balancing implicit Generation MLMP credits are calculated using MW deviations and the real-time MLMP for each bus where a deviation exists.

- **Explicit Loss Charges.** Explicit loss charges are the net loss costs associated with point to point energy transactions, including UTCs. These costs equal the product of the transacted MW and MLMP differences between sources (origins) and sinks (destinations) in the day-ahead energy market. Balancing energy market explicit loss costs equal the product of the differences between the real-time and day-ahead transacted MW and the differences between the real-time MLMP at the transactions' sources and sinks.
- **Inadvertent Loss Charges.** Inadvertent loss charges are the net loss charges resulting from the differences between the net actual energy flow and the net scheduled energy flow into or out of the PJM control area each hour. This inadvertent interchange of energy may be positive or negative, where positive interchange typically results in a charge while negative interchange typically results in a credit. Inadvertent loss charges are common costs, not directly attributable to specific participants, that are distributed on a load plus export ratio basis.³⁶

Total Marginal Loss Cost

Total marginal loss is the difference between what withdrawals (load) pay for energy and what injections (generation) are paid for energy due to losses, after generation is paid and virtuals' marginal loss related charges and credits are settled. Load pays losses.

The total marginal loss cost in PJM for the first three months of 2021 was \$209.7 million, which was comprised of implicit load MLMP charges of \$2.1 million minus implicit generation MLMP credits of -\$208.8 million plus explicit loss charges of -\$1.2 million plus inadvertent loss charges of \$0.0 million (Table 11-34).

³⁶ PJM Operating Agreement Schedule 1 §3.7.

Monthly marginal loss costs in the first three months of 2021 ranged from \$47.2 million in March to \$102.7 million in February. Total marginal loss surplus increased in the first three months of 2021 by \$43.8 million or 131.9 percent from \$33.2 million in the first three months of 2020 to \$77.1 million in the first three months of 2021.

Table 11-33 shows the total marginal loss component costs and the total PJM billing for the first three months of 2008 through 2021.

Table 11-33 Total loss component costs (Dollars (Millions)): January through March, 2008 through 2021³⁷

(Jan - Mar)	Loss Costs	Percent Change	Total PJM Billing	Percent of PJM Billing
2008	\$607	NA	\$7,718	7.9%
2009	\$454	(25.2%)	\$7,515	6.0%
2010	\$417	(8.2%)	\$8,415	5.0%
2011	\$410	(1.7%)	\$9,584	4.3%
2012	\$234	(42.8%)	\$6,938	3.4%
2013	\$278	18.5%	\$7,762	3.6%
2014	\$776	179.5%	\$21,070	3.7%
2015	\$425	(45.2%)	\$14,040	3.0%
2016	\$170	(60.0%)	\$9,500	1.8%
2017	\$172	0.9%	\$9,710	1.8%
2018	\$339	97.9%	\$14,520	2.3%
2019	\$204	(39.9%)	\$10,980	1.9%
2020	\$109	(46.8%)	\$8,110	1.3%
2021	\$210	93.2%	\$10,400	2.0%

³⁷ The loss costs include net inadvertent charges.

Table 11-34 shows PJM total marginal loss costs by accounting category for the first three months of 2008 through 2021. Table 11-35 shows PJM total marginal loss costs by accounting category by market for the first three months of 2008 through 2021.

Table 11-34 Total marginal loss costs by accounting category (Dollars (Millions)): January through March, 2008 through 2021

Marginal Loss Costs (Millions)					
(Jan - Mar)	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Inadvertent Charges	Total
2008	(\$52.1)	(\$634.0)	\$25.1	\$0.0	\$606.9
2009	(\$21.3)	(\$460.6)	\$14.7	\$0.0	\$454.0
2010	(\$3.8)	(\$414.1)	\$6.3	(\$0.0)	\$416.6
2011	(\$26.5)	(\$421.2)	\$14.9	\$0.0	\$409.6
2012	(\$11.2)	(\$252.1)	(\$6.6)	\$0.0	\$234.3
2013	\$8.0	(\$277.8)	(\$8.2)	(\$0.0)	\$277.6
2014	(\$15.1)	(\$813.7)	(\$22.8)	\$0.0	\$775.9
2015	(\$4.0)	(\$434.0)	(\$4.9)	\$0.0	\$425.1
2016	(\$8.0)	(\$184.4)	(\$6.3)	\$0.0	\$170.1
2017	(\$13.0)	(\$196.2)	(\$11.6)	(\$0.0)	\$171.5
2018	(\$13.2)	(\$356.7)	(\$4.0)	\$0.0	\$339.4
2019	(\$13.7)	(\$220.9)	(\$3.2)	\$0.0	\$203.9
2020	(\$9.8)	(\$122.1)	(\$3.8)	(\$0.0)	\$108.5
2021	\$2.1	(\$208.8)	(\$1.2)	\$0.0	\$209.7

Table 11-35 Total marginal loss costs by accounting category by market (Dollars (Millions)): January through March, 2008 through 2021

Marginal Loss Costs (Millions)										
(Jan - Mar)	Day-Ahead				Balancing				Inadvertent Charges	Grand Total
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total		
2008	(\$17.1)	(\$603.7)	\$31.3	\$617.9	(\$35.0)	(\$30.2)	(\$6.2)	(\$11.0)	\$0.0	\$606.9
2009	(\$23.3)	(\$457.6)	\$30.9	\$465.2	\$2.1	(\$3.0)	(\$16.3)	(\$11.2)	\$0.0	\$454.0
2010	(\$8.5)	(\$413.5)	\$12.8	\$417.8	\$4.7	(\$0.6)	(\$6.5)	(\$1.2)	(\$0.0)	\$416.6
2011	(\$37.1)	(\$430.1)	\$26.0	\$419.1	\$10.6	\$8.9	(\$11.1)	(\$9.5)	\$0.0	\$409.6
2012	(\$16.7)	(\$256.8)	\$8.0	\$248.1	\$5.6	\$4.7	(\$14.6)	(\$13.8)	\$0.0	\$234.3
2013	(\$0.1)	(\$288.2)	\$8.1	\$296.2	\$8.1	\$10.4	(\$16.3)	(\$18.6)	(\$0.0)	\$277.6
2014	(\$48.6)	(\$847.4)	\$32.3	\$831.1	\$33.5	\$33.7	(\$55.1)	(\$55.3)	\$0.0	\$775.9
2015	(\$17.4)	(\$441.6)	\$7.8	\$432.0	\$13.5	\$7.6	(\$12.8)	(\$6.9)	\$0.0	\$425.1
2016	(\$10.7)	(\$186.3)	\$7.6	\$183.3	\$2.7	\$1.9	(\$14.0)	(\$13.2)	\$0.0	\$170.1
2017	(\$15.1)	(\$197.5)	\$17.5	\$199.9	\$2.1	\$1.3	(\$29.1)	(\$28.3)	(\$0.0)	\$171.5
2018	(\$15.3)	(\$352.2)	\$10.1	\$347.0	\$2.1	(\$4.5)	(\$14.1)	(\$7.5)	\$0.0	\$339.4
2019	(\$13.8)	(\$219.3)	\$14.5	\$219.9	\$0.1	(\$1.6)	(\$17.7)	(\$16.1)	\$0.0	\$203.9
2020	(\$10.0)	(\$122.6)	\$9.5	\$122.0	\$0.2	\$0.4	(\$13.2)	(\$13.4)	(\$0.0)	\$108.5
2021	\$2.7	(\$208.8)	\$9.0	\$220.5	(\$0.6)	(\$0.0)	(\$10.2)	(\$10.8)	\$0.0	\$209.7

Table 11-36 and Table 11-37 show PJM accounting based total loss costs for each transaction type in the first three months of 2021 and 2020.

Virtual transaction loss costs, when positive, measure the total loss costs to virtual transactions and when negative, measure the total loss credits to virtual transaction. In the first three months of 2021, DECs paid \$1.6 million in LLMP charges in the day-ahead market, were paid \$0.6 million in LLMP credits in the balancing energy market and paid \$1.0 million in total LLMP charges. In the first three months of 2021, INCs paid \$2.8 million in LLMP charges in the day-ahead market, were paid \$3.3 million in LLMP credits in the balancing energy market and were paid \$0.5 million in total LLMP credits. In the first three months of 2021, up to congestion paid \$9.1 million in LLMP charges in the day-ahead market, were paid \$10.5 million in LLMP credits in the balancing energy market and received \$1.4 million in total LLMP credits.

Table 11-36 Total loss costs by transaction type by market (Dollars (Millions)): January through March, 2021

Transaction Type	Marginal Loss Costs (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Grand Total
DEC	\$1.6	\$0.0	\$0.0	\$1.6	(\$0.6)	\$0.0	\$0.0	(\$0.6)	\$0.0	\$1.0
Demand	\$8.7	\$0.0	\$0.0	\$8.7	\$1.0	\$0.0	\$0.0	\$1.0	\$0.0	\$9.6
Demand Response	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0
Explicit Congestion and Loss Only	\$0.0	\$0.0	(\$0.2)	(\$0.2)	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	(\$0.2)
Export	(\$4.3)	\$0.0	(\$0.0)	(\$4.3)	(\$0.5)	\$0.0	\$0.2	(\$0.3)	\$0.0	(\$4.6)
Generation	\$0.0	(\$202.3)	\$0.0	\$202.3	\$0.0	(\$2.0)	\$0.0	\$2.0	\$0.0	\$204.3
Import	\$0.0	(\$0.5)	\$0.0	\$0.5	\$0.0	(\$0.9)	\$0.0	\$0.9	\$0.0	\$1.4
INC	\$0.0	(\$2.8)	\$0.0	\$2.8	\$0.0	\$3.3	\$0.0	(\$3.3)	\$0.0	(\$0.5)
Internal Bilateral	(\$3.3)	(\$3.1)	\$0.1	\$0.0	(\$0.5)	(\$0.5)	\$0.0	(\$0.0)	\$0.0	(\$0.0)
Up to Congestion	\$0.0	\$0.0	\$9.1	\$9.1	\$0.0	\$0.0	(\$10.5)	(\$10.5)	\$0.0	(\$1.4)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Total	\$2.7	(\$208.8)	\$9.0	\$220.5	(\$0.6)	(\$0.0)	(\$10.2)	(\$10.8)	\$0.0	\$209.7

Table 11-37 Total loss costs by transaction type by market (Dollars (Millions)): January through March, 2020

Transaction Type	Marginal Loss Costs (Millions)									
	Day-Ahead				Balancing					
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Inadvertent Charges	Grand Total
DEC	(\$0.6)	\$0.0	\$0.0	(\$0.6)	\$0.7	\$0.0	\$0.0	\$0.7	\$0.0	\$0.1
Demand	(\$1.0)	\$0.0	\$0.0	(\$1.0)	\$0.6	\$0.0	\$0.0	\$0.6	\$0.0	(\$0.4)
Demand Response	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)
Explicit Congestion and Loss Only	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)
Export	(\$2.5)	\$0.0	(\$0.0)	(\$2.5)	(\$0.8)	\$0.0	\$0.1	(\$0.6)	\$0.0	(\$3.2)
Generation	\$0.0	(\$114.6)	\$0.0	\$114.6	\$0.0	(\$1.3)	\$0.0	\$1.3	\$0.0	\$115.9
Import	\$0.0	(\$0.3)	\$0.0	\$0.3	\$0.0	(\$0.4)	(\$0.0)	\$0.4	\$0.0	\$0.6
INC	\$0.0	(\$1.9)	\$0.0	\$1.9	\$0.0	\$2.4	\$0.0	(\$2.4)	\$0.0	(\$0.5)
Internal Bilateral	(\$5.9)	(\$5.8)	\$0.1	(\$0.0)	(\$0.3)	(\$0.3)	\$0.0	(\$0.0)	\$0.0	(\$0.0)
Up to Congestion	\$0.0	\$0.0	\$9.4	\$9.4	\$0.0	\$0.0	(\$13.4)	(\$13.4)	\$0.0	(\$3.9)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.0	(\$0.0)
Total	(\$10.0)	(\$122.6)	\$9.5	\$122.0	\$0.2	\$0.4	(\$13.2)	(\$13.4)	\$0.0	\$108.5

Monthly Marginal Loss Costs

Table 11-38 shows a monthly summary of marginal loss costs by market type for January 2020 through March 2021.

Table 11-38 Monthly marginal loss costs by market (Millions): January 2020 through March 2021

	Marginal Loss Costs (Millions)							
	2020				2021			
	Day-Ahead	Balancing	Inadvertent Charges	Total	Day-Ahead	Balancing	Inadvertent Charges	Total
Jan	\$49.8	(\$5.3)	(\$0.0)	\$44.5	\$62.0	(\$2.1)	(\$0.0)	\$59.9
Feb	\$39.8	(\$4.6)	(\$0.0)	\$35.2	\$107.7	(\$5.1)	\$0.0	\$102.7
Mar	\$32.4	(\$3.5)	(\$0.0)	\$28.8	\$50.8	(\$3.7)	\$0.0	\$47.2
Apr	\$25.9	(\$3.4)	(\$0.0)	\$22.5				
May	\$30.4	(\$4.8)	\$0.0	\$25.7				
Jun	\$41.0	(\$4.3)	\$0.0	\$36.7				
Jul	\$73.2	(\$6.1)	\$0.0	\$67.0				
Aug	\$59.8	(\$5.8)	(\$0.0)	\$54.0				
Sep	\$39.1	(\$4.4)	\$0.0	\$34.8				
Oct	\$37.0	(\$3.0)	\$0.0	\$34.0				
Nov	\$37.8	(\$1.4)	\$0.0	\$36.4				
Dec	\$59.9	(\$1.1)	\$0.0	\$58.8				
Total	\$526.3	(\$47.7)	\$0.0	\$478.5	\$220.5	(\$10.8)	\$0.0	\$209.7

Figure 11-8 shows PJM monthly marginal loss costs for January 2008 through March 2021.

Figure 11-8 Monthly marginal loss costs (Dollars (Millions)): January 2008 through March 2021

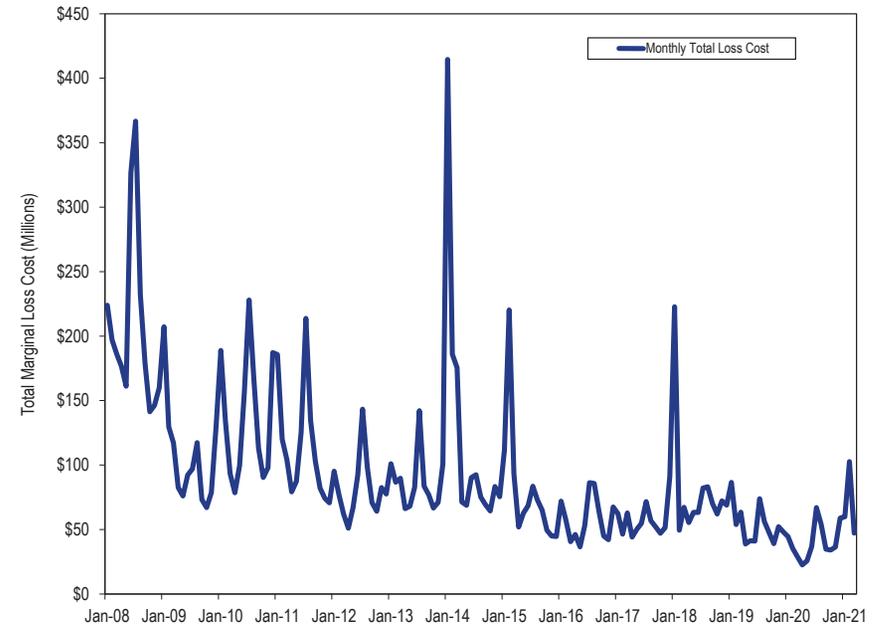


Table 11-39 shows the monthly total loss costs for each virtual transaction type in January 2020 through March 2021.

Table 11-39 Monthly loss charges by virtual transaction type and by market (Dollars (Millions)): January 2020 through March 2021

		Marginal Loss Charges (Millions)									
		DEC			INC			Up to Congestion			
Year		Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	Grand Total
2020	Jan	(\$0.1)	\$0.1	(\$0.0)	\$0.7	(\$0.9)	(\$0.2)	\$3.7	(\$5.2)	(\$1.5)	(\$1.7)
	Feb	(\$0.1)	\$0.2	\$0.0	\$0.6	(\$0.8)	(\$0.2)	\$3.2	(\$4.4)	(\$1.2)	(\$1.3)
	Mar	(\$0.3)	\$0.4	\$0.1	\$0.6	(\$0.7)	(\$0.1)	\$2.5	(\$3.7)	(\$1.2)	(\$1.3)
	Apr	(\$0.2)	\$0.4	\$0.1	\$0.6	(\$0.7)	(\$0.1)	\$2.3	(\$3.5)	(\$1.2)	(\$1.1)
	May	(\$0.1)	\$0.2	\$0.1	\$0.8	(\$0.8)	\$0.0	\$3.7	(\$4.8)	(\$1.1)	(\$0.9)
	Jun	(\$0.2)	\$0.5	\$0.2	\$0.5	(\$0.6)	(\$0.1)	\$3.1	(\$4.6)	(\$1.4)	(\$1.3)
	Jul	(\$0.3)	\$0.8	\$0.4	\$0.9	(\$0.9)	(\$0.0)	\$5.1	(\$6.5)	(\$1.4)	(\$1.0)
	Aug	(\$0.1)	\$0.4	\$0.3	\$0.6	(\$0.7)	(\$0.1)	\$4.1	(\$6.2)	(\$2.2)	(\$2.0)
	Sep	(\$0.1)	\$0.2	\$0.2	\$0.5	(\$0.6)	(\$0.1)	\$2.8	(\$4.2)	(\$1.4)	(\$1.4)
	Oct	\$0.0	\$0.1	\$0.2	\$0.7	(\$0.8)	(\$0.1)	\$2.5	(\$3.0)	(\$0.6)	(\$0.5)
	Nov	(\$0.5)	\$0.6	\$0.1	\$0.7	(\$0.8)	(\$0.0)	\$1.6	(\$2.1)	(\$0.4)	(\$0.4)
	Dec	\$0.3	\$0.1	\$0.4	\$0.7	(\$0.9)	(\$0.3)	\$1.9	(\$2.4)	(\$0.5)	(\$0.4)
	Total	(\$1.8)	\$3.9	\$2.1	\$7.7	(\$9.0)	(\$1.3)	\$36.5	(\$50.6)	(\$14.1)	(\$13.3)
2021	Jan	\$0.3	(\$0.1)	\$0.2	\$0.8	(\$1.1)	(\$0.3)	\$2.2	(\$2.6)	(\$0.4)	(\$0.5)
	Feb	\$1.1	(\$0.7)	\$0.4	\$0.8	(\$0.9)	(\$0.1)	\$4.5	(\$4.7)	(\$0.2)	\$0.1
	Mar	\$0.2	\$0.2	\$0.4	\$1.2	(\$1.3)	(\$0.2)	\$2.5	(\$3.2)	(\$0.7)	(\$0.5)
	Total	\$1.6	(\$0.6)	\$1.0	\$2.8	(\$3.3)	(\$0.5)	\$9.1	(\$10.5)	(\$1.4)	(\$0.8)

Marginal Loss Costs and Loss Credits

Total marginal loss surplus is calculated by adding the total system energy costs, the total marginal loss costs and net residual market adjustments. The total system energy costs are equal to the net implicit energy charges (implicit withdrawal charges minus implicit injection credits) plus net inadvertent energy charges. Total marginal loss costs are equal to the net implicit marginal loss charges (implicit load MLMP charges less implicit generation MLMP credits) plus net explicit loss charges plus net inadvertent loss charges.

Ignoring interchange, total generation MWh must be greater than total load MWh in any hour in order to provide for losses. Since the hourly integrated energy component of LMP is the same for every bus within every hour, the net energy bill is negative (ignoring net interchange), with more injection

credits than withdrawal charges in every hour. The greater the level of load the greater the difference between energy charges collected from load (SMP x load MW) and credited to generation (SMP x generation MW). Total system energy costs plus total marginal loss costs plus net residual market adjustments equal marginal loss credits which are distributed to the PJM market participants according to the ratio of their real-time load plus their real-time exports to total PJM real-time load plus real-time exports as marginal loss credits. The net residual market adjustment is calculated as known day-ahead error value minus day-ahead loss MW congestion value and minus balancing loss MW congestion value.

Table 11-40 shows the total system energy costs, the total marginal loss costs collected, the net residual market adjustments and total marginal loss surplus redistributed for the first three months of 2008 through 2021. The total marginal loss surplus increased \$43.8 million or 131.9 percent in the first three months of 2021 from the first three months of 2020.

Table 11-40 Marginal loss surplus (Dollars (Millions)): January through March, 2008 through 2021³⁸

(Jan - Mar)	Marginal Loss Surplus (Millions)					Total Marginal Loss Surplus
	System Energy Cost	Marginal Loss Costs	Net Residual Market Adjustments			
			Known Day-Ahead Error	Day-Ahead Loss MW Congestion	Balancing Loss MW Congestion	
2008	(\$288.2)	\$606.9	\$0.0	\$0.0	\$0.0	\$318.7
2009	(\$218.3)	\$454.0	(\$0.0)	(\$0.4)	(\$0.1)	\$236.2
2010	(\$207.6)	\$416.6	\$0.0	(\$0.9)	(\$0.0)	\$209.9
2011	(\$209.9)	\$409.6	\$0.0	\$0.0	(\$0.0)	\$199.7
2012	(\$136.4)	\$234.3	(\$0.0)	(\$0.5)	\$0.0	\$98.3
2013	(\$177.9)	\$277.6	\$0.1	\$0.3	\$0.0	\$99.4
2014	(\$515.3)	\$775.9	\$0.0	\$3.1	\$0.2	\$257.2
2015	(\$271.7)	\$425.1	(\$0.5)	\$2.9	(\$0.0)	\$150.0
2016	(\$113.6)	\$170.1	\$0.0	\$0.8	(\$0.0)	\$55.7
2017	(\$122.1)	\$171.5	\$0.0	\$0.2	(\$0.0)	\$49.2
2018	(\$226.6)	\$339.4	(\$0.0)	\$1.2	(\$0.0)	\$111.6
2019	(\$136.3)	\$203.9	\$0.0	\$0.7	(\$0.0)	\$66.9
2020	(\$75.3)	\$108.5	(\$0.0)	(\$0.0)	(\$0.0)	\$33.2
2021	(\$131.7)	\$209.7	(\$0.0)	\$1.0	(\$0.0)	\$77.1

System Energy Costs Energy Accounting

The system energy component of LMP is the system reference bus LMP, also called the system marginal price (SMP). The system energy cost is based on the day-ahead and real-time energy components of LMP. Total system energy costs, analogous to total congestion costs or total loss costs, are equal to the withdrawal energy charges minus injection energy credits, incurred in both the day-ahead energy market and the balancing energy market, plus net inadvertent energy charges. Total system energy costs can be more accurately thought of as net system energy costs.

³⁸ The net residual market adjustments included in the table are comprised of the known day-ahead error value minus the sum of the day-ahead loss MW congestion value, balancing loss MW congestion value and measurement error caused by missing data.

Total System Energy Costs

The total system energy cost for the first three months of 2021 was -\$131.7 million, which was comprised of implicit withdrawal energy charges of \$8,663.3 million, implicit injection energy credits of \$8,795.7 million, explicit energy charges of \$0.0 million and inadvertent energy charges of \$0.6 million. The monthly system energy costs for the first three months of 2021 ranged from -\$63.1 million in February to -\$30.8 million in March.

Table 11-41 shows total system energy costs and total PJM billing, for the first three months of 2008 through 2021.

Table 11-41 Total system energy costs (Dollars (Millions)): January through March, 2008 through 2021³⁹

(Jan - Mar)	System Energy Costs	Percent Change	Total PJM Billing	Percent of PJM Billing
2008	(\$288)	NA	\$7,718	(3.7%)
2009	(\$218)	(24.2%)	\$7,515	(2.9%)
2010	(\$208)	(4.9%)	\$8,415	(2.5%)
2011	(\$210)	1.1%	\$9,584	(2.2%)
2012	(\$136)	(35.0%)	\$6,938	(2.0%)
2013	(\$178)	30.4%	\$7,762	(2.3%)
2014	(\$515)	189.7%	\$21,070	(2.4%)
2015	(\$272)	(47.3%)	\$14,040	(1.9%)
2016	(\$114)	(58.2%)	\$9,500	(1.2%)
2017	(\$122)	7.5%	\$9,710	(1.3%)
2018	(\$227)	85.6%	\$14,520	(1.6%)
2019	(\$136)	(39.8%)	\$10,980	(1.2%)
2020	(\$75)	(44.8%)	\$8,110	(0.9%)
2021	(\$132)	74.8%	\$10,400	(1.3%)

³⁹ The system energy costs include net inadvertent charges.

System energy costs for the first three months of 2008 through 2021 are shown in Table 11-42 and Table 11-43. Table 11-42 shows PJM system energy costs by accounting category and Table 11-43 shows PJM system energy costs by market category.

Table 11-42 Total system energy costs by accounting category (Dollars (Millions)): January through March, 2008 through 2021

System Energy Costs (Millions)					
(Jan - Mar)	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Inadvertent Charges	Total
2008	\$28,435.7	\$28,723.9	\$0.0	\$0.0	(\$288.2)
2009	\$14,058.4	\$14,277.4	\$0.0	\$0.7	(\$218.3)
2010	\$13,424.4	\$13,629.0	\$0.0	(\$3.0)	(\$207.6)
2011	\$11,943.9	\$12,160.7	\$0.0	\$6.9	(\$209.9)
2012	\$8,485.4	\$8,628.7	\$0.0	\$6.8	(\$136.4)
2013	\$10,357.2	\$10,535.1	\$0.0	(\$0.0)	(\$177.9)
2014	\$28,506.2	\$29,014.7	\$0.0	(\$6.9)	(\$515.3)
2015	\$15,702.1	\$15,976.4	\$0.0	\$2.6	(\$271.7)
2016	\$7,764.7	\$7,879.3	\$0.0	\$1.0	(\$113.6)
2017	\$8,789.3	\$8,910.2	\$0.0	(\$1.3)	(\$122.1)
2018	\$13,910.8	\$14,142.2	\$0.0	\$4.7	(\$226.6)
2019	\$8,856.0	\$8,993.5	\$0.0	\$1.2	(\$136.3)
2020	\$5,541.1	\$5,616.0	\$0.0	(\$0.4)	(\$75.3)
2021	\$8,663.3	\$8,795.7	\$0.0	\$0.6	(\$131.7)

Table 11-43 Total system energy costs by market category (Dollars (Millions)): January through March, 2008 through 2021

System Energy Costs (Millions)										
(Jan - Mar)	Day-Ahead				Balancing				Inadvertent Charges	Grand Total
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total		
2008	\$20,253.8	\$20,579.6	\$0.0	(\$325.8)	\$8,182.0	\$8,144.3	\$0.0	\$37.6	\$0.0	(\$288.2)
2009	\$14,129.6	\$14,375.6	\$0.0	(\$246.0)	(\$71.2)	(\$98.2)	\$0.0	\$27.0	\$0.7	(\$218.3)
2010	\$13,408.9	\$13,619.2	\$0.0	(\$210.2)	\$15.5	\$9.8	\$0.0	\$5.6	(\$3.0)	(\$207.6)
2011	\$12,055.5	\$12,259.3	\$0.0	(\$203.9)	(\$111.6)	(\$98.6)	\$0.0	(\$12.9)	\$6.9	(\$209.9)
2012	\$8,534.4	\$8,649.0	\$0.0	(\$114.6)	(\$49.0)	(\$20.4)	\$0.0	(\$28.6)	\$6.8	(\$136.4)
2013	\$10,387.2	\$10,580.9	\$0.0	(\$193.7)	(\$29.9)	(\$45.8)	\$0.0	\$15.9	(\$0.0)	(\$177.9)
2014	\$28,412.1	\$29,082.9	\$0.0	(\$670.9)	\$94.2	(\$68.3)	\$0.0	\$162.4	(\$6.9)	(\$515.3)
2015	\$15,764.8	\$16,077.5	\$0.0	(\$312.6)	(\$62.7)	(\$101.1)	\$0.0	\$38.4	\$2.6	(\$271.7)
2016	\$7,847.5	\$7,997.9	\$0.0	(\$150.4)	(\$82.8)	(\$118.6)	\$0.0	\$35.8	\$1.0	(\$113.6)
2017	\$8,927.5	\$9,111.3	\$0.0	(\$183.8)	(\$138.1)	(\$201.1)	\$0.0	\$63.0	(\$1.3)	(\$122.1)
2018	\$13,877.2	\$14,123.7	\$0.0	(\$246.5)	\$33.6	\$18.5	\$0.0	\$15.1	\$4.7	(\$226.6)
2019	\$8,965.4	\$9,131.8	\$0.0	(\$166.4)	(\$109.4)	(\$138.4)	\$0.0	\$28.9	\$1.2	(\$136.3)
2020	\$5,612.2	\$5,708.5	\$0.0	(\$96.3)	(\$71.1)	(\$92.5)	\$0.0	\$21.4	(\$0.4)	(\$75.3)
2021	\$8,749.4	\$8,901.4	\$0.0	(\$152.0)	(\$86.0)	(\$105.7)	\$0.0	\$19.7	\$0.6	(\$131.7)

Table 11-44 and Table 11-45 show the total system energy costs for each transaction type in the first three months of 2021 and 2020. In the first three months of 2021, generation was paid \$6,535.9 million and demand paid \$6,067.3 million in net energy payment. In the first three months of 2020, generation was paid \$3,980.6 million and demand paid \$3,763.2 million in net energy payment.

Table 11-44 Total system energy costs by transaction type by market (Dollars (Millions)): January through March, 2021

Transaction Type	System Energy Costs (Millions)								Grand Total
	Day-Ahead				Balancing				
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	
DEC	\$327.3	\$0.0	\$0.0	\$327.3	(\$322.7)	\$0.0	\$0.0	(\$322.7)	\$4.5
Demand	\$6,007.6	\$0.0	\$0.0	\$6,007.6	\$59.7	\$0.0	\$0.0	\$59.7	\$6,067.3
Demand Response	(\$0.2)	\$0.0	\$0.0	(\$0.2)	\$0.2	\$0.0	\$0.0	\$0.2	(\$0.0)
Export	\$243.7	\$0.0	\$0.0	\$243.7	\$156.8	\$0.0	\$0.0	\$156.8	\$400.5
Generation	\$0.0	\$6,566.9	\$0.0	(\$6,566.9)	\$0.0	(\$31.0)	\$0.0	\$31.0	(\$6,535.9)
Import	\$0.0	\$16.3	\$0.0	(\$16.3)	\$0.0	\$51.6	\$0.0	(\$51.6)	(\$67.8)
INC	\$0.0	\$147.2	\$0.0	(\$147.2)	\$0.0	(\$146.3)	\$0.0	\$146.3	(\$0.9)
Internal Bilateral	\$2,171.0	\$2,171.0	\$0.0	(\$0.0)	\$11.9	\$11.9	\$0.0	\$0.0	\$0.0
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$8.1	\$0.0	(\$8.1)	(\$8.1)
Wheel Out	\$0.0	\$0.0	\$0.0	\$0.0	\$8.1	\$0.0	\$0.0	\$8.1	\$8.1
Total	\$8,749.4	\$8,901.4	\$0.0	(\$152.0)	(\$86.0)	(\$105.7)	\$0.0	\$19.7	(\$132.3)

Table 11-45 Total system energy costs by transaction type by market (Dollars (Millions)): January through March, 2020

Transaction Type	System Energy Costs (Millions)								Grand Total
	Day-Ahead				Balancing				
	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	Implicit Withdrawal Charges	Implicit Injection Credits	Explicit Charges	Total	
DEC	\$131.3	\$0.0	\$0.0	\$131.3	(\$129.7)	\$0.0	\$0.0	(\$129.7)	\$1.6
Demand	\$3,772.5	\$0.0	\$0.0	\$3,772.5	(\$9.3)	\$0.0	\$0.0	(\$9.3)	\$3,763.2
Demand Response	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)
Export	\$127.1	\$0.0	\$0.0	\$127.1	\$53.6	\$0.0	\$0.0	\$53.6	\$180.7
Generation	\$0.0	\$4,002.0	\$0.0	(\$4,002.0)	\$0.0	(\$21.4)	\$0.0	\$21.4	(\$3,980.6)
Import	\$0.0	\$14.5	\$0.0	(\$14.5)	\$0.0	\$23.1	\$0.0	(\$23.1)	(\$37.6)
INC	\$0.0	\$110.6	\$0.0	(\$110.6)	\$0.0	(\$108.4)	\$0.0	\$108.4	(\$2.2)
Internal Bilateral	\$1,581.3	\$1,581.3	\$0.0	(\$0.0)	\$6.6	\$6.6	\$0.0	(\$0.0)	(\$0.0)
Wheel In	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$7.7	\$0.0	(\$7.7)	(\$7.7)
Wheel Out	\$0.0	\$0.0	\$0.0	\$0.0	\$7.7	\$0.0	\$0.0	\$7.7	\$7.7
Total	\$5,612.2	\$5,708.5	\$0.0	(\$96.3)	(\$71.1)	(\$92.5)	\$0.0	\$21.4	(\$74.9)

Monthly System Energy Costs

Table 11-46 shows a monthly summary of system energy costs by market type for January 2020 through March 2021. Total balancing system energy costs in the first three months of 2021 decreased from the first three months of 2020. Monthly total system energy costs in the first three months of 2021 ranged from -\$63.1 million in February to -\$30.8 million in March.

Table 11-46 Monthly system energy costs by market type (Dollars (Millions)): January 2020 through March 2021

	System Energy Costs (Millions)							
	2020				2021			
	Day-Ahead	Balancing	Inadvertent Charges	Total	Day-Ahead	Balancing	Inadvertent Charges	Total
Jan	(\$40.0)	\$9.4	(\$0.1)	(\$30.7)	(\$42.7)	\$5.0	(\$0.1)	(\$37.8)
Feb	(\$30.7)	\$6.8	(\$0.3)	(\$24.2)	(\$73.5)	\$9.6	\$0.7	(\$63.1)
Mar	(\$25.5)	\$5.2	(\$0.1)	(\$20.4)	(\$35.8)	\$5.1	\$0.0	(\$30.8)
Apr	(\$21.1)	\$5.2	(\$0.0)	(\$15.9)				
May	(\$25.4)	\$6.9	\$0.4	(\$18.1)				
Jun	(\$32.8)	\$7.6	\$0.6	(\$24.6)				
Jul	(\$52.4)	\$9.0	\$0.9	(\$42.5)				
Aug	(\$44.9)	\$9.9	(\$0.2)	(\$35.2)				
Sep	(\$30.7)	\$7.6	\$0.6	(\$22.5)				
Oct	(\$29.4)	\$7.3	\$0.3	(\$21.9)				
Nov	(\$27.3)	\$2.3	\$0.1	(\$24.9)				
Dec	(\$41.2)	\$2.7	\$0.2	(\$38.3)				
Total	(\$401.4)	\$79.9	\$2.5	(\$319.0)	(\$152.0)	\$19.7	\$0.6	(\$131.7)

Figure 11-9 shows PJM monthly system energy costs for January through March, 2008 through 2021. Ignoring interchange, total generation MWh must be greater than total load MWh in any hour in order to provide for losses. Since the hourly integrated energy component of LMP (SMP) is the same for every bus in the market in every hour, the net energy bill is always negative (ignoring net interchange): $(SMP \times \text{withdrawals} + SMP \times \text{injections}) < 0$. Assuming power balance is maintained in the presence of losses, the greater the level of load the greater the difference between energy charges collected from load ($SMP \times \text{load MW}$) and credited to generation ($SMP \times \text{generation MW}$). With higher load levels, there are generally higher SMPs and more negative total energy charges.

Figure 11-9 Monthly system energy costs (Millions): January 2008 through March 2021

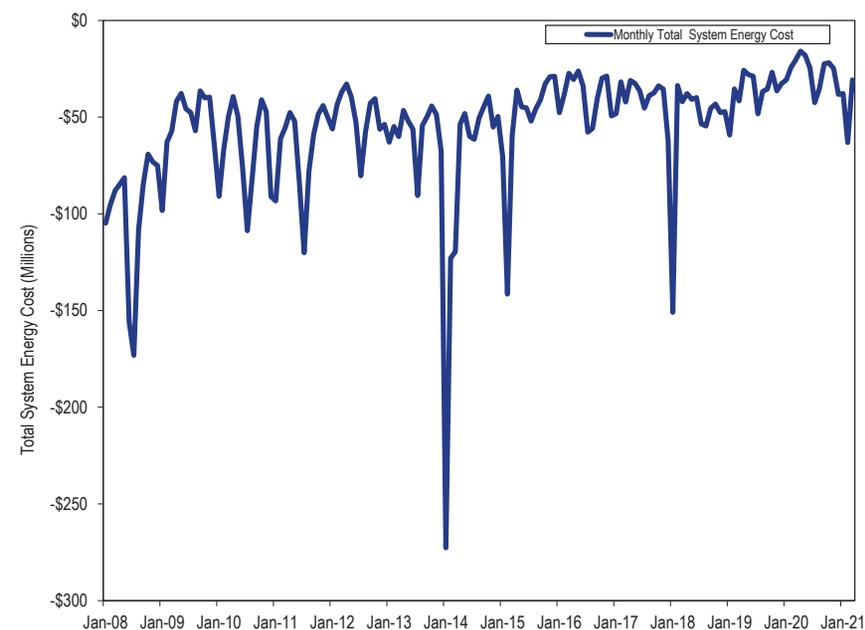


Table 11-47 shows the monthly total system energy costs for each virtual transaction type in the first three months of 2021 and year of 2020. In the first three months of 2021, DECs paid \$327.3 million in energy charges in the day-ahead market, were paid \$322.7 million in energy credits in the balancing energy market and paid \$4.5 million in total energy charges. In the first three months of 2021, INCs were paid \$147.2 million in energy credits in the day-ahead market, paid \$146.3 million in energy charges in the balancing market and were paid \$0.9 million in total energy credits. In the first three months of 2020, DECs paid \$131.3 million in energy charges in the day-ahead market, were paid \$129.7 million in energy credits in the balancing energy market and paid \$1.6 million in total energy charges. In the first three months of 2020, INCs were paid \$110.6 million in energy credits in the day-ahead market, paid \$108.4 million in energy charges in the balancing energy market and were

paid \$2.2 million in total energy credits. The system energy costs are zero for UTCs because the system energy costs for UTCs equal the difference in the energy component between source and sink and the energy component is the same at all buses.

Table 11-47 Monthly energy charges by virtual transaction type and by market (Dollars (Millions)): January 2020 through March 2021

		Energy Charges (Millions)						
		DEC			INC			
Year		Day-Ahead	Balancing	Total	Day-Ahead	Balancing	Total	Grand Total
2020	Jan	\$44.4	(\$43.3)	\$1.0	(\$44.0)	\$43.2	(\$0.8)	\$0.2
	Feb	\$43.0	(\$42.4)	\$0.6	(\$34.5)	\$33.5	(\$1.0)	(\$0.3)
	Mar	\$43.9	(\$44.0)	(\$0.1)	(\$32.1)	\$31.7	(\$0.4)	(\$0.5)
	Apr	\$42.4	(\$43.8)	(\$1.4)	(\$32.4)	\$33.6	\$1.2	(\$0.2)
	May	\$59.9	(\$62.4)	(\$2.5)	(\$34.7)	\$35.2	\$0.5	(\$2.0)
	Jun	\$79.9	(\$83.8)	(\$3.9)	(\$32.4)	\$33.2	\$0.8	(\$3.1)
	Jul	\$116.8	(\$119.2)	(\$2.4)	(\$48.7)	\$49.9	\$1.2	(\$1.2)
	Aug	\$99.9	(\$105.4)	(\$5.5)	(\$35.0)	\$35.7	\$0.7	(\$4.8)
	Sep	\$77.6	(\$76.2)	\$1.4	(\$33.4)	\$32.6	(\$0.8)	\$0.6
	Oct	\$78.9	(\$81.4)	(\$2.5)	(\$39.2)	\$40.9	\$1.7	(\$0.8)
	Nov	\$72.4	(\$74.8)	(\$2.4)	(\$38.4)	\$38.8	\$0.4	(\$2.1)
	Dec	\$92.6	(\$95.1)	(\$2.5)	(\$40.5)	\$41.4	\$0.9	(\$1.6)
	Total	\$851.8	(\$871.8)	(\$20.0)	(\$445.5)	\$449.8	\$4.3	(\$15.7)
2021	Jan	\$76.5	(\$76.2)	\$0.3	(\$41.9)	\$41.6	(\$0.3)	(\$0.0)
	Feb	\$167.0	(\$157.6)	\$9.4	(\$54.4)	\$51.4	(\$3.0)	\$6.5
	Mar	\$83.8	(\$89.0)	(\$5.2)	(\$50.9)	\$53.3	\$2.4	(\$2.8)
	Total	\$327.3	(\$322.7)	\$4.5	(\$147.2)	\$146.3	(\$0.9)	\$3.7

Generation and Transmission Planning¹

Overview

Generation Interconnection Planning

Existing Generation Mix

- As of March 31, 2021, PJM had a total installed capacity of 197,274.9 MW, of which 49,877.4 MW (25.3 percent) are coal fired steam units, 50,194.0 MW (25.4 percent) are combined cycle units and 33,452.6 MW (17.0 percent) are nuclear units. This measure of installed capacity differs from capacity market installed capacity because it includes energy only units, excludes all external units, and uses nameplate values for solar and wind resources.
- Of the 197,274.9 MW of installed capacity, 71,985.4 MW (36.5 percent) are from units older than 40 years, of which 38,446.4 MW (53.4 percent) are coal fired steam units, 191.0 MW (0.3 percent) are combined cycle units and 16,184.6 MW (22.5 percent) are nuclear units.

Generation Retirements²

- There are 45,070.3 MW of generation that have been, or are planned to be, retired between 2011 and 2024, of which 32,084.1 MW (71.2 percent) are coal fired steam units. Coal unit retirements are primarily a result of the inability of coal units to compete with efficient combined cycle units burning low cost natural gas.
- In the first three months of 2021, 430.4 MW of generation retired. The largest generator that retired in the first three months of 2021 was the 237.9 MW Birchwood coal fired steam unit located in the Dominion Zone. Of the 430.4 MW of generation that retired, 353.4 MW (82.1 percent) were located in the Dominion Zone.
- As of March 31, 2021, there are 4,622.5 MW of generation that have requested retirement after March 31, 2021, of which 1,786.5 MW (38.7

percent) are located in the COMED Zone. Of the generation requesting retirement in the COMED Zone, all 1,786.5 MW (100.0 percent) are nuclear units.

Generation Queue³

- There were 173,182.4 MW in generation queues, in the status of active, under construction or suspended, at the end of 2020. In the first three months of 2021, the AG2 queue window closed. As projects move through the queue process, projects can be removed from the queue due to incomplete or invalid data, withdrawn by the market participant or placed in service. On March 31, 2021, there were 177,645.3 MW in generation queues, in the status of active, under construction or suspended, an increase of 4,462.9 MW (2.6 percent) from the end of 2020.⁴
- As of March 31, 2021, 5,982 projects, representing 668,740.7 MW, have entered the queue process since its inception in 1998. Of those, 967 projects, representing 73,369.0 MW, went into service. Of the projects that entered the queue process, 3,088 projects, representing 417,726.4 MW (62.5 percent of the MW) withdrew prior to completion. Such projects may create barriers to entry for projects that would otherwise be completed by taking up queue positions, increasing interconnection costs and creating uncertainty.
- As of March 31, 2021, 177,645.3 MW were in generation request queues in the status of active, under construction or suspended. Based on historical completion rates, 37,491.5 MW of new generation in the queue are expected to go into service.
- The number of queue entries has increased during the past several years, primarily renewable projects. Of the 3,330 projects entered from January 2015 through March 2021, 2,515 projects (75.5 percent) were renewable. Of the 140 projects entered in the first three months of 2021, 117 projects (83.6 percent) were renewable. Renewable projects make up 79.1 percent of all projects in the queue and those projects account for 76.0 percent of

¹ Totals presented in this section include corrections to historical data and may not match totals presented in previous reports.

² See PJM. Planning. "Generator Deactivations," (Accessed on March 31, 2021) <<http://www.pjm.com/planning/services-requests/generator-deactivations.aspx>>.

³ See PJM. Planning. "New Services Queue," (Accessed on March 31, 2021) <<https://www.pjm.com/planning/services-requests/interconnection-queues.aspx>>.

⁴ The queue totals in this report are the winter net MW energy for the interconnection requests ("MW Energy") as shown in the queue.

the nameplate MW currently active, suspended or under construction in the queue as of March 31, 2021.

But of the 134,968.2 MW of renewable projects in the queue, only 7,506.5 MW (5.6 percent) of capacity resources are expected to go into service, based on both historical completion rates and average derate factors for wind and solar.

Regional Transmission Expansion Plan (RTEP)

Market Efficiency Process

- There are significant issues with PJM's benefit/cost analysis that should be addressed prior to approval of additional projects. PJM's benefit/cost analysis does not correctly account for the costs of increased congestion associated with market efficiency projects.
- Through March 31, 2021, PJM has completed four market efficiency cycles under Order No. 1000.⁵

PJM MISO Interregional Market Efficiency Process (IMEP)

- PJM and MISO developed a process to facilitate the construction of interregional projects in response to the Commission's concerns about interregional coordination along the PJM-MISO seam. This process, called the Interregional Market Efficiency Process (IMEP), operates on a two year study schedule and is designed to address forward looking congestion.

But the use of an inaccurate cost-benefit method by PJM and the correct method by MISO results in an over allocation of the costs associated with joint PJM/MISO projects to PJM participants and in some cases approval of projects that do not pass an accurate cost-benefit test.

⁵ See *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Order No. 1000, FERC Stats. & Regs. ¶ 31,323 (2011) (Order No. 1000), *order on reh'g*, Order No. 1000-A, 139 FERC ¶ 61,132 (2012).

PJM MISO Targeted Market Efficiency Process (TMEP)

- PJM and MISO developed the Targeted Market Efficiency Process (TMEP) to facilitate the resolution of historic congestion issues that could be addressed through small, quick implementation projects.

Supplemental Transmission Projects

- Supplemental projects are defined to be “transmission expansions or enhancements that are not required for compliance with PJM criteria and are not state public policy projects according to the PJM Operating Agreement. These projects are used as inputs to RTEP models, but are not required for reliability, economic efficiency or operational performance criteria, as determined by PJM.”⁶ Supplemental projects are exempt from the competitive planning process.
- The average number of supplemental projects in each expected in service year increased by 795.0 percent, from 20 for years 1998 through 2007 (pre Order No. 890⁷) to 179 for years 2008 through 2021 (post Order 890).
- The process for designating projects as supplemental projects should be reviewed and modified to ensure that the supplemental project designation is not used to exempt transmission projects from a transparent, robust and clearly defined mechanism to permit competition to build the project, or used to effectively replace the RTEP process.⁸

End of Life Transmission Projects

- An end of life transmission project is a project submitted for the purpose of replacing existing infrastructure that is at, or is approaching, the end of its useful life. End of life transmission projects should be included in the RTEP process and should be subject to a transparent, robust and clearly

⁶ See PJM, “Transmission Construction Status,” (Accessed on March 31, 2021) <<http://www.pjm.com/planning/rtep-upgrades-status/construct-status.aspx>>.

⁷ See *Preventing Undue Discrimination and Preference in Transmission Service*, Order No. 890, 118 FERC ¶ 61,119, *order on reh'g*, Order No. 890-A, 121 FERC ¶ 61,297 (2007), *order on reh'g*, Order No. 890-B, 123 FERC ¶ 61,299 (2008), *order on reh'g*, Order No. 890-C, 126 FERC ¶ 61,228, *order on clarification*, Order No. 890-D, 129 FERC ¶ 61,126 (2009).

⁸ FERC accepted tariff provisions that exclude supplemental projects from competition in the RTEP. 162 FERC ¶ 61,129 (2018), *reh'g denied*, 164 FERC ¶ 61,217 (2018).

defined mechanism to permit competition to build the project. Under the current approach, end of life projects are excluded from competition.⁹

Board Authorized Transmission Upgrades

- The Transmission Expansion Advisory Committee (TEAC) reviews internal and external proposals to improve transmission reliability throughout PJM. These proposals, which include reliability baseline, network, market efficiency and targeted market efficiency projects, as well as scope changes and project cancellations, but exclude supplemental and end of life projects, are periodically presented to the PJM Board of Managers for authorization.¹⁰ In the first three months of 2021, the PJM Board approved \$349.8 million in upgrades. As of March 31, 2021, the PJM Board has approved \$38.2 billion in system enhancements since 1999.

Transmission Competition

- The MMU makes several recommendations related to the competitive transmission planning process. The recommendations include improved process transparency, incorporation of competition between transmission and generation alternatives and the removal of barriers to competition from nonincumbent transmission. These recommendations would help ensure that the process is an open and transparent process that results in the most competitive solutions.
- On May 24, 2018, the PJM Markets and Reliability Committee (MRC) approved a motion that required PJM, with input from the MMU, to develop a comparative framework to evaluate the quality and effectiveness of competitive transmission proposals with binding cost containment proposals compared to proposals from incumbent and nonincumbent transmission companies without cost containment provisions.

⁹ In recent decisions addressing competing proposals on end of life projects, the Commission accepted a transmission owner proposal excluding end of life projects from competition in the RTEP process, 172 FERC ¶ 61,136 (2020), *reh'g denied*, 173 FERC ¶ 61,225 (2020), and rejected a proposal from PJM stakeholders that would have included end of life projects in competition in the RTEP process, 173 FERC ¶ 61,242 (2020).

¹⁰ Supplemental Projects, including the end of life subset of supplemental projects, do not require PJM Board of Managers authorization.

Qualifying Transmission Upgrades (QTU)

- A Qualifying Transmission Upgrade (QTU) is an upgrade to the transmission system that increases the Capacity Emergency Transfer Limit (CETL) into an LDA and can be offered into capacity auctions as capacity. Once a QTU is in service, the upgrade is eligible to continue to offer the approved incremental import capability into future RPM Auctions. As of March 31, 2021, no QTUs have cleared a Base Residual Auction or an Incremental Auction.

Transmission Facility Outages

- PJM maintains a list of reportable transmission facilities. When the reportable transmission facilities need to be taken out of service, PJM transmission owners are required to report planned transmission facility outages as early as possible. PJM processes the transmission facility outage requests according to rules in PJM's Manual 3 to decide if the outage is on time or late and whether or not they will allow the outage.¹¹
- There were 16,542 transmission outage requests submitted in the first ten months of the 2020/2021 planning period. Of the requested outages, 77.2 percent of the requested outages were planned for less than or equal to five days and 8.4 percent of requested outages were planned for greater than 30 days. Of the requested outages, 42.7 percent were late according to the rules in PJM's Manual 3.

Recommendations

Generation Retirements

- The MMU recommends that the question of whether Capacity Interconnection Rights (CIRs) should persist after the retirement of a unit be addressed. The rules need to ensure that incumbents cannot exploit control of CIRs to block or postpone entry of competitors.¹² (Priority: Low. First reported 2013. Status: Partially adopted, 2012.)

¹¹ See PJM. "PJM Manual 03: Transmission Operations," Rev. 58 (November 19, 2020).

¹² See "Comments of the Independent Market Monitor for PJM," Docket No. ER12-1177-000 (March 12, 2012) <http://www.monitoringanalytics.com/Filings/2012/IMM_Comments_ER12-1177-000_20120312.PDF>.

Generation Queue

- The MMU recommends that barriers to entry be addressed in a timely manner in order to help ensure that the capacity market will result in the entry of new capacity to meet the needs of PJM market participants and reflect the uncertainty and resultant risks in the cost of new entry used to establish the capacity market demand curve in RPM. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends improvements in queue management including that PJM establish a review process to ensure that projects are removed from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress, subject to rules to prevent gaming. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends continuing analysis of the study phase of PJM's transmission planning to reduce the need for postponements of study results, to decrease study completion times, and to improve the likelihood that a project at a given phase in the study process will successfully go into service. (Priority: Medium. First reported 2014. Status: Partially adopted.)
- The MMU recommends outsourcing interconnection studies to an independent party to avoid potential conflicts of interest. Currently, these studies are performed by incumbent transmission owners under PJM's direction. This creates potential conflicts of interest, particularly when transmission owners are vertically integrated and the owner of transmission also owns generation. (Priority: Low. First reported 2013. Status: Not adopted.)

Market Efficiency Process

- The MMU recommends that the market efficiency process be eliminated because it is not consistent with a competitive market design. (Priority: Medium. First reported 2019. Status: Not adopted.)

- The MMU recommends that, if the market efficiency process is retained, PJM modify the rules governing benefit/cost analysis, the evaluation process for selecting among competing market efficiency projects and cost allocation for economic projects in order to ensure that all costs, including increased congestion costs and the risk of project cost increases, in all zones are included in order to ensure that the correct metrics are used for defining benefits. (Priority: Medium. First reported 2018. Status: Not adopted.)

Comparative Cost Framework

- The MMU recommends that PJM modify the project proposal templates to include data necessary to perform a detailed project lifetime financial analysis. The required data includes, but is not limited to: capital expenditure; capital structure; return on equity; cost of debt; tax assumptions; ongoing capital expenditures; ongoing maintenance; and expected life. (Priority: Medium. First reported 2020. Status: Not adopted.)

Transmission Competition

- The MMU recommends, to increase the role of competition, that the exemption of supplemental projects from the Order No. 1000 competitive process be terminated and that the basis for all such exemptions be reviewed and modified to ensure that the supplemental project designation is not used to exempt transmission projects from a transparent, robust and clearly defined mechanism to permit competition to build such projects or to effectively replace the RTEP process. (Priority: Medium. First reported 2017. Status: Not adopted. Rejected by FERC.)
- The MMU recommends, to increase the role of competition, that the exemption of end of life projects from the Order No. 1000 competitive process be terminated and that end of life transmission projects be included in the RTEP process and should be subject to a transparent, robust and clearly defined mechanism to permit competition to build such projects. (Priority: Medium. First reported 2019. Status: Not adopted. Rejected by FERC.)

- The MMU recommends that PJM enhance the transparency and queue management process for nonincumbent transmission investment. Issues related to data access and complete explanations of cost impacts should be addressed. The goal should be to remove barriers to competition from nonincumbent transmission providers. (Priority: Medium. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM continue to incorporate the principle that the goal of transmission planning should be the incorporation of transmission investment decisions into market driven processes as much as possible. (Priority: Low. First reported 2001. Status: Not adopted.)
- The MMU recommends the creation of a mechanism to permit a direct comparison, or competition, between transmission and generation alternatives, including which alternative is less costly and who bears the risks associated with each alternative. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM establish fair terms of access to rights of way and property, such as at substations, in order to remove any barriers to entry and permit competition between incumbent transmission providers and nonincumbent transmission providers in the RTEP. (Priority: Medium. First reported 2014. Status: Not adopted.)
- The MMU recommends that rules be implemented to permit competition to provide financing for transmission projects. This competition could reduce the cost of capital for transmission projects and significantly reduce total costs to customers. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that rules be implemented to require that project cost caps on new transmission projects be part of the evaluation of competing projects. (Priority: Medium. First reported 2015. Status: Adopted 2020.)
- The MMU recommends that storage resources not be includable as transmission assets for any reason. (Priority: High. First reported 2020. Status: Not adopted.)

Cost Allocation

- The MMU recommends a comprehensive review of the ways in which the solution based dfax is implemented. The goal for such a process would be to ensure that the most rational and efficient approach to implementing the solution based dfax method is used in PJM. Such an approach should allocate costs consistent with benefits and appropriately calibrate the incentives for investment in new transmission capability. No replacement approach should be approved until all potential alternatives, including the status quo, are thoroughly reviewed. (Priority: Medium. First reported 2020. Status: Not adopted.)
- The MMU recommends consideration of changing the minimum distribution factor in the allocation from 0.01 to 0.00 and adding a threshold minimum usage impact on the line.¹³ (Priority: Medium. First reported 2015. Status: Not adopted.)

Transmission Line Ratings

- The MMU recommends that all PJM transmission owners use the same methods to define line ratings, subject to NERC standards and guidelines, subject to review by NERC and approval by FERC. (Priority: Medium. First reported 2019. Status: Not adopted.)

Transmission Facility Outages

- The MMU recommends that PJM reevaluate all transmission outage tickets as on time or late as if they were new requests when an outage is rescheduled, and apply the standard rules for late submissions to any such outages. (Priority: Low. First reported 2014. Status: Not adopted.)
- The MMU recommends that PJM draft a clear definition of the congestion analysis required for transmission outage requests to include in Manual 3 after appropriate review. (Priority: Low. First reported 2015. Status: Not adopted.)

¹³ See the *2015 State of the Market Report for PJM*, Volume II, Section 12: Generation and Transmission Planning, at p. 463, Cost Allocation Issues.

- The MMU recommends that PJM modify the rules to reduce or eliminate the approval of late outage requests submitted or rescheduled after the FTR auction bidding opening date. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not permit transmission owners to divide long duration outages into smaller segments to avoid complying with the requirements for long duration outages. (Priority: Low. First reported 2015. Status: Not adopted.)

Conclusion

The goal of PJM market design should be to enhance competition and to ensure that competition is the driver for all the key elements of PJM markets. But transmission investments have not been fully incorporated into competitive markets. The construction of new transmission facilities has significant impacts on the energy and capacity markets. But when generating units retire or load increases, there is no market mechanism in place that would require direct competition between transmission and generation to meet loads in the affected area. In addition, despite FERC Order No. 1000, there is not yet a transparent, robust and clearly defined mechanism to permit competition to build transmission projects, to ensure that competitors provide a total project cost cap, or to obtain least cost financing through the capital markets.

The MMU recognizes that the Commission has recently issued orders that are inconsistent with the recommendations of the MMU and that PJM cannot unilaterally modify those directives. It remains the recommendation of the MMU that the PJM rules for competitive transmission development through the RTEP should build upon FERC Order No. 1000 to create real competition between incumbent transmission providers and nonincumbent transmission providers. The ability of transmission owners to block competition for supplemental projects and end of life projects and reasons for that policy should be reevaluated. PJM should enhance the transparency and queue management process for nonincumbent transmission investment. Issues related to data access and complete explanations of cost impacts should be addressed. The goal should be to remove barriers to competition from nonincumbent

transmission. Another element of opening competition would be to consider transmission owners' ownership of property and rights of way at or around transmission substations. In many cases, the land acquired included property intended to support future expansion of the grid. Incumbents have included the costs of the property in their rate base, paid for by customers. Because PJM now has the responsibility for planning the development of the grid under its RTEP process, property bought to facilitate future expansion should be a part of the RTEP process and be made available to all providers on equal terms.

The process for determining the reasonableness or purpose of supplemental transmission projects that are asserted to be not needed for reliability, economic efficiency or operational performance as defined under the RTEP process needs additional oversight and transparency. If there is a need for a supplemental project, that need should be clearly defined and there should be a transparent, robust and clearly defined mechanism to permit competition to build the project. If there is no defined need for of a supplemental project for reliability, economic efficiency or operational performance then the project should not be included in rates.

Managing the generation queues is a highly complex process. The PJM queue evaluation process has been substantially improved in recent years and it is more efficient and effective as a result. The PJM queue evaluation process should continue to be improved to help ensure that barriers to competition for new generation investments are not created. Issues that need to be addressed include the ownership rights to CIRs, whether transmission owners should perform interconnection studies, and improvements in queue management to ensure that projects are removed from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress.

The addition of a planned transmission project changes the parameters of the capacity auction for the area, changes the amount of capacity needed in the area, changes the capacity market supply and demand fundamentals in the area and may effectively forestall the ability of generation to compete. But there is no mechanism to permit a direct comparison, let alone competition,

between transmission and generation alternatives. There is no mechanism to evaluate whether the generation or transmission alternative is less costly, whether there is more risk associated with the generation or transmission alternatives, or who bears the risks associated with each alternative. Creating such a mechanism should be an explicit goal of PJM market design.

The current market efficiency process does exactly the opposite by permitting transmission projects to be approved without competition from generation. The broader issue is that the market efficiency project approach explicitly allows transmission projects to compete against future generation projects, but without allowing the generation projects to compete. Projecting speculative transmission related benefits for 15 years based on the existing generation fleet and existing patterns of congestion eliminates the potential for new generation to respond to market signals. The market efficiency process allows assets built under the cost of service regulatory paradigm to displace generation assets built under the competitive market paradigm. In addition, there are significant issues with PJM's current benefit/cost analysis which cause it to consistently overstate the potential benefits of market efficiency projects. The MMU recommends that the market efficiency process be eliminated.

In addition, the use of an inaccurate cost-benefit method by PJM and the correct method by MISO results in an over allocation of the costs associated with joint PJM/MISO projects to PJM participants and in some cases approval of projects that do not pass an accurate cost-benefit test.

If it is retained, there are significant issues with PJM's benefit/cost analysis that should be addressed prior to approval of additional projects. The current benefit/cost analysis for a regional project, for example, explicitly and incorrectly ignores the increased congestion in zones that results from an RTEP project when calculating the energy market benefits. All costs should be included in all zones and LDAs. The definition of benefits should also be reevaluated.

The benefit/cost analysis should also account for the fact that the transmission project costs are not subject to cost caps and may exceed the estimated costs

by a wide margin. When actual costs exceed estimated costs, the cost benefit analysis is effectively meaningless and low estimated costs may result in inappropriately favoring transmission projects over market generation projects. The risk of cost increases for transmission projects should be incorporated in the cost benefit analysis.

There are currently no market incentives for transmission owners to submit and complete transmission outages in a timely and efficient manner. Requiring transmission owners to pay does not create an effective incentive when those payments are passed through to transmission customers. The process for the submission of planned transmission outages needs to be carefully reviewed and redesigned to limit the ability of transmission owners to submit transmission outages that are late for FTR auction bid submission dates and are late for the day-ahead energy market. The submission of late transmission outages can inappropriately affect market outcomes when market participants do not have the ability to modify market bids and offers.

Generation Interconnection Planning

Existing Generation Mix

Table 12-1 shows the existing PJM capacity by control zone and unit type.¹⁴ As of March 31, 2021, PJM had an installed capacity of 197,274.9 MW, of which 49,877.4 MW (25.3 percent) are coal fired steam units, 50,194.0 MW (25.4 percent) are combined cycle units and 33,452.6 MW (17.0 percent) are nuclear units. This measure of installed capacity differs from capacity market installed capacity because it includes energy only units, external units and uses nameplate values for solar and wind resources.

The AEP Zone has the most installed capacity of any PJM zone. Of the 197,274.9 MW of PJM installed capacity, 31,720.1 MW (16.1 percent) are in the AEP Zone, of which 13,463.0 MW (42.4 percent) are coal fired steam units, 6,990.0 MW (22.0 percent) are combined cycle units and 2,071.0 MW (6.5 percent) are nuclear units.

¹⁴ The unit type RICE refers to Reciprocating Internal Combustion Engines.

Table 12-1 Existing capacity: March 31, 2021 (By zone and unit type (MW))¹⁵

Zone	Battery	CT -		CT - Oil	CT - Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE -			Solar + Storage	Solar + Wind	Steam -			Wind +		Total		
		Combined Cycle	Natural Gas							Natural Gas	RICE - Oil	RICE - Other			Steam - Coal	Steam - Gas	Steam - Oil	Other	Wind		Storage	
ACEC	0.0	901.9	544.7	26.0	0.0	1.6	0.0	0.0	0.0	0.0	4.0	8.9	64.1	0.0	0.0	458.9	0.0	0.0	0.0	7.5	0.0	2,017.5
AEP	6.0	6,990.0	4,108.2	16.2	4.8	0.0	66.0	420.9	2,071.0	0.0	0.0	20.4	264.7	0.0	0.0	13,463.0	738.0	0.0	50.0	3,500.9	0.0	31,720.1
APS	80.4	2,179.0	1,223.3	0.0	2.0	0.0	0.0	129.2	0.0	29.6	0.0	18.3	114.4	0.0	0.0	5,299.0	0.0	0.0	0.0	875.1	0.0	9,950.3
ATSI	0.0	3,495.5	958.0	629.0	6.4	0.0	0.0	0.0	2,134.0	0.0	18.5	46.1	0.0	0.0	0.0	2,264.0	325.0	0.0	0.0	0.0	0.0	9,876.5
BGE	0.0	0.0	267.6	228.8	0.0	0.0	0.0	0.4	1,716.0	0.0	0.0	4.2	1.1	0.0	0.0	1,578.0	143.5	397.0	57.0	0.0	0.0	4,393.6
COMED	148.5	2,621.1	6,673.3	226.2	0.0	0.0	0.0	0.0	10,473.5	0.0	0.0	30.3	9.0	0.0	0.0	3,840.1	1,326.0	0.0	0.0	4,831.0	0.0	30,179.0
DAY	0.0	0.0	897.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	932.6
DUKE	18.0	522.2	598.0	56.0	0.0	0.0	0.0	112.0	0.0	0.0	0.0	4.8	200.0	0.0	0.0	1,857.0	47.0	0.0	0.0	0.0	0.0	3,415.0
DUQ	0.0	101.0	0.0	15.0	0.0	0.0	0.0	6.3	1,777.0	0.0	0.0	0.0	0.0	0.0	0.0	565.0	0.0	0.0	0.0	0.0	0.0	2,464.3
DOM	0.0	9,138.0	3,835.3	256.4	10.0	0.0	3,003.0	586.3	3,581.3	0.0	39.0	106.4	2,382.2	0.0	0.0	3,499.2	35.0	800.0	368.4	587.0	0.0	28,227.5
DPL	0.0	1,742.5	978.2	478.2	0.0	30.0	0.0	0.0	0.0	0.0	88.0	14.1	300.4	0.0	0.0	410.0	812.0	153.0	70.0	0.0	0.0	5,076.4
EKPC	0.0	0.0	774.0	0.0	0.0	0.0	0.0	136.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,687.0	0.0	0.0	0.0	0.0	0.0	2,597.0
JCPLC	40.0	2,229.5	531.1	225.6	0.0	0.4	400.0	0.0	0.0	0.0	0.0	14.1	371.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,812.5
MEC	0.0	2,646.0	2.0	398.5	0.0	0.0	0.0	19.0	0.0	0.0	0.0	33.4	0.0	0.0	0.0	115.0	0.0	0.0	60.0	0.0	0.0	3,273.9
OVEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,388.8	0.0	0.0	0.0	0.0	0.0	2,388.8
PECO	0.0	4,089.0	0.0	828.0	0.0	0.0	1,070.0	572.0	4,546.8	0.0	2.0	0.9	3.0	0.0	0.0	0.0	762.0	0.0	103.0	0.0	0.0	11,976.7
PE	28.4	1,900.0	350.5	57.0	0.0	0.0	513.0	77.8	0.0	120.1	28.0	17.8	13.5	0.0	0.0	6,053.5	610.0	0.0	42.0	1,100.4	0.0	10,912.0
PEPCO	0.0	1,736.5	764.2	308.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	2.5	0.0	0.0	1,896.0	1,164.1	0.0	52.0	0.0	0.0	5,934.4
PPL	20.0	5,558.5	252.0	213.5	20.6	0.0	0.0	706.6	2,520.0	12.0	5.0	14.7	35.0	0.0	0.0	2,547.9	2,449.0	0.0	29.0	216.5	0.0	14,600.3
PSEG	7.7	4,343.3	1,039.2	0.0	0.0	0.0	0.0	5.0	3,493.0	0.0	0.0	9.0	224.6	0.0	0.0	0.0	3.0	0.0	179.1	0.0	0.0	9,303.8
XIC	0.0	0.0	858.6	0.0	0.0	0.0	0.0	269.1	1,140.0	0.0	0.0	0.0	0.0	0.0	0.0	1,955.0	0.0	0.0	0.0	0.0	0.0	4,222.7
Total	349.0	50,194.0	24,655.7	3,962.4	43.8	32.0	5,052.0	3,040.6	33,452.6	161.7	218.5	354.4	3,987.3	0.0	0.0	49,877.4	8,414.6	1,350.0	1,010.5	11,118.4	0.0	197,274.9

¹⁵ The capacity described in this section refers to all capacity in PJM at the summer installed capacity rating, regardless of whether the capacity entered the RPM Auction.

Table 12-2 shows the installed capacity by state for each fuel type. Pennsylvania has the most installed capacity of any PJM state. Of the 197,274.9 MW of installed capacity, 48,057.9 MW (24.4 percent) are in Pennsylvania, of which 9,281.4 MW (19.3 percent) are coal fired steam units, 17,473.5 MW (36.4 percent) are combined cycle units and 8,843.8 MW (18.4 percent) are nuclear units.

Table 12-2 Existing capacity: March 31, 2021 (By state and unit type (MW))

State	Battery	Combined Cycle	CT - Natural Gas	CT - Oil	CT - Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural Gas	RICE - Oil	RICE - Other	Solar	Solar + Storage	Solar + Wind	Steam - Coal	Steam - Natural Gas	Steam - Oil	Steam - Other	Wind	Wind + Storage	Total
DC	0.0	19.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5
DE	0.0	742.5	325.5	116.3	0.0	30.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0	410.0	812.0	0.0	70.0	0.0	0.0	2,514.4
IL	148.5	2,621.1	6,673.3	226.2	0.0	0.0	0.0	0.0	10,473.5	0.0	0.0	30.3	9.0	0.0	0.0	3,840.1	1,326.0	0.0	0.0	4,831.0	0.0	30,179.0
IN	0.0	1,835.0	441.4	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	3.2	30.1	0.0	0.0	3,923.8	0.0	0.0	0.0	2,353.2	0.0	8,594.9
KY	0.0	0.0	1,618.1	0.0	0.0	0.0	0.0	136.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,687.0	278.0	0.0	0.0	0.0	0.0	3,719.1
MD	20.0	2,717.0	1,684.5	552.7	0.0	0.0	0.0	0.4	1,716.0	0.0	76.0	21.3	313.4	0.0	0.0	3,654.0	1,307.6	550.0	109.0	295.0	0.0	13,016.9
MI	0.0	1,200.0	0.0	0.0	4.8	0.0	0.0	11.8	2,071.0	0.0	0.0	3.2	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,295.4
NC	0.0	165.0	0.0	0.0	0.0	0.0	0.0	315.0	0.0	0.0	18.0	0.0	921.5	0.0	0.0	0.0	0.0	0.0	0.0	208.0	0.0	1,627.5
NJ	47.7	7,474.7	2,115.0	251.6	0.0	2.0	400.0	5.0	3,493.0	0.0	4.0	32.0	660.4	0.0	0.0	458.9	3.0	0.0	179.1	7.5	0.0	15,133.8
OH	22.0	6,972.7	4,201.2	701.2	6.4	0.0	0.0	200.0	2,134.0	0.0	47.0	50.9	351.1	0.0	0.0	9,689.0	47.0	0.0	0.0	1,147.7	0.0	25,570.2
PA	49.9	17,473.5	1,491.9	1,512.0	20.6	0.0	1,583.0	1,445.7	8,843.8	161.7	40.5	85.1	106.5	0.0	0.0	9,281.4	4,146.0	0.0	234.0	1,582.3	0.0	48,057.9
TN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0
VA	0.0	8,973.0	4,172.3	591.4	12.0	0.0	3,069.0	460.1	3,581.3	0.0	33.0	112.4	1,570.7	0.0	0.0	2,494.2	495.0	800.0	368.4	12.0	0.0	26,744.8
WV	60.9	0.0	1,073.9	11.0	0.0	0.0	0.0	189.3	0.0	0.0	0.0	8.0	20.0	0.0	0.0	12,484.0	0.0	0.0	0.0	681.7	0.0	14,528.8
XIC	0.0	0.0	858.6	0.0	0.0	0.0	0.0	269.1	1,140.0	0.0	0.0	0.0	0.0	0.0	0.0	1,955.0	0.0	0.0	0.0	0.0	0.0	4,222.7
Total	349.0	50,194.0	24,655.7	3,962.4	43.8	32.0	5,052.0	3,040.6	33,452.6	161.7	218.5	354.4	3,987.3	0.0	0.0	49,877.4	8,414.6	1,350.0	1,010.5	11,118.4	0.0	197,274.9

Table 12-3 and Figure 12-1 show the age of existing PJM generators, by unit type, as of March 31, 2021. Of the 197,274.9 MW of installed capacity, 71,985.4 MW (36.5 percent) are from units older than 40 years, of which 38,446.4 MW (53.4 percent) are coal fired steam units, 191.0 MW (0.3 percent) are combined cycle units and 16,184.6 MW (22.5 percent) are nuclear units.

Table 12-3 Capacity (MW) by unit type and age (years): March 31, 2021

Age (years)	Battery	Combined Cycle	CT - Natural Gas	CT - Oil	CT - Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural Gas	RICE - Oil	RICE - Other	Solar	Solar + Storage	Solar + Wind	Steam - Coal	Steam - Natural Gas	Steam - Oil	Steam - Other	Wind	Wind + Storage	Total
Less than 20	349.0	44,971.7	16,235.2	604.5	43.8	32.0	0.0	297.2	0.0	149.7	20.0	283.4	3,987.3	0.0	0.0	3,475.0	82.0	0.0	97.4	11,118.4	0.0	81,746.5
20 to 40	0.0	5,031.3	7,950.8	355.5	0.0	0.0	3,003.0	427.2	17,268.0	12.0	25.0	71.0	0.0	0.0	0.0	7,956.0	600.0	0.0	843.1	0.0	0.0	43,542.9
40 to 60	0.0	191.0	469.7	3,002.4	0.0	0.0	2,049.0	340.0	16,184.6	0.0	173.5	0.0	0.0	0.0	0.0	35,593.6	5,971.1	1,350.0	70.0	0.0	0.0	65,394.9
Greater than 60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,976.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,852.8	1,761.5	0.0	0.0	0.0	0.0	6,590.5
Total	349.0	50,194.0	24,655.7	3,962.4	43.8	32.0	5,052.0	3,040.6	33,452.6	161.7	218.5	354.4	3,987.3	0.0	0.0	49,877.4	8,414.6	1,350.0	1,010.5	11,118.4	0.0	197,274.9

Figure 12-1 Capacity (MW) by age (years): March 31, 2021

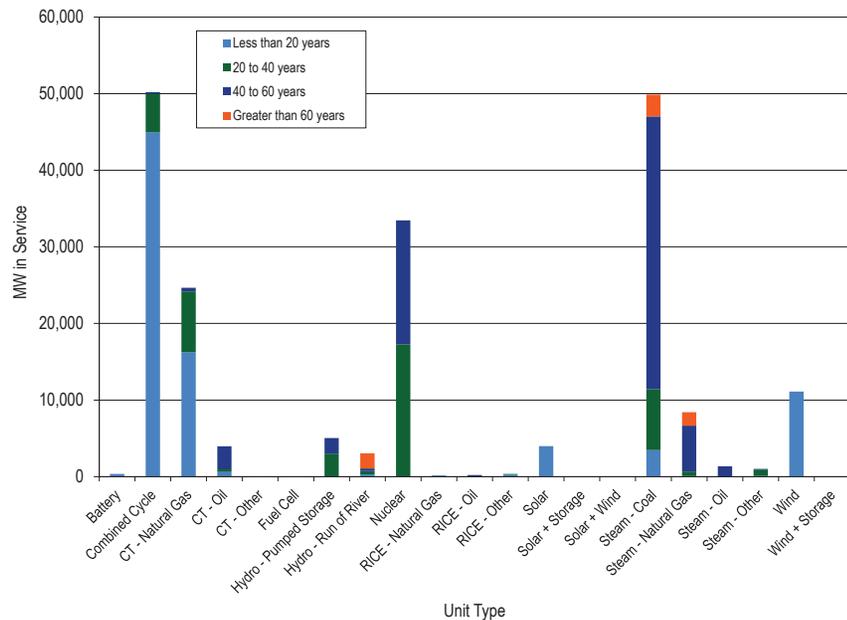


Figure 12-2 is a map of units, less than 20 MW in size, that came online between January 1, 2011 and March 31, 2021. A mapping to these unit names is in Table 12-4.

Figure 12-2 Map of unit additions (less than 20 MW): January 1, 2011 through March 31, 2021

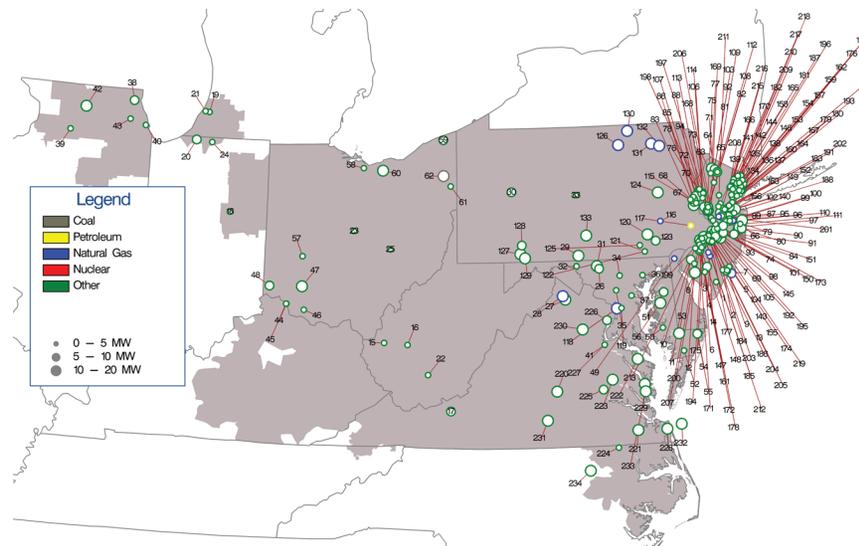


Table 12-4 Unit identification for map of unit additions (less than 20 MW): January 1, 2011 through March 31, 2021

ID	Unit	ID	Unit	ID	Unit	ID	Unit
1	ACE CAPE MAY COUNTY 1 LF	56	DPL WYE MILLS 1 SP	111	JC UPPER FREEHOLD 1 SP	166	PS HINCHMANS SOLAR 1 SP
2	ACE CATES ROAD 2 SP	57	FE DOVETAIL 1 CT	112	JC WANTAGE 2 SP	167	PS HOBOKEN SOLAR 2 SP
3	ACE CEDAR BRANCH 1 SP	58	FE ERIE COUNTY 1 LF	113	JC WARREN 1 SP	168	PS HOPEWELL 1 SP
4	ACE EGG HARBOR-KELLOGG 1 FC	59	FE GENEVA 1 LF	114	JC WASHBURN AVE 4 SP	169	PS HOPEWELL 2 BT
5	ACE GALLOWAY LANDFILL 2 SP	60	FE LORAIN 1 LF	115	ME GLENDON 1 LF	170	PS JACKSON SOLAR 1 SP
6	ACE MAYS LANDING 1 SP	61	FE MAHONING 1 LF	116	ME READING HOSPITAL 1 CT	171	PS KINSLEY BEAVER 2 SP
7	ACE MIDTOWN THERMAL 2 CT	62	FE WARREN-EVERGREEN 1 CT	117	PE MORRIS ROAD 1 D	172	PS KINSLEY DEPTFORD 1 SP
8	ACE OAK FAIRTON 1 SP	63	JC AUGUSTA 1 SP	118	PEP CAPITAL POWER PLANT 1 CT	173	PS KUSER SOLAR 1 SP
9	ACE PEAR STREET 1 SP	64	JC BEAVER RUN 3 SP	119	PEP ROLLINS AVENUE 3 SP	174	PS LANDFILL 5 SP
10	ACE PILESGROVE 1 SP	65	JC BERNARDS TOWNSHIP 1 SP	120	PL DART CONTAINER 1-2 LF	175	PS LAWSIDE 14 BT
11	ACE PILESGROVE 2 SP	66	JC BRICKYARD 4 SP	121	PL HOLTWOOD 11	176	PS LEONIA SOLAR 1 SP
12	ACE PITTSBORO 1 SP	67	JC COPPER HILL 4 SP	122	PL HOLTWOOD 13	177	PS LUMBERTON STACY HAINES 5 SP
13	ACE SEASHORE 1 SP	68	JC CYPHERS ROAD 5 SP	123	PL KEYSTONE 1 SP	178	PS MANTUA CREEK 7 BT
14	ACE TANSBORO ROAD 1 FC	69	JC DIXSOLAR 5 SP	124	PL PA SOLAR 1 SP	179	PS MARION SOLAR 1 SP
15	AEP BALLS GAP 1 BT	70	JC DOMIN LANE 1 SP	125	PL TURKEY HILL 1 WF	180	PS MATRIX PA SOLAR 2 SP
16	AEP CHARLESTON 1 LF	71	JC DURBAN AVENUE 1 SP	126	PN ALPACA GLORY BARN 1 D	181	PS MAYWOOD SOLAR 1 SP
17	AEP CLOYDS MT 1 LF	72	JC E FLEMINGTON 5 SP	127	PN GARRETT 1 BT	182	PS METRO HQ 2 SP
18	AEP DEERCREEK 1 SP	73	JC EAST AMWELL 7 SP	128	PN LAUREL HIGHLANDS 2 LF	183	PS MIDDLESEX 1 SP
19	AEP EAST WATERVLIET 1 SP	74	JC EGYPT 3 SP	129	PN MEYERSDALE 2 BT	184	PS MILL CREEK 1 SP
20	AEP OLIVE 1 SP	75	JC FISCHER 8 SP	130	PN MILAN ENERGY 1 D	185	PS MOORESTOWN 1 SP
21	AEP ORCHARD HILLS 1 LF	76	JC FOUL RIFT ROAD 1 SP	131	PN NORTH MESHOPPEN 1 CT	186	PS MT LAUREL 1 SP
22	AEP RALEIGH COUNTY 1 LF	77	JC FRANKFORD 4 SP	132	PN OXBOW CREEK ENERGY CENTER 1 D	187	PS NEW MILFORD SOLAR 1 SP
23	AEP TRENT 1 BT	78	JC FRANKLIN 7 SP	133	PN WHITETAIL 1 SP	188	PS NEW ROAD 1 SP
24	AEP TWINBRANCH 1 SP	79	JC FREEMALL 1 FC	134	PS ALDENE SOLAR 1 SP	189	PS NEWARK SOLAR 1 SP
25	AEP ZANESVILLE 2 LF	80	JC FRENCHES 2 SP	135	PS ATHENIA SOLAR 1 SP	190	PS NEWARK SOLAR 3 SP
26	AP BAKER POINT 1 SP	81	JC FRENCHTOWN 1 SP	136	PS BAYONNE 1 SP	191	PS NIXON LANE 2 SP
27	AP DOUBLE TOLLGATE SP	82	JC FRENCHTOWN 2 SP	137	PS BAYONNE SOLAR 2 SP	192	PS NORTH AMERICAN 4 SP
28	AP HP HOOD 1 CT	83	JC FRENCHTOWN 3 SP	138	PS BELLEVILLE SOLAR 1 SP	193	PS NORTH AVE SOLAR 1 SP
29	AP LETZBURG - ELK HILL 2 SP	84	JC HANOVER 2 SP	139	PS BENNETTS SOLAR 1 SP	194	PS OWENS CORNING 1 SP
30	AP MAHONING CREEK 1 H	85	JC HARMONY 1 SP	140	PS BLACK ROCK 1 SP	195	PS PARKLANDS 1 SP
31	AP MT ST MARYS PV PARK 2 SP	86	JC HIGH STREET 6 SP	141	PS BRIDGEWATER SOLAR 2 SP	196	PS PATERSON PLANK ROAD 1 SP
32	AP PINESBURG 1 SP	87	JC HOFFMAN STATION ROAD 2 SP	142	PS CALDWELL PUMP 2 BT	197	PS PENNINGTON 3 BT
33	AP STATE COLLEGE 1 BT	88	JC HOLLAND 4 SP	143	PS CAMPUS DRIVE 2 SP	198	PS PENNINGTON 4 SP
34	BC ALPHA RIDGE 1 LF	89	JC HOLMDEL 9 SP	144	PS CEDAR GROVE SOLAR 1 SP	199	PS PENNSAUKEN 1 LF
35	BC BRIGHTON DAM 1 H	90	JC HOWELL 1 SP	145	PS CEDAR LANE FLORENCE 6 SP	200	PS PENNSAUKEN 3 SP
36	BC KINGSVILLE 1 SP	91	JC JACOBSTOWN 1 SP	146	PS COOK ROAD SOLAR 2 SP	201	PS PRINCETON HOSPITAL 1 CT
37	BC MILLERSVILLE 1 LF	92	JC JUNCTION ROAD 6 SP	147	PS COOPER HOSPITAL 1 BT	202	PS RARITAN CENTER 3 SP
38	COM COUNTRYSIDE 1 LF	93	JC LAKEHURST 3 SP	148	PS COOPER HOSPITAL 15 SP	203	PS REEVES EAST 3 SP
39	COM DIXON LEE 5 LF	94	JC LEBANON 1 SP	149	PS CRANBURY 2 SP	204	PS REEVES SOUTH 1 SP
40	COM GRAND RIDGE 6 BT	95	JC MANALAPAN 1 SP	150	PS CROSSWIC 1 SP	205	PS REEVES WEST 4 SP
41	COM MORRIS 1 LF	96	JC MILLHURST 3 SP	151	PS CROSSWIC 2 SP	206	PS RIDER UNIVERSITY 3 SP
42	COM ORCHARD 1 LF	97	JC MUDDY FORGE 3 SP	152	PS DEVILSBROOK 1 SP	207	PS RIVER ROAD 2 SP
43	COM SOLBERG 1 BT	98	JC NORTH HANOVER 4 SP	153	PS DOREMUS SOLAR 1 SP	208	PS ROSELAND SOLAR 1 SP
44	DEOK BECKJORD 1 BT	99	JC NORTH PARK 1 SP	154	PS E RUTHERFORD SOLAR 1 SP	209	PS SADDLE BROOK SOLAR 1 SP
45	DEOK BECKJORD 2 BT	100	JC NORTH PARK 2 SP	155	PS EASTAMPTON 1 SP	210	PS SPRINGFIELD SOLAR 1 SP
46	DEOK BROWN COUNTY 1 LF	101	JC NORTH RUN 11 SP	156	PS EDISON 1 SP	211	PS SUNNYMEADE SOLAR 1 SP
47	DEOK CLINTON 1 BT	102	JC OLD BRIDGE 1 SP	157	PS ESSEX 105 CT	212	PS TAYLORS LANE 1 SP
48	DEOK WILLEY 1 BT	103	JC PAUCH 3 SP	158	PS FAIRLAWN SOLAR 1 SP	213	PS THOROFARE SOLAR 2 SP
49	DPL BLOOM ENERGY 1 FC	104	JC PEMBERTON 1 SP	159	PS FOODBANK 1 SP	214	PS TURNPIKE 1 SP
50	DPL BUCKTOWN 1 SP	105	JC PEMBERTON 2 SP	160	PS FORTY NINTH SOLAR 1 SP	215	PS W CALDWELL SOLAR 1 SP
51	DPL CHURCH HILL 1 SP	106	JC QUAKERTOWN 9 SP	161	PS GLOUCESTER SOLAR 1 SP	216	PS W CALDWELL SOLAR 2 SP
52	DPL COSTEN 1 SP	107	JC RICHLINE 3 SP	162	PS HACKENSACK 1 SP	217	PS WALDWICK SOLAR 1 SP
53	DPL HEBRON 1 SP	108	JC RINGOES 1 SP	163	PS HIGHLAND PARK 3 BT	218	PS WEST ORANGE SOLAR 1 SP
54	DPL WORCESTER NORTH 1 SP	109	JC SUSSEX 1 LF	164	PS HIGHLAND PARK 4 SP	219	PS WEST PEMBERTON 1 SP
55	DPL WORCESTER SOUTH 2 SP	110	JC TINTON FALLS 3 SP	165	PS HILLSDALE SOLAR 1 SP	220	VP BUCKINGHAM 1 SP
						221	VP GARDNER FARMS 1 SP
						222	VP GARDYS MILL ROAD 5 SP
						223	VP HOLLYFIELD 1 SP
						224	VP MURPHY 1 SP
						225	VP NORTHEAST 2 LF
						226	VP OCCOQUAN 1 LF
						227	VP OCCOQUAN 2 LF
						228	VP OCEANA 1 SP
						229	VP PULLER 1 SP
						230	VP REMINGTON 1 SP
						231	VP TWITTYS CREEK 1 SP
						232	VP VIRGINIA OFFSHORE 1 WF
						233	VP WAN - GLOUCESTER 1 SP
						234	VP WHITAKERS 1 SP

Figure 12-3 is a map of units, 20 MW or greater in size, that came online between January 1, 2011 and March 31, 2021. A mapping to these unit names is in Table 12-5.

Figure 12-3 Map of unit additions (20 MW or greater): January 1, 2011 through March 31, 2021

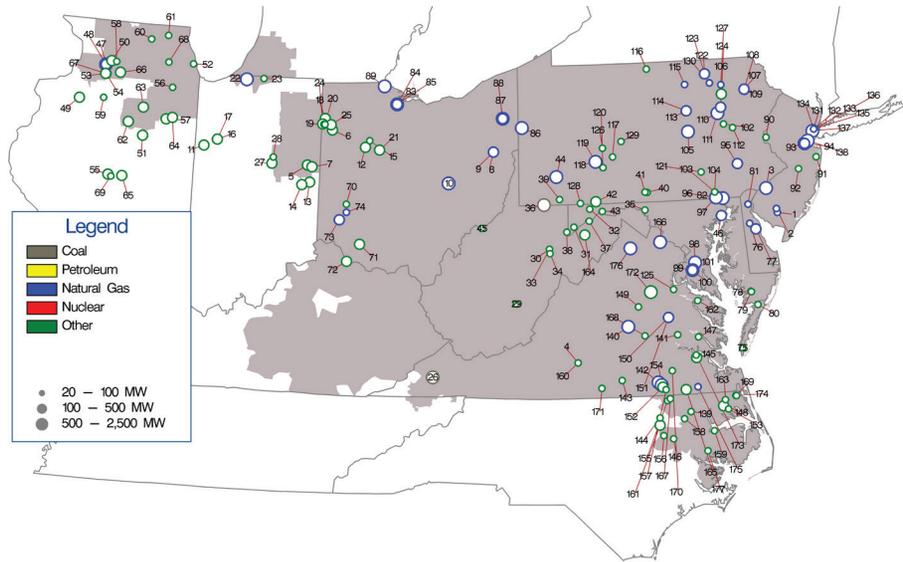


Table 12-5 Unit identification for map of unit additions (20 MW or greater): January 1, 2011 through March 31, 2021

ID	Unit	ID	Unit	ID	Unit	ID	Unit
1	ACE CLAYVILLE 1 CT	51	COM BRIGHT STALK 1 WF	101	PEP ST CHARLES-KELSON RIDGE 2 CC	151	VP DOSWELL 3 CT
2	ACE VINELAND 11 CT	52	COM GRAND RIDGE 7 BT	102	PL HAZEL 1 FW	152	VP DRY BREAD 1 SP
3	ACE WEST DEPTFORD CROWN POINT 1 CC	53	COM GREEN RIVER 1 WF	103	PL HOLTWOOD 18	153	VP ELIZABETH CITY 1 SP
4	AEP ALTAVISTA 1 SP	54	COM GREEN RIVER 2 WF	104	PL HOLTWOOD 19	154	VP GREENSVILLE 1 CC
5	AEP BITTER RIDGE 1 WF	55	COM HILLTOPPER 1 WF	105	PL HUMMEL STATION 1 CC	155	VP GUTENBERG - OCONECHE 1 SP
6	AEP BLUE CREEK 3 WF	56	COM JOLIET 1 BT	106	PL HUNLOCK CC	156	VP HARTS MILL 1 SP
7	AEP BLUFF POINT 2 WF	57	COM KELLY CREEK 1 WF	107	PL LACKAWANNA COUNTY 1 CC	157	VP IVORY LANE 1 SP
8	AEP CARROLL COUNTY 1 CC	58	COM LEE DEKALB 3 BT	108	PL LACKAWANNA COUNTY 2 CC	158	VP KELFORD 1 SP
9	AEP CARROLL COUNTY 2 CC	59	COM LONE TREE 3 WF	109	PL LACKAWANNA COUNTY 3 CC	159	VP MACKEYS 1 SP
10	AEP DRESDEN 1 CC	60	COM MARENGO 1 BT	110	PL MOXIE FREEDOM 11 CC	160	VP MECHANICSVILLE 2 SP
11	AEP FOWLER RIDGE 4 WF	61	COM MCHENRY 1 BT	111	PL MOXIE FREEDOM 21 CC	161	VP MOCCASIN CREEK 1 SP
12	AEP HARDIN 2 SP	62	COM MINONK 1 WF	112	PL PA SOLAR 2 SP	162	VP MONTROSS 1 SP
13	AEP HEADWATERS 1 WF	63	COM OTTER CREEK 1 WF	113	PL PATRIOT 1 F	163	VP MORGAN CORNER 1 SP
14	AEP HEADWATERS 2 WF	64	COM PILOT HILL 1 WF	114	PL PATRIOT 2 F	164	VP NEW CREEK 1 WF
15	AEP HOG CREEK 1 WF	65	COM RADFORDS RUN 1 WF	115	PN BEAVER DAM 1 D	165	VP NEWSOMS 1 SP
16	AEP MEADOW LAKE 5 WF	66	COM SHADY OAKS 1 WF	116	PN BIG LEVEL 1 WF	166	VP PANDA STONEWALL 1 CC
17	AEP MEADOW LAKE 6 WF	67	COM WALNUT RIDGE 1 WF	117	PN CHESTNUT FLATS 1 WF	167	VP PECAN 1 SP
18	AEP PAULDING 3 WF	68	COM WEST CHICAGO 3 BT	118	PN FAIRVIEW 1 CC	168	VP POWHATAN 2 SP
19	AEP PAULDING 4 WF	69	COM WHITNEY HILL 2 WF	119	PN FAIRVIEW 2 CC	169	VP RANCHLAND 2 SP
20	AEP PAULDING 42 WF	70	DAY TAIT 8 BT	120	PN HIGHLAND NORTH 2 WF	170	VP SAPONY 1 SP
21	AEP SCIOTO RIDGE 1 WF	71	DEOK HILLCREST 1 SP	121	PN LAUREL HILLS 1 WF	171	VP SOUTH BOSTON 1 F
22	AEP ST JOSEPH ENERGY CENTER 1 CC	72	DEOK MELDAHL DAM 1 H	122	PN LIBERTY ASYLUM 10 F	172	VP SPOTSYLVANIA 1 SP
23	AEP ST JOSEPH SOLAR PARK 1 SP	73	DEOK MIDDLETOWN ENERGY 1 CC	123	PN LIBERTY ASYLUM 20 F	173	VP SPRING GROVE 1 SP
24	AEP TIMBER2 1 WF	74	DEOK YANKEE 1 F	124	PN MEHOOPANY 1 WF	174	VP SUMMIT FARMS 1 SP
25	AEP TRISHE 1 WF	75	DPL CHERRYDALE 1 SP	125	PN MEHOOPANY 2 WF	175	VP UNION CAMP 9-10 F
26	AEP VIRGINIA CITY 1 F	76	DPL DEMEC - CLAYTON 2 CT	126	PN PATTON 1 WF	176	VP WARREN COUNTY FRONT ROYAL CC
27	AEP WILDCAT 1A WF	77	DPL GARRISON EC 1 CC	127	PN PGCOGEN 2 CT	177	VP WILKINSON ENERGY CENTER 1 SP
28	AEP WILDCAT 1B WF	78	DPL GREAT BAY KINGS CREEK 1 SP	128	PN RINGER HILL 1 WF		
29	AP BEECH RIDGE 2 WF	79	DPL GREAT BAY KINGS CREEK 2 SP	129	PN SANDY RIDGE 1 WF		
30	AP BEECH RIDGE 3 BT	80	DPL OAK HALL 1 SP	130	PN SUGAR RUN 2 CT		
31	AP FAIR WIND 2 WF	81	DPL RED LION 1 FC	131	PS KEARNY 131 CT		
32	AP FOURMILE RIDGE 1 WF	82	DPL WILDCAT POINT 1 CC	132	PS KEARNY 132 CT		
33	AP LAUREL MOUNTAIN 1 BT	83	FE FREMONT 1 SCCT	133	PS KEARNY 133 CT		
34	AP LAUREL MOUNTAIN 1 WF	84	FE FREMONT 2 SCCT	134	PS KEARNY 134 CT		
35	AP MARLOWE 1 SP	85	FE FREMONT ENERGY CENTER 3 CC	135	PS KEARNY 141 CT		
36	AP NORTH LONGVIEW 1 F	86	FE HICKORY RUN 1 CC	136	PS KEARNY 142 CT		
37	AP PINNACLE 1 WF	87	FE LORDSTOWN ENERGY CENTER 1 CC	137	PS NEWARK ENERGY CENTER 10 CC		
38	AP ROTH ROCK 1 WF	88	FE LORDSTOWN ENERGY CENTER 2 CC	138	PS SEWAREN 7 CC		
39	AP SOUTH CHESTNUT 1 WF	89	FE OREGON ENERGY CENTER 1 CC	139	VP AULANDER HOLLOMAN 1 SP		
40	AP ST THOMAS 1 SP	90	JC EDGE ROAD 5 BT	140	VP BEAR GARDEN		
41	AP ST THOMAS 2 SP	91	JC HAMILTON ROAD 5 SP	141	VP BRIEL FARM 1 SP		
42	AP TWIN RIDGES 1 WF	92	JC PLUMSTED ENERGY 6 BT	142	VP BRUNSWICK 1CC		
43	AP WARRIOR RUN 2 BT	93	JC WOODBRIDGE 1 CC	143	VP BUTCHER CREEK 1 SP		
44	AP WESTMORELAND 1 CC	94	JC WOODBRIDGE 2 CC	144	VP CHESTNUT 1 SP		
45	AP WILLOW ISLAND 1 H	95	ME BIRDSBORO 1 CC	145	VP COLONIAL TRAIL WEST 1 SP		
46	BC PERRYMAN 6 CT	96	PE DELTA 1-4 CC	146	VP CONETOE 2 SP		
47	COM 942 NELSON 1 CC	97	PE DELTA 5-7 CC	147	VP CORRECTIONAL 1 SP		
48	COM 942 NELSON 2 CC	98	PEP KEYS ENERGY CENTER 1 CC	148	VP DESERT 1 WF		
49	COM BISHOP HILL SP in PJM WF	99	PEP ST CHARLES - KELSON RIDGE 1 CC	149	VP DESPER 1 SP		
50	COM BLOOMING GROVE 1 WF1	100	PEP ST CHARLES-KELSON RIDGE 1 CC	150	VP DOSWELL 2 CT		

Generation Retirements^{16 17}

Generating units generally plan to retire when they are not economic and do not expect to be economic. The MMU performs an analysis of the economics of all units that plan to retire in order to verify that the units are not economic and there is no potential exercise of market power through physical withholding that could advantage the owner's portfolio.¹⁸ The definition of economic is that unit net revenues are greater than or equal to the unit's avoidable or going forward costs.

PJM does not have the authority to order generating plants to continue operating. PJM's responsibility is to ensure system reliability. When a unit retirement creates reliability issues based on existing and planned generation facilities and on existing and planned transmission facilities, PJM identifies transmission solutions.¹⁹

Rules that preserve the Capacity Interconnection Rights (CIRs) associated with retired units, and with the conversion from Capacity Performance (CP) to energy only status, impose significant costs on new entrants. Currently, CIRs persist for one year if unused, and they can be further extended, at no cost, if assigned to a new project in the interconnection queue at the same point of interconnection.²⁰ There are currently no rules governing the retention of CIRs when units want to convert to energy only status or require time to upgrade to retain CP status. The rules governing conversion or upgrades should be the same as the rules governing retired units. Reforms that require the holders of CIRs to use or lose them, and/or impose costs to holding or transferring them, could make new entry appropriately more attractive. The economic and policy rationale for extending CIRs for inactive units is not clear. Incumbent providers receive a significant advantage simply by imposing on new entrants the entire cost of system upgrades needed to accommodate new entrants. The policy question of whether CIRs should persist after the retirement of a

unit should be addressed. Even if the policy treatment of such CIRs remains unchanged, the rules need to ensure that incumbents cannot exploit control of CIRs to block or postpone entry of competitors.

In May 2012, PJM stakeholders (through the Interconnection Process Senior Task Force (IPSTF)) modified the rules to reduce the length of time for which CIRs are retained by the current owner after unit retirements from three years to one.²¹ The MMU recognized the progress made in this rule change, but it did not fully address the issues. The MMU recommends that the question of whether CIRs should persist after the retirement of a unit, or conversion from CP to energy only status, be addressed. The rules need to ensure that incumbents cannot exploit control of CIRs to block or postpone entry of competitors.²²

¹⁶ See PJM. Planning. "Generator Deactivations," (Accessed on March 31, 2021) <<http://www.pjm.com/planning/services-requests/gen-deactivations.aspx>>.

¹⁷ Generation retirements reported in this section do not include external units. Therefore, retirement totals reported in this section may not match totals reported elsewhere in this report where external units are included.

¹⁸ See OATT Section V and Attachment M-Appendix § IV.

¹⁹ See PJM. "Explaining Power Plant Retirements in PJM," at <<http://learn.pjm.com/three-priorities/planning-for-the-future/explaining-power-plant-retirements.aspx>>.

²⁰ See OATT § 230.3.3.

²¹ See PJM Interconnection, L.L.C., Docket No. ER12-1177 (Feb. 29, 2012).

²² See "Comments of the Independent Market Monitor for PJM," Docket No. ER12-1177-000 (March 12, 2012) <http://www.monitoringanalytics.com/Filings/2012/IMM_Comments_ER12-1177-000_20120312.PDF>.

Generation Retirements 2011 through 2024

Table 12-6 shows that as of March 31, 2021, there are 45,070.3 MW of generation that have been, or are planned to be, retired between 2011 and 2024, of which 32,084.1 MW (71.2 percent) are coal fired steam units. Retirements are primarily a result of the inability of coal and other units to compete with efficient combined cycle units burning low cost gas.

Table 12-6 Summary of unit retirements by unit type (MW): 2011 through 2024

	Battery	Combined Cycle	CT - Natural Gas	CT - Oil	CT - Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural Gas	RICE - Oil	RICE - Other	Solar + Storage	Solar + Wind	Steam - Coal	Steam - Natural Gas	Steam - Oil	Steam - Other	Wind + Storage	Total	
Retirements 2011	0.0	0.0	0.0	128.3	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	543.0	522.5	0.0	0.0	0.0	0.0	1,196.5
Retirements 2012	0.0	0.0	250.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,907.9	0.0	548.0	16.0	0.0	0.0	6,961.9
Retirements 2013	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	7.0	0.0	0.0	2,589.9	82.0	166.0	8.0	0.0	0.0	2,858.8
Retirements 2014	0.0	0.0	136.0	422.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	0.0	0.0	2,239.0	158.0	0.0	0.0	0.0	0.0	2,970.3
Retirements 2015	0.0	0.0	1,319.0	856.2	2.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0	7,064.8	0.0	0.0	0.0	10.4	0.0	9,262.7
Retirements 2016	0.0	0.0	0.0	65.0	6.0	0.0	0.5	0.0	0.0	0.0	8.0	3.9	0.0	0.0	243.0	74.0	0.0	0.0	0.0	0.0	400.4
Retirements 2017	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	2,038.0	34.0	0.0	0.0	0.0	0.0	2,112.8
Retirements 2018	1.0	425.0	0.0	38.0	1.6	0.0	0.0	0.0	614.5	0.0	17.2	6.9	0.0	0.0	3,186.5	996.0	148.0	108.0	0.0	0.0	5,542.7
Retirements 2019	0.0	0.0	346.8	51.4	6.4	0.0	0.0	0.0	805.0	0.0	0.0	15.9	0.0	0.0	4,113.8	97.0	10.0	10.0	0.0	0.0	5,456.3
Retirements 2020	0.0	0.0	232.5	24.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	0.0	2,131.8	0.0	786.0	60.0	0.0	0.0	3,255.0
Retirements 2021	2.0	67.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	353.4	0.0	0.0	0.0	0.0	0.0	430.4
Planned Retirements (April 2021 and later)	2.0	51.0	80.0	28.0	0.0	0.0	0.0	0.0	1,786.5	0.0	0.0	0.0	0.0	0.0	1,673.0	952.0	0.0	50.0	0.0	0.0	4,622.5
Total	45.0	543.0	2,364.3	1,852.9	22.0	0.0	0.5	0.0	3,206.0	0.0	44.1	72.5	0.0	0.0	32,084.1	2,915.5	1,658.0	252.0	10.4	0.0	45,070.3

Table 12-7 shows the capacity, average size, and average age of units retiring in PJM, from 2011 through 2024, while Table 12-8 shows these retirements by state. Of the 45,070.3 MW of units that has been, or are planned to be, retired between 2011 and 2024, 32,084.1 MW (71.2 percent) are coal fired steam units. These coal fired steam units have an average age of 52.7 years and an average size of 188.7 MW. Over half of the retiring coal fired steam units, 55.9 percent, are located in Ohio or Pennsylvania.

Table 12-7 Retirements by unit type: 2011 through 2024

Unit Type	Number of Units	Avg. Size (MW)	Avg. Age at Retirement (Years)	Total MW	Percent
Battery	4	11.3	5.9	45.0	0.1%
Combined Cycle	4	135.8	29.1	543.0	1.2%
Combustion Turbine	116	26.7	34.8	4,239.2	9.4%
Natural Gas	60	39.4	40.9	2,364.3	5.2%
Oil	50	37.1	44.3	1,852.9	4.1%
Other	6	3.7	19.2	22.0	0.0%
Fuel Cell	0	0.0	0.0	0.0	0.0%
Hydro	1	0.5	113.8	0.5	0.0%
Pumped Storage	1	0.5	113.8	0.5	0.0%
Run of River	0	0.0	0.0	0.0	0.0%
Nuclear	4	801.5	49.1	3,206.0	7.1%
RICE	28	4.2	28.5	116.6	0.3%
Natural Gas	0	0.0	0.0	0.0	0.0%
Oil	10	4.4	45.7	44.1	0.1%
Other	18	4.0	11.2	72.5	0.2%
Solar	0	0	0	0	0.0%
Solar + Storage	0	0	0	0	0.0%
Solar + Wind	0	0	0	0	0.0%
Steam	203	162.5	45.5	36,909.6	81.9%
Coal	170	188.7	52.7	32,084.1	71.2%
Natural Gas	19	153.4	60.0	2,915.5	6.5%
Oil	6	276.3	45.6	1,658.0	3.7%
Other	8	31.5	23.8	252.0	0.6%
Wind	1	10.4	15.6	10.4	0.0%
Wind + Storage	0	0	0	0	0.0%
Total	361	124.8	45.6	45,070.3	100.0%

Table 12-8 Retirements (MW) by unit type and state: 2011 through 2024

State	CT -					Hydro -			RICE -			Steam -					Wind +		Total		
	Battery	Combined Cycle	Natural Gas	CT - Oil	CT - Other	Fuel Cell	Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural Gas	RICE - Oil	RICE - Other	Solar + Storage	Solar + Wind	Steam - Coal	Steam - Natural Gas	Steam - Oil	Steam - Other		Wind Storage	
DC	0.0	0.0	0.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	548.0	0.0	0.0	0.0	788.0
DE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254.0	136.0	0.0	0.0	0.0	0.0	390.0
IL	0.0	0.0	296.0	0.0	0.0	0.0	0.0	0.0	1,786.5	0.0	0.0	20.4	0.0	0.0	1,624.0	0.0	0.0	0.0	0.0	0.0	3,726.9
IN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	982.0	0.0	0.0	0.0	0.0	0.0	982.0
KY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	995.0	0.0	0.0	0.0	0.0	0.0	995.0
MD	0.0	0.0	347.5	104.0	1.6	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	1,839.0	171.0	0.0	0.0	0.0	0.0	2,463.9
NC	0.0	0.0	0.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	324.5	0.0	0.0	0.0	0.0	0.0	355.5
NJ	0.0	225.0	1,590.0	1,040.2	6.4	0.0	0.5	0.0	614.5	0.0	8.0	19.5	0.0	0.0	1,543.0	932.5	148.0	10.0	0.0	0.0	6,137.6
OH	42.0	0.0	0.0	286.0	0.0	0.0	0.0	0.0	0.0	19.3	5.4	0.0	0.0	0.0	13,179.4	0.0	0.0	0.0	0.0	0.0	13,532.1
PA	1.0	51.0	50.8	72.0	14.0	0.0	0.0	0.0	805.0	0.0	13.9	18.0	0.0	0.0	4,734.3	1,133.0	176.0	109.0	10.4	0.0	7,188.4
TN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0
VA	0.0	267.0	80.0	79.7	0.0	0.0	0.0	0.0	0.0	2.9	8.4	0.0	0.0	0.0	3,917.9	543.0	786.0	83.0	0.0	0.0	5,767.9
WV	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,691.0	0.0	0.0	0.0	0.0	0.0	2,693.0
Total	45.0	543.0	2,364.3	1,852.9	22.0	0.0	0.5	0.0	3,206.0	0.0	44.1	72.5	0.0	0.0	32,084.1	2,915.5	1,658.0	252.0	10.4	0.0	45,070.3

Figure 12-4 is a map of unit retirements between 2011 and 2024, with a mapping to unit names in Table 12-9.

Figure 12-4 Map of unit retirements: 2011 through 2024

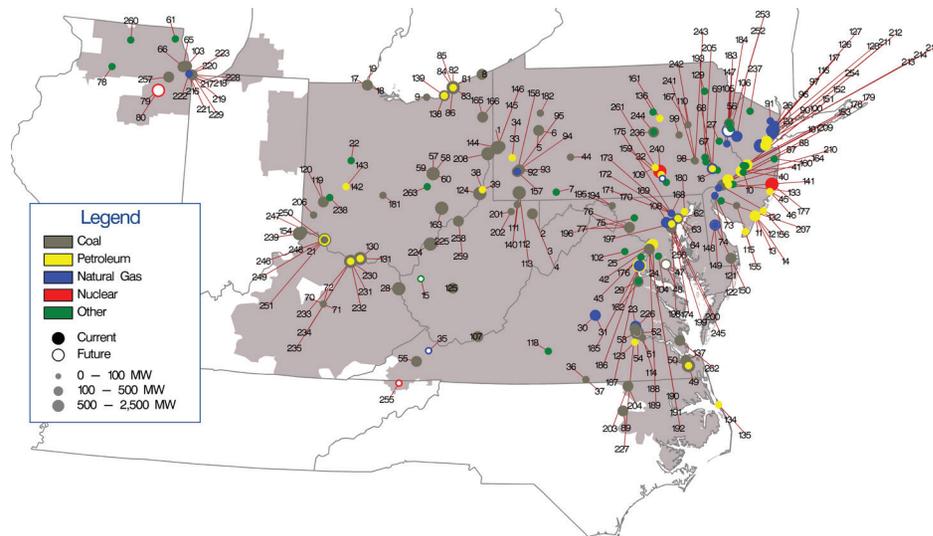


Table 12-9 Unit identification for map of unit retirements: 2011 through 2024

ID	Unit	ID	Unit	ID	Unit	ID	Unit	ID	Unit
1	AES Beaver Valley	56	Columbia Dam Hydro	111	Hatfield's Ferry 1	166	Niles 2	221	Southeast Chicago CT8
2	Albright 1	57	Conesville 3	112	Hatfield's Ferry 2	167	Northeastern Power NEPCO	222	Southeast Chicago GT10
3	Albright 2	58	Conesville 4	113	Hatfield's Ferry 3	168	Notch Cliff GT1	223	Southeast Chicago GT9
4	Albright 3	59	Conesville 5	114	Hopewell James River Cogeneration	169	Notch Cliff GT2	224	Sporn 1-4
5	Armstrong 1	60	Conesville 6	115	Howard Down 10	170	Notch Cliff GT3	225	Sporn 5
6	Armstrong 2	61	Countryside Landfill	116	Hudson 1	171	Notch Cliff GT4	226	Spruance NUG1 (Rich 1-2)
7	Arnold (Green Mtn. Wind Farm)	62	Crane 1	117	Hudson 2	172	Notch Cliff GT5	227	Spruance NUG2 (Rich 3-4)
8	Ashtabula 5	63	Crane 2	118	Hurt NUG	173	Notch Cliff GT6	228	State Line 3
9	Avon Lake 7	64	Crane GT1	119	Hutchings 1-3, 5-6	174	Notch Cliff GT7	229	State Line 4
10	BC Landfill	65	Crawford 7	120	Hutchings 4	175	Notch Cliff GT8	230	Stuart 1
11	BL England 1	66	Crawford 8	121	Indian River 1	176	Occoquan 1 LF	231	Stuart 2
12	BL England 2	67	Cromby 1	122	Indian River 3	177	Oyster Creek	232	Stuart 3
13	BL England 3	68	Cromby 2	123	Ingenco Petersburg	178	Pennsbury Generator Landfill 1	233	Stuart 4
14	BL England Diesel Units 1-4	69	Cromby D	124	Kammer 1-3	179	Pennsbury Generator Landfill 2	234	Stuart Diesels 1-4
15	Balls Gap Battery Facility	70	Dale 1-2	125	Kanawha River 1-2	180	Perryman 2	235	Stuart Diesels 1-4
16	Barbados AES Battery	71	Dale 3	126	Kearny 10	181	Picway 5	236	Sunbury 1-4
17	Bay Shore 2	72	Dale 4	127	Kearny 11	182	Piney Creek NUG	237	Sussex County LF
18	Bay Shore 3	73	Deepwater 1	128	Kearny 9	183	Portland 1	238	Tait Battery
19	Bay Shore 4	74	Deepwater 6	129	Keystone Recovery (Units 1 - 7)	184	Portland 2	239	Tanners Creek 1-4
20	Bayonne Cogen Plant (CC)	75	Dickerson Unit 1	130	Killen 2	185	Possum Point 3	240	Three Mile Island Unit 1
21	Beckjord Battery Unit 2	76	Dickerson Unit 2	131	Killen CT	186	Possum Point 4	241	Titus 1
22	Bellefontaine Landfill Generating Station	77	Dickerson Unit 3	132	Kimberly Clark Generator	187	Possum Point 5	242	Titus 2
23	Bellemeade	78	Dixon Lee Landfill Generator	133	Kinsley Landfill	188	Potomac River 1	243	Titus 3
24	Benning 15	79	Dresden 2	134	Kitty Hawk GT 1	189	Potomac River 2	244	Viking Energy NUG
25	Benning 16	80	Dresden 3	135	Kitty Hawk GT 2	190	Potomac River 3	245	Wagner 2
26	Bergen 3	81	Eastlake 1	136	Koppers Co. IPP	191	Potomac River 4	246	Walter C Beckjord 1
27	Bethlehem Renewable Energy Generator (Landfill)	82	Eastlake 2	137	Lake Kingman	192	Potomac River 5	247	Walter C Beckjord 2
28	Big Sandy 2	83	Eastlake 3	138	Lake Shore 18	193	Pottstown LF (Moser)	248	Walter C Beckjord 3
29	Birchwood Plant	84	Eastlake 4	139	Lake Shore EMD	194	R Paul Smith 3	249	Walter C Beckjord 4
30	Bremo 3	85	Eastlake 5	140	MEA NUG (WVU)	195	R Paul Smith 4	250	Walter C Beckjord 5-6
31	Bremo 4	86	Eastlake 6	141	MH50 Markus Hook Co-gen	196	Reichs Ford Road Landfill Generator	251	Walter C Beckjord GT 1-4
32	Brunner Island Diesels	87	Eddystone 1	142	Mad River CTs A	197	Riverside 4	252	Warren County Landfill
33	Brunot Island 1B	88	Eddystone 2	143	Mad River CTs B	198	Riverside 6	253	Warren County NUG
34	Brunot Island 1C	89	Edgecomb NUG (Rocky 1-2)	144	Mansfield 1	199	Riverside 7	254	Werner 1-4
35	Buchanan 1-2	90	Edison 1-3	145	Mansfield 2	200	Riverside 8	255	West Kingsport LF
36	Buggs Island 1 (Mecklenberg)	91	Elmwood Park Power	146	Mansfield 3	201	Riversville 5	256	Westport 5
37	Buggs Island 2 (Mecklenberg)	92	Elrama 1	147	Martins Creek CT 4	202	Riversville 6	257	Will County 3
38	Burger 3	93	Elrama 2	148	McKee 1	203	Roanoke Valley 1	258	Willow Island 1
39	Burger EMD	94	Elrama 3	149	McKee 2	204	Roanoke Valley 2	259	Willow Island 2
40	Burlington 8,11	95	Elrama 4	150	McKee 3	205	Rolling Hills Landfill Generator	260	Winnebago Landfill
41	Burlington 9	96	Essex 10-11	151	Mercer 1	206	SMART Paper	261	York Generation Facility
42	Buzzard Point East Banks 1,2,4-8	97	Essex 12	152	Mercer 2	207	Salem County LF	262	Yorktown 1-2
43	Buzzard Point West Banks 1-9	98	Evergreen Power United Corstack	153	Mercer 3	208	Sammis 1-4	263	Zanesville Landfill
44	Cambria CoGen	99	FRACKVILLE WHEELABRATOR 1	154	Miami Fort 6	209	Schuykill 1		
45	Cedar 1	100	Fairless Hills Landfill A	155	Middle 1-3	210	Schuykill Diesel		
46	Cedar 2	101	Fairless Hills Landfill B	156	Missouri Ave B,C,D	211	Sewaren 1		
47	Chalk Point Unit 1	102	Fauquier County Landfill	157	Mitchell 2	212	Sewaren 2		
48	Chalk Point Unit 2	103	Fisk Street 19	158	Mitchell 3	213	Sewaren 3		
49	Chesapeake 1-4	104	GUDE Landfill	159	Modern Power Landfill NUG	214	Sewaren 4		
50	Chesapeake 7-10	105	Gilbert 1-4	160	Monmouth NUG landfill	215	Sewaren 6		
51	Chesterfield 3	106	Glen Gardner 1-8	161	Montour ATG	216	Southeast Chicago CT11		
52	Chesterfield 4	107	Glen Lyn 5-6	162	Morris Landfill Generator	217	Southeast Chicago CT12		
53	Chesterfield 5	108	Gould Street Generation Station	163	Muskingum River 1-5	218	Southeast Chicago CT5		
54	Chesterfield 6	109	Harrisburg 4 CT	164	National Park 1	219	Southeast Chicago CT6		
55	Clinch River 3	110	Harwood 1-2	165	Niles 1	220	Southeast Chicago CT7		

Current Year Generation Retirements

Table 12-10 shows that in the first three months of 2021, 430.4 MW of generation retired. The largest generator that retired in the first three months of 2021 was the 237.9 MW Birchwood coal fired steam unit located in the Dominion Zone. Of the 430.4 MW of generation that retired, 353.4 MW (82.1 percent) were located in the Dominion Zone.

Table 12-10 Unit deactivations: January through March, 2021

Company	Unit Name	ICAP (MW)	Unit Type	Zone Name	Age (Years)	Retirement Date
Ares Management LP	Spruance NUG1 (aka Spruance 1 Rich 1-2)	115.5	Steam-Coal	DOM	28.7	12-Jan-21
Biogas Energy Solutions, LLC	Countryside Landfill	8.0	RICE-Other	COMED	8.5	27-Jan-21
Galt Power Inc.	Beckjord Battery Unit 2	2.0	Battery	DUKE	5.3	03-Feb-21
General Electric Company	Birchwood Plant	237.9	Steam-Coal	DOM	24.3	01-Mar-21
Riverstone Holdings LLC	Elmwood Park Power	67.0	Combined Cycle	PSEG	32.0	12-Mar-21

Planned Generation Retirements

Table 12-11 shows that, as of March 31, 2021, there are 4,622.5 MW of generation that have requested retirement after March 31, 2021, of which 1,786.5 MW (38.7 percent) are located in the COMED Zone. Of the generation requesting retirement in the COMED Zone, all 1,786.5 MW (100.0 percent) are nuclear units.

Table 12-11 Planned retirement of units: March 31, 2021

Company	Unit Name	ICAP (MW)	Unit Type	Zone Name	Projected Deactivation Date
American Electric Power Company, Inc.	Balls Gap Battery Facility	2.0	Battery	AEP	22-Apr-21
Riverstone Holdings LLC	Harwood 1-2	28.0	CT-Oil	PPL	31-May-21
Domtar Corporation	West Kingsport LF	50.0	Steam-Other	AEP	31-May-21
GenOn Energy, Inc.	Chalk Point Unit 1	331.0	Steam-Coal	PEPCO	01-Jun-21
GenOn Energy, Inc.	Chalk Point Unit 2	336.0	Steam-Coal	PEPCO	01-Jun-21
City of Dover	McKee 3	102.0	Steam-Natural Gas	DPL	01-Jun-21
Exelon Corporation	Dresden 2	883.5	Nuclear	COMED	08-Nov-21
Exelon Corporation	Dresden 3	903.0	Nuclear	COMED	29-Nov-21
Riverstone Holdings LLC	Martins Creek CT 4	850.0	Steam-Natural Gas	PPL	31-May-22
Riverstone Holdings LLC	York Generation Facility	51.0	Combined Cycle	MEC	31-May-22
Dominion Resources, Inc.	Chesterfield 5	336.0	Steam-Coal	DOM	31-May-23
Dominion Resources, Inc.	Chesterfield 6	670.0	Steam-Coal	DOM	31-May-23
LS Power Equity Partners, L.P.	Buchanan 1-2	80.0	CT-Natural-Gas	AEP	01-Jun-23
		4,622.5			

Generation Queue²³

Any entity that requests interconnection of a new generating facility, including increases to the capacity of an existing generating unit, or that requests interconnection of a merchant transmission facility, must follow the process defined in the PJM tariff to obtain interconnection service.²⁴ PJM's process is designed to ensure that new generation is added in a reliable and systematic manner. The process is complex and time consuming at least in part as a result of the required analyses. The cost, time and uncertainty associated with interconnecting to the grid may create barriers to entry for potential entrants. The MMU recommends that barriers to entry be addressed in a timely manner in order to help ensure that the market will result in the entry of new capacity to meet the needs of PJM market participants.

Generation request queues are groups of proposed projects, including new units, reratings of existing units, capacity resources and energy only resources. Each queue is open for a fixed amount of time. Studies commence on all projects in a given queue when that queue closes. Queues A and B were open for one year. Queues C through T were open for six months. Starting in February 2008, Queues U through Y1 were open for three months. In May 2012, the duration of the queue period was reset to six months, starting with Queue Y2. Queue AG2 opened on October 1, 2020 and closed on March 31, 2021.

Projects that do not meet submission requirements are removed from the queue. All projects that have entered a queue and have met the submission requirements have a status assigned. Projects listed as active are undergoing one of the studies (feasibility, system impact, facility) required to proceed. Other status options are under construction, suspended, and in service. A project cannot be suspended until it has reached the status of under construction. Any project that entered the queue before February 1, 2011, can be suspended for up to three years. Projects that entered the queue after February 1, 2011, face an additional restriction in that the suspension period is reduced to one year if they affect any project later in the queue.²⁵ When a project is suspended,

PJM extends the scheduled milestones by the duration of the suspension. If, at any time, a milestone is not met, PJM will initiate the termination of the Interconnection Service Agreement (ISA) and the corresponding cancellation costs must be paid by the customer.²⁶

The PJM queue evaluation process has been substantially improved in recent years and it is more efficient and effective as a result.²⁷ The PJM queue evaluation process should continue to be improved to help ensure that barriers to competition from new generation investments are not created. The MMU recommends improvements in queue management including that PJM establish a review process to ensure that projects are removed from the queue if they are not viable, as well as a process to allow commercially viable projects to advance in the queue ahead of projects which have failed to make progress, subject to rules to prevent gaming.

²³ The queue totals in this report are the winter net MW energy for the interconnection requests ("MW Energy") as shown in the queue.

²⁴ See OATT Parts IV & VI.

²⁵ See PJM, "PJM Manual 14C: Generation and Transmission Interconnection Process," Rev. 14 (January 27, 2021).

²⁶ PJM does not track the duration of suspensions or PJM termination of projects.

²⁷ See *PJM Interconnection, LLC*, Docket No. ER12-1177 (Feb. 29, 2012).

Process Timelines

In the study phase of the interconnection planning process, a series of studies are performed to determine the feasibility, impact, and cost of projects in the queue. Table 12-12 is an overview of PJM's study process. System impact and facilities studies are often redone when a project is withdrawn in order to determine the impact on the projects remaining in the queue.

In 2016, the PJM Earlier Queue Submitted Task Force stakeholder group made changes to the interconnection process to address some of the issues related to delays observed in the various stages of the study phase. The changes became effective with the AC2 Queue that closed on March 31, 2017. The MMU recommends continuing analysis of the study phase of PJM's transmission planning to reduce the need for postponements of study results, to decrease study completion times, and to improve the likelihood that a project at a given phase in the study process will successfully go into service.

Table 12-12 Generation planning process

Process Step	Start on	Financial Obligation	Days for PJM to Complete	Days for Applicant to Decide Whether to Continue
Feasibility Study	Close of current queue	Cost of study (partially refundable deposit)	90	30
System Impact Study	Upon acceptance of the System Impact Study Agreement	Cost of study (partially refundable deposit)	120	30
Facilities Study	Upon acceptance of the Facilities Study Agreement	Cost of study (refundable deposit)	Varies	60
Schedule of Work	Upon acceptance of Interconnection Service Agreement (ISA)	Letter of credit for upgrade costs	Varies	37
Construction (only for new generation)	Upon acceptance of Interconnection Construction Service Agreement (ICSA)	None	Varies	NA

Process improvements have allowed PJM to continue to meet the deadlines for feasibility and system impact studies despite the increase in interconnection requests. The increase in the number of projects submitted in the queue combined with the rules for evaluating projects have contributed to a significant backlog in performing timely facility studies. The facility study includes the conceptual design, stability analyses and determines the network upgrades, and the costs associated with those upgrades. Modifications to proposed facilities and restudies resulting from the withdrawal of projects

from the queue also affect the time to complete a facility study. In 2020, PJM conducted interconnection process workshops designed to review current processes, receive input and recommendations from stakeholders and to develop improvements to the process, including ways to resolve the current interconnection study backlog.

Planned Generation Additions

Expected net revenues provide incentives to build new generation to serve PJM markets. The amount of planned new generation in PJM reflects investors' perception of the incentives provided by the combination of revenues from the PJM energy, capacity and ancillary service markets. On March 31, 2021, 177,645.3 MW were in generation request queues for construction through 2029. Although it is clear that not all generation in the queues will be built, PJM has added capacity steadily since markets were implemented on April 1, 1999.²⁸

²⁸ See "PJM Generation Capacity and Funding Sources 2007/2008 through 2021/2022 Delivery Years," <http://www.monitoringanalytics.com/reports/Reports/2020/IMM_2020_PJM_Generation_Capacity_and_Funding_Sources_20072008_through_20212022_DY_20200915.pdf>.

There were 173,182.4 MW in generation queues, in the status of active, under construction or suspended, at the end of 2020. The AG2 queue remained open during the first three months of 2021, closing on March 31, 2021. As projects move through the queue process, projects can be removed from the queue due to incomplete or invalid data, withdrawn by the market participant or placed in service. On March 31, 2021, there were 177,645.3 MW in generation queues, in the status of active, under construction or suspended, an increase of 4,462.9 MW (2.6 percent) from December 31, 2020. Table 12-13 shows MW in queues by expected completion year and MW changes in the queue between December 31, 2020, and March 31, 2021, for ongoing projects, i.e. projects with the status active, under construction or suspended.²⁹

Table 12-13 Queue comparison by expected completion year (MW): December 31, 2020 and March 31, 2021³⁰

Year	As of		Year Change	
	12/31/2020	03/31/2021	MW	Percent
2008	0.0	0.0	0.0	0.0%
2009	0.0	0.0	0.0	0.0%
2010	0.0	0.0	0.0	0.0%
2011	0.0	0.0	0.0	0.0%
2012	16.1	16.1	0.0	0.0%
2013	20.0	20.0	0.0	0.0%
2014	0.0	0.0	0.0	0.0%
2015	0.0	0.0	0.0	0.0%
2016	19.4	7.4	(12.0)	(61.9%)
2017	905.8	791.8	(114.0)	(12.6%)
2018	2,054.0	1,498.0	(556.0)	(27.1%)
2019	7,898.3	7,120.4	(777.9)	(9.8%)
2020	11,896.1	11,200.7	(695.4)	(5.8%)
2021	31,545.0	32,442.2	897.2	2.8%
2022	41,605.7	42,834.1	1,228.4	3.0%
2023	41,060.4	44,558.1	3,497.7	8.5%
2024	19,435.5	24,981.1	5,545.7	28.5%
2025	3,995.6	5,070.0	1,074.4	26.9%
2026	2,645.2	4,205.2	1,560.0	59.0%
2027	2,100.1	2,100.1	0.0	0.0%
2028	0.0	0.0	0.0	0.0%
2029	800.1	800.1	0.0	0.0%
Total	165,997.3	177,645.3	11,647.9	7.0%

²⁹ Expected completion dates are entered when the project enters the queue. Actual completion dates are generally different than expected completion dates.

³⁰ Wind and solar capacity in Table 12-11 through Table 12-15 have not been adjusted to reflect derating.

Table 12-14 shows the project status changes in more detail and how scheduled queue MW have changed between December 31, 2020, and March 31, 2021. For example, 11,793.3 MW entered the queue in the first three months of 2021. Of those 11,793.3 MW, 145.4 MW have been withdrawn. Of the total 156,594.4 MW marked as active on December 31, 2020, 5,930.0 MW were withdrawn, 2,106.5 MW were suspended, 1,799.8 MW started construction, and 16.5 MW went into service by March 31, 2021. Analysis of projects that were suspended on December 31, 2020 show that 513.4 MW came out of suspension and are now active as of March 31, 2021.

Table 12-14 Change in project status (MW): December 31, 2020 to March 31, 2021

Status at 12/31/2020 (Entered during 2021)	Status at 3/31/2021					
	Total at 12/31/2020	Active	In Service	Under Construction	Suspended	Withdrawn
Active	156,594.4	146,741.6	16.5	1,799.8	2,106.5	5,930.0
In Service	73,092.3	0.0	73,090.2	0.0	0.0	2.1
Under Construction	9,570.8	22.7	262.3	9,275.8	0.0	10.0
Suspended	7,017.3	513.4	0.0	0.0	5,447.5	1,056.4
Withdrawn	410,672.5	90.0	0.0	0.0	0.0	410,582.5
Total	656,947.3	159,015.6	73,369.0	11,075.6	7,554.0	417,726.4

On March 31, 2021, 177,645.3 MW were in generation request queues in the status of active, suspended or under construction. Table 12-15 shows each status by unit type. Of the 159,015.6 MW in the status of Active on March 31, 2021, 8,268.3 MW (5.2 percent) were combined cycle projects. Of the 11,075.6 MW in the status of under construction, 7,840.3 MW (70.8 percent) were combined cycle projects. A significant amount of renewable hybrid projects (defined as solar + storage, solar + wind and wind + storage projects) have entered the queue in recent years. Of the 159,015.6 MW in the status of Active on March 31, 2021, 19,061.6 MW (12.0 percent) were renewable hybrid projects. Of the 11,075.6 MW in the status of under construction, 5.7 MW (.05 percent) were renewable hybrid projects.

Table 12-15 Current project status (MW) by unit type: March 31, 2021

	CT -		Natural	CT -			Hydro -	Hydro -	RICE -			Steam -							Wind +	Total		
	Battery	Combined Cycle		Oil	Other	Fuel Cell	Pumped Storage	Run of River	Nuclear	Gas	RICE - Oil	Other	Solar	Solar + Storage	Solar + Wind	Coal	Natural Gas	- Oil			Other	Wind
Active	15,977.5	8,268.3	4,545.8	18.0	0.0	0.0	700.0	147.3	145.5	0.0	0.0	0.0	79,635.4	18,862.6	199.0	40.0	11.0	0.0	0.0	30,465.3	0.0	159,015.6
Suspended	14.0	4,667.0	705.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,224.2	100.0	0.0	0.0	0.0	0.0	0.0	737.6	106.3	7,554.0
Under Construction	1.0	7,840.3	349.4	13.0	0.0	3.0	0.0	0.0	44.0	1.3	0.0	0.0	2,021.9	5.7	0.0	36.0	0.0	0.0	0.0	760.0	0.0	11,075.6
Total	15,992.5	20,775.6	5,600.2	31.0	0.0	3.0	700.0	147.3	189.5	1.3	0.0	0.0	82,881.4	18,968.3	199.0	76.0	11.0	0.0	0.0	31,962.9	106.3	177,645.3

A significant shift in the distribution of unit types within the PJM footprint continues to develop as natural gas fired units and renewable resources enter the queue and coal fired steam units retire. As of March 31, 2021, of the 177,645.3 MW in the generation request queues in the status of active, suspended or under construction, 82,881.4 MW (46.7 percent) were solar projects, 31,962.9 MW (18.0 percent) were wind projects, 26,388.1 MW (14.9 percent) were natural gas fired projects (including combined cycle units, CTs, RICE units, and natural gas fired steam units), 19,273.6 MW (10.8 percent) were renewable hybrid projects (solar + storage, solar + wind and wind + storage units), and 76.0 MW (.04 percent) were coal fired steam projects.

As of March 31, 2021, there are 1,673.0 MW of coal fired steam units and 1,032.0 MW of natural gas units slated for deactivation between April 1, 2021, and December 31, 2024 (See Table 12-11). The ongoing replacement of coal fired steam units by natural gas units will continue to significantly affect future congestion, the role of firm and interruptible gas supply, and natural gas supply infrastructure.

Table 12-16 shows the total MW in the status of active, in service, under construction, suspended, or withdrawn for each queue since the beginning of the RTEP process and the total MW that had been included in each queue. All items in queues A-R are either in service or have been withdrawn. As of March 31, 2021, there are 177,645.3 MW in queues that are not yet in service or withdrawn, of which 4.3 percent are suspended, 6.2 percent are under construction and 89.5 percent have not begun construction.

Table 12-16 Queue totals by status (MW): March 31, 2021³¹

Queue	Active	In Service	Under			Total
			Construction	Suspended	Withdrawn	
A Expired 31-Jan-98	0.0	9,094.0	0.0	0.0	17,252.0	26,346.0
B Expired 31-Jan-99	0.0	4,643.4	0.0	0.0	14,958.8	19,602.2
C Expired 31-Jul-99	0.0	531.0	0.0	0.0	3,558.3	4,089.3
D Expired 31-Jan-00	0.0	850.6	0.0	0.0	7,358.0	8,208.6
E Expired 31-Jul-00	0.0	795.2	0.0	0.0	8,021.8	8,817.0
F Expired 31-Jan-01	0.0	52.0	0.0	0.0	3,092.5	3,144.5
G Expired 31-Jul-01	0.0	1,189.6	0.0	0.0	17,961.8	19,151.4
H Expired 31-Jan-02	0.0	702.5	0.0	0.0	8,421.9	9,124.4
I Expired 31-Jul-02	0.0	103.0	0.0	0.0	3,728.4	3,831.4
J Expired 31-Jan-03	0.0	42.0	0.0	0.0	846.0	888.0
K Expired 31-Jul-03	0.0	93.1	0.0	0.0	485.3	578.4
L Expired 31-Jan-04	0.0	256.5	0.0	0.0	4,033.7	4,290.2
M Expired 31-Jul-04	0.0	504.8	0.0	0.0	3,705.6	4,210.4
N Expired 31-Jan-05	0.0	2,398.8	0.0	0.0	8,129.3	10,528.0
O Expired 31-Jul-05	0.0	1,890.2	0.0	0.0	5,466.8	7,357.0
P Expired 31-Jan-06	0.0	3,290.3	0.0	0.0	5,320.5	8,610.8
Q Expired 31-Jul-06	0.0	3,147.9	0.0	0.0	11,385.7	14,533.6
R Expired 31-Jan-07	0.0	1,892.5	0.0	0.0	20,708.9	22,601.4
S Expired 31-Jul-07	70.0	3,543.5	0.0	0.0	12,396.5	16,010.0
T Expired 31-Jan-08	0.0	4,196.5	0.0	0.0	23,313.3	27,509.8
U1 Expired 30-Apr-08	0.0	218.9	0.0	0.0	7,937.8	8,156.7
U2 Expired 31-Jul-08	0.0	327.5	450.0	0.0	16,218.6	16,996.1
U3 Expired 31-Oct-08	100.0	333.0	0.0	0.0	2,535.6	2,968.6
U4 Expired 31-Jan-09	0.0	85.2	0.0	200.0	4,745.0	5,030.2
V1 Expired 30-Apr-09	0.0	197.9	0.0	0.0	2,572.8	2,770.7
V2 Expired 31-Jul-09	0.0	989.9	16.1	0.0	3,625.1	4,631.1
V3 Expired 31-Oct-09	0.0	912.0	220.0	0.0	3,822.7	4,954.7
V4 Expired 31-Jan-10	200.0	748.8	0.0	0.0	3,508.0	4,456.8
W1 Expired 30-Apr-10	0.0	567.4	0.0	0.0	5,139.5	5,706.9
W2 Expired 31-Jul-10	0.0	351.7	0.0	0.0	3,051.7	3,403.4
W3 Expired 31-Oct-10	22.7	508.7	0.0	0.0	8,673.2	9,204.6
W4 Expired 31-Jan-11	0.0	1,415.8	0.0	0.0	4,152.6	5,568.4
X1 Expired 30-Apr-11	0.0	1,103.8	0.0	0.0	6,200.6	7,304.4
X2 Expired 31-Jul-11	0.0	3,706.4	0.0	0.0	5,578.4	9,284.7
X3 Expired 31-Oct-11	0.0	89.2	20.0	0.0	7,665.9	7,775.1
X4 Expired 31-Jan-12	0.0	2,948.9	0.0	0.0	2,419.4	5,368.3
Y1 Expired 30-Apr-12	0.0	1,795.5	0.0	72.0	6,207.7	8,075.2
Y2 Expired 31-Oct-12	0.0	1,657.2	0.0	0.0	9,636.5	11,293.7
Y3 Expired 30-Apr-13	0.0	1,425.5	205.0	0.0	4,609.2	6,239.6
Z1 Expired 31-Oct-13	38.0	3,074.5	0.0	975.3	4,037.0	8,124.8
Z2 Expired 30-Apr-14	0.0	3,063.0	0.0	10.0	3,027.8	6,100.8
AA1 Expired 31-Oct-14	904.6	3,526.9	1,302.0	0.0	6,335.4	12,068.9
AA2 Expired 30-Apr-15	405.2	1,310.6	1,510.0	1,640.0	11,200.5	16,066.3
AB1 Expired 31-Oct-15	2,878.6	1,283.0	1,334.7	3,045.0	11,904.6	20,445.9

³¹ Projects listed as partially in service are counted as in service for the purposes of this analysis.

Queue	Active	In Service	Under			Total
			Construction	Suspended	Withdrawn	
AB2 Expired 31-Mar-16	2,236.9	862.4	2,152.2	95.0	9,849.4	15,195.9
AC1 Expired 30-Sep-16	5,930.9	839.6	2,959.8	828.6	9,513.5	20,072.3
AC2 Expired 30-Apr-17	3,134.9	313.0	283.5	199.9	8,670.3	12,601.6
AD1 Expired 30-Sep-17	5,633.4	161.9	66.6	255.0	5,195.7	11,312.6
AD2 Expired 31-Mar-18	6,628.3	267.4	446.4	49.0	12,978.9	20,369.9
AE1 Expired 30-Sep-18	16,105.6	11.6	40.0	27.6	17,722.1	33,907.0
AE2 Expired 31-Mar-19	22,424.2	49.0	4.8	110.4	11,259.9	33,848.2
AF1 Expired 30-Sep-19	22,278.7	2.4	61.4	28.0	6,627.4	28,997.9
AF2 Expired 31-Mar-20	22,183.2	3.0	3.2	18.3	6,070.3	28,277.9
AG1 Expired 30-Sep-20	33,360.1	0.0	0.0	0.0	4,568.0	37,928.1
AG2 Expired 31-Mar-21	14,480.3	0.0	0.0	0.0	320.4	14,800.7
Total	159,015.6	73,369.0	11,075.6	7,554.0	417,726.4	668,740.7

Table 12-17 shows the projects with a status of active, suspended or under construction, by unit type, and control zone. As of March 31, 2021, 177,645.3 MW were in generation request queues for construction through 2029. Table 12-17 also shows the planned retirements for each zone.

Table 12-17 Queue totals for projects (active, suspended and under construction) by LDA, control zone and unit type (MW): March 31, 2021³²

LDA	Zone	Battery	CT -			Fuel	Hydro - Pumped	Hydro - Run of River	Nuclear	RICE -			Steam -						Wind + Storage	Queue Capacity	Planned Retirements					
			Natural	CC	Gas					Oil	Other	Natural	RICE - Oil	RICE - Other	Solar	Solar + Storage	Solar + Wind	Coal				Natural	Oil	Other		
EMAAC	ACEC	793.0	7.6	230.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	739.0	93.0	0.0	0.0	0.0	0.0	0.0	0.0	3,441.6	0.0	5,304.2	0.0
	DPL	670.0	451.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,950.2	130.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,337.1	0.0	5,538.3	102.0
	JCPLC	669.8	35.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	269.6	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,269.2	0.0	5,453.5	0.0
	PECO	20.0	67.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	0.0	0.0	0.0	45.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	176.8	0.0
	PSEG	987.0	51.1	675.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.7	22.6	0.0	0.0	5.0	0.0	0.0	0.0	1,300.0	0.0	3,100.4	0.0	
	REC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	EMAAC Total	3,139.8	611.7	905.0	0.0	0.0	0.0	30.0	44.0	0.0	0.0	0.0	0.0	3,064.3	425.6	0.0	0.0	5.0	0.0	0.0	0.0	11,347.9	0.0	19,573.2	102.0	
SWMAAC	BGE	598.5	0.0	144.6	14.0	0.0	0.0	0.0	0.0	45.5	1.3	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	833.9	0.0
	PEPCO	1.0	0.0	57.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.9	562.5	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	709.7	667.0
	SWMAAC Total	599.5	0.0	201.9	18.0	0.0	0.0	0.0	0.0	45.5	1.3	0.0	0.0	108.9	562.5	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	1,543.6	667.0
WMAAC	MEC	405.2	75.0	13.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	888.1	182.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,571.4	51.0
	PE	530.8	248.0	585.5	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3,790.5	697.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	210.2	0.0	6,065.1	0.0
	PPL	390.0	106.6	0.0	0.0	0.0	0.0	700.0	0.0	100.0	0.0	0.0	0.0	2,098.4	280.0	0.0	0.0	0.0	0.0	0.0	0.0	514.9	90.0	4,279.9	878.0	
	WMAAC Total	1,326.0	429.6	599.0	7.5	0.0	3.0	700.0	0.0	100.0	0.0	0.0	0.0	6,777.0	1,159.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	725.1	90.0	11,916.4	929.0
Non-MAAC	AEP	2,903.8	6,015.0	719.0	0.0	0.0	0.0	0.0	51.0	0.0	0.0	0.0	0.0	26,162.1	7,725.7	0.0	76.0	0.0	0.0	0.0	0.0	4,754.6	0.0	48,407.1	132.0	
	APS	422.8	3,584.7	112.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,587.1	1,465.3	0.0	0.0	0.0	0.0	0.0	0.0	767.0	16.3	9,955.2	0.0	
	ATSI	440.3	3,597.0	533.7	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,090.3	270.9	0.0	0.0	0.0	0.0	0.0	0.0	816.1	0.0	9,753.7	0.0	
	COMED	2,127.1	3,712.6	1,125.2	0.0	0.0	0.0	0.0	22.7	0.0	0.0	0.0	0.0	7,656.9	1,439.9	199.0	0.0	0.0	0.0	0.0	0.0	8,135.1	0.0	24,418.5	1,786.5	
	DAY	175.0	1,150.0	43.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,189.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,637.5	0.0
	DUKE	72.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	533.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	606.1	0.0
	DLCO	55.0	0.0	222.9	0.0	0.0	0.0	0.0	43.6	0.0	0.0	0.0	0.0	58.9	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	417.9	0.0
	DOM	4,655.0	1,675.0	1,138.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24,325.1	3,744.8	0.0	0.0	0.0	0.0	0.0	5,417.2	0.0	40,955.1	1,006.0		
	EKPC	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,208.0	2,057.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,341.0	0.0
	OVEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.0	0.0
	RMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Non-MAAC Total	10,927.2	19,734.3	3,894.3	5.5	0.0	0.0	0.0	117.3	0.0	0.0	0.0	0.0	72,931.2	16,821.0	199.0	76.0	0.0	0.0	0.0	0.0	19,889.9	16.3	144,612.0	2,924.5	
	Total	15,992.5	20,775.6	5,600.2	31.0	0.0	3.0	700.0	147.3	189.5	1.3	0.0	0.0	82,881.4	18,968.3	199.0	76.0	11.0	0.0	0.0	0.0	31,962.9	106.3	177,645.3	4,622.5	

Since wind resources cannot be dispatched on demand, PJM rules previously required that the unforced capacity of wind resources be derated to 20 percent of nameplate capacity until actual generation data are available. Beginning with Queue U, PJM derated wind resources to 13 percent of nameplate capacity until there was operational data to support a different conclusion.³³ PJM derated solar resources to 38 percent of nameplate capacity. Effective June 1, 2017, PJM adjusted the derates of wind and solar resources. The capacity factor derates for wind resources are dependent on the wind farm locations and have an average derate of 16.2 percent. The capacity factor derates for solar resources are dependent on the solar installation type and have an average derate of 46.7 percent. Using the average derate factors, based on the derating of 31,962.9 MW of wind resources to 5,178.0 MW and 82,881.4 MW of solar resources to 38,705.6 MW, the 177,645.3 MW currently under construction, suspended or active in the queue would be reduced to 106,684.6 MW.³⁴

³² This data includes only projects with a status of active, under construction, or suspended.
³³ See PJM, "PJM Manual 14B: PJM Region Transmission Planning Process," Rev. 48 (Oct. 1, 2020).
³⁴ Adjustments to totals for derates are applied to the solar and wind fuel types only. Additional derates may apply to hybrid units.

Withdrawn Projects

The queue contains a substantial number of projects that are not likely to be built. The queue process results in a substantial number of projects that are withdrawn. Manual 14B requires PJM to apply a commercial probability factor at the feasibility study stage to improve the accuracy of capacity and cost estimates. The commercial probability factor is based on the historical incidence of projects dropping out of the queue at the impact study stage, but the actual calculation of commercial probability factors is less than transparent.³⁵ The impact and facilities studies are performed using the full amount of planned generation in the queues. The actual withdrawal rates are shown in Table 12-18 and Table 12-19.

Table 12-18 shows the milestone status when projects were withdrawn, for all withdrawn projects. Of the 3,088 projects withdrawn as of March 31, 2021, 1,546 (50.1 percent) were withdrawn before the system impact study was completed. Once a Construction Service Agreement (CSA) is executed, the financial obligation for any necessary transmission upgrades cannot be retracted. Of the 3,088 projects withdrawn, 595 (19.3 percent) were withdrawn after the completion of a Construction Service Agreement.

Table 12-18 Last milestone at time of withdrawal: January 1, 1997 through March 31, 2021

Milestone Completed	Projects			Maximum Days
	Withdrawn	Percent	Average Days	
Never Started	519	16.8%	112	900
Feasibility Study	1,027	33.3%	267	1,633
System Impact Study	647	21.0%	709	3,248
Facilities Study	300	9.7%	1,133	4,107
Construction Service Agreement (CSA) or beyond	595	19.3%	1,357	7,864
Total	3,088	100.0%		

Average Time in Queue

Table 12-19 shows the time spent at various stages in the queue process and the completion time for the studies performed. For completed projects, there is an average time of 1,075 days, or 2.9 years, between entering a queue and

³⁵ See PJM, "PJM Manual 14B: PJM Region Transmission Planning Process," Rev. 48 (Oct. 1, 2020).

going into service. For withdrawn projects, there is an average time of 623 days, or 1.7 years, between entering a queue and withdrawing.

Table 12-19 Project queue times by status (days): March 31, 2021³⁶

Status	Average (Days)	Standard Deviation	Minimum	Maximum
Active	294	463	0	4,761
In-Service	1,075	785	0	5,306
Suspended	1,279	846	0	4,113
Under Construction	1,185	926	14	4,269
Withdrawn	623	736	0	7,864

Table 12-20 presents information on the time in the stages of the queue for those projects not yet in service or already withdrawn. Of the 1,927 projects in the queue as of March 31, 2021, 465 (24.1 percent) had a completed feasibility study and 386 (20.0 percent) had a completed construction service agreement.

Table 12-20 Project queue times by milestone (days): March 31, 2021

Milestone Reached	Number of Projects	Percent of Total Projects	Average Days	Maximum Days
Under Review	211	10.9%	0	0
Feasibility Study	465	24.1%	39	981
System Impact Study	836	43.4%	345	1,978
Facilities Study	29	1.5%	1,335	4,201
Construction Service Agreement (CSA) or beyond	386	20.0%	922	4,761
Total	1,927	100.0%		

Table 12-21 shows the time spent in the queue by fuel type, and year the project entered the queue, for projects that are in service. The time from when a project enters the queue to the time the project goes in service has generally been decreasing. For example, for a battery project entering the queue in 2015, there was an average of 1,082 days from the time it entered the queue until it went in service, compared to only 293 days when entering the queue in 2018, but the time increased to 504 days in 2019.

³⁶ The queue data shows that some projects were withdrawn and a withdrawal date was not identified. These projects were removed for the purposes of this analysis.

Table 12-21 Average time in queue (days) by fuel type and year submitted (In Service Projects): March 31, 2021³⁷

Unit Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Battery	983	609	417	692	789	1,082	941	383	293	504		
CC	1,310	1,551	1,663	1,419	1,106	838	746	801	309	512		
CT - Natural Gas	1,131	804	953	1,021	734	901	1,192	657	564	206	319	
CT - Oil	717		259									
CT - Other	729	634	954	1,248	718	360						
Fuel Cell						827	643					
Hydro - Pumped Storage						1,402						
Hydro - Run of River			1,325	614	332		580	426	606			
Nuclear	885	866		1,234								
RICE - Natural Gas			1,702	1,053	1,332	798		250				
RICE - Oil						1,849						
RICE - Other	638	1,385	1,479	241	627	622	491		466			
Solar	1,701	1,313	969	1,014	1,003	1,416	988	658	643	508	296	
Solar + Storage												553
Solar + Wind												
Steam - Coal	745		513	1,010	583	853	677	647				
Steam - Natural Gas				1,182		421	751					
Steam - Oil												
Steam - Other	256	838	643									
Wind	2,748	2,711	1,750	1,589	1,494	1,463	1,362	1,200	561			
Wind + Storage												

Completion Rates

The probability of a project going into service increases as each step of the planning process is completed.

Table 12-22 shows the historic completion rates (MW energy) by unit type for projects that have completed the system impact study (SIS), facilities study agreement (FSA) and construction service agreement (CSA) milestones as well as the historic completion rates for all projects including those withdrawn before reaching the SIS milestone. For each unit type, the total MW in service was divided by the total energy MW entered in the queue. To calculate the completion rates for projects that reached the individual milestones, only those projects that reached a final status of withdrawn or in service were evaluated. For example, if a project was withdrawn after the completion of its SIS, but before the completion of the FSA, the totals would be included in

³⁷ A blank cell in this table means that no project of that fuel type, that was submitted to the queue in that year, subsequently went into service.

the calculation of the SIS completion rate, but not in the calculation of the FSA or CSA completion rates. Similarly, if a project was withdrawn after the completion of its FSA, but before the completion of the CSA, the totals would be included in the calculation of the SIS and FSA completion rates, but not in the calculation of the CSA completion rate. The completion rates show that of all battery projects to ever enter the queue and complete the system impact study stage, 15.3 percent of the queued MW have gone into service. The completion rate for battery projects increases to 36.1 percent when battery projects complete the facility study agreement and further increases to 43.1 percent when battery projects complete the construction service agreement. Of all battery projects to enter the queue, only 1.2 percent of the queued MW have gone into service.

Table 12-22 Historic completion rates (MW energy) by unit type for projects with a completed SIS, FSA and CSA: March 31, 2021

Unit Type	Completion Rate (SIS)	Completion Rate (FSA)	Completion Rate (CSA)	Completion Rate (ALL)
Battery	15.3%	36.1%	43.1%	1.2%
CC	32.0%	49.6%	77.4%	13.8%
CT - Natural Gas	66.7%	82.2%	85.8%	42.7%
CT - Oil	35.6%	60.2%	90.8%	25.4%
CT - Other	12.3%	18.6%	29.5%	10.7%
Fuel Cell	30.6%	31.6%	31.6%	43.6%
Hydro - Pumped Storage	100.0%	100.0%	100.0%	24.5%
Hydro - Run of River	43.2%	61.3%	68.9%	20.8%
Nuclear	35.2%	42.1%	51.3%	28.6%
RICE - Natural Gas	30.7%	42.9%	47.6%	26.4%
RICE - Oil	34.0%	59.7%	59.7%	26.2%
RICE - Other	89.0%	91.4%	92.0%	78.1%
Solar	15.4%	34.9%	44.4%	2.6%
Solar + Storage	0.1%	100.0%	100.0%	0.0%
Solar + Wind	0.0%	0.0%	0.0%	0.0%
Steam - Coal	13.6%	25.4%	37.5%	6.2%
Steam - Natural Gas	91.1%	91.1%	91.1%	90.0%
Steam - Oil	0.0%	0.0%	0.0%	0.0%
Steam - Other	30.4%	39.9%	47.8%	27.4%
Wind	18.9%	35.4%	52.0%	8.4%
Wind + Storage	0.0%	0.0%	0.0%	0.0%

On March 31, 2021, 177,645.3 MW were in generation request queues in the status of active, under construction or suspended. Of the total 177,645.3 MW in the queue, 118,959.5 MW (67.0 percent) have reached at least the SIS milestone and 58,685.8 MW (23.0 percent) have not received a completed SIS. Based on historical completion rates, (applying the unit type specific completion rates for those projects that have reached the SIS, FSA or CSA milestone, and using the overall completion rates for those projects that have not yet reached the SIS milestone), 37,491.5 MW of new generation in the queue are expected to go into service.

Table 12-23 shows the percent of all project MW, by unit type, to go in service by year submitted to the queue. Of all battery projects that entered the queue in 2010, 65.5 percent reached the status of in service by March 31, 2021. Of all battery projects that entered the queue in 2016, only 1.3 percent have reached the status of in service as of March 31, 2021.

Table 12-23 Percent of all projects (MW energy) to go in service by unit type and year submitted to the queue: March 31, 2021

Unit Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Battery	65.5%	8.3%	15.1%	43.9%	21.5%	7.7%	1.3%	4.1%	0.3%	0.0%	0.0%	0.0%
CC	14.6%	24.5%	30.8%	35.6%	43.7%	3.7%	2.2%	2.5%	1.2%	0.5%	NA	NA
CT - Natural Gas	100.0%	98.3%	89.7%	23.5%	32.0%	0.2%	8.2%	16.5%	3.6%	0.0%	0.5%	0.0%
CT - Oil	100.0%	NA	1.2%	0.0%	0.0%	NA	NA	NA	0.0%	0.0%	0.0%	NA
CT - Other	28.8%	27.1%	36.1%	100.0%	0.0%	100.0%	NA	0.0%	NA	NA	NA	NA
Fuel Cell	NA	NA	NA	NA	NA	67.4%	12.5%	0.0%	NA	0.0%	NA	NA
Hydro - Pumped Storage	NA	NA	NA	NA	NA	100.0%	NA	NA	0.0%	0.0%	NA	NA
Hydro - Run of River	0.0%	0.0%	57.6%	49.6%	11.2%	NA	100.0%	26.8%	100.0%	0.0%	0.0%	0.0%
Nuclear	15.5%	1.6%	0.0%	100.0%	NA	NA	0.0%	71.6%	0.0%	NA	0.0%	NA
RICE - Natural Gas	NA	NA	100.0%	66.7%	5.4%	6.2%	0.0%	5.4%	NA	NA	NA	NA
RICE - Oil	0.0%	0.0%	NA	NA	NA	30.8%	NA	NA	NA	NA	NA	NA
RICE - Other	100.0%	100.0%	100.0%	100.0%	79.7%	25.5%	2.8%	0.0%	100.0%	NA	NA	NA
Solar	10.7%	7.1%	16.9%	24.4%	30.7%	17.8%	5.3%	0.4%	0.1%	0.0%	0.0%	0.0%
Solar + Storage	NA	NA	NA	NA	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Solar + Wind	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Steam - Coal	100.0%	0.0%	1.4%	68.4%	1.2%	23.4%	37.5%	100.0%	0.0%	0.0%	NA	NA
Steam - Natural Gas	NA	NA	NA	100.0%	0.0%	100.0%	100.0%	100.0%	NA	NA	0.0%	NA
Steam - Oil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Steam - Other	0.5%	61.2%	16.6%	0.0%	0.0%	NA	NA	NA	NA	NA	NA	NA
Wind	6.1%	3.4%	2.5%	5.8%	20.7%	12.5%	12.3%	2.6%	0.0%	0.0%	0.0%	0.0%
Wind + Storage	NA	NA	NA	NA	NA	NA	0.0%	0.0%	NA	NA	NA	NA
All	10.4%	18.9%	26.5%	32.1%	34.3%	6.5%	2.8%	1.5%	0.4%	0.0%	0.0%	0.0%

Queue Analysis by Fuel Group

The time it takes to complete a study depends on the backlog and the number of projects in the queue, but not on the size of the project. Table 12-24 shows the number of projects that entered the queue by year and by fuel group. The fuel groups are nuclear units, renewable units (including solar, hydro, biomass, renewable hybrid and wind) and traditional units (all other fuels). The number of queue entries has increased during the past several years, primarily by renewable projects. Of the 3,330 projects entered from January 2015 through March 2021, 2,515 projects (75.5 percent) were renewable. Of the 140 projects entered in the first three months of 2021, 117 projects (83.6 percent) were renewable.

Table 12-24 Number of projects entered in the queue: March 31, 2021

Year Entered	Fuel Group			Total
	Nuclear	Renewable	Traditional	
1997	2	0	11	13
1998	0	0	18	18
1999	1	5	84	90
2000	2	3	78	83
2001	4	6	81	91
2002	3	15	33	51
2003	1	34	18	53
2004	4	17	33	54
2005	3	75	55	133
2006	9	67	81	157
2007	9	65	145	219
2008	3	102	111	216
2009	10	107	56	173
2010	5	370	66	441
2011	6	264	85	355
2012	2	59	98	159
2013	1	54	99	154
2014	0	100	92	192
2015	0	134	175	309
2016	2	298	99	399
2017	2	293	60	355
2018	1	343	96	440
2019	0	544	153	697
2020	2	786	202	990
2021	0	117	23	140
Total	72	3,858	2,052	5,982

As of March 31, 2021, renewable projects make up 79.1 percent of all projects in the queue and those projects account for 76.0 percent of the nameplate MW currently active, suspended or under construction in the queue as of March 31, 2021 (Table 12-25).

Table 12-25 Queue details by fuel group: March 31, 2021

Fuel Group	Number of Projects	Percent of Projects	MW	Percent MW
Nuclear	6	0.3%	189.5	0.1%
Renewable	1,525	79.1%	134,968.2	76.0%
Traditional	396	20.6%	42,487.6	23.9%
Total	1,927	100.0%	177,645.3	100.0%

Historical completion rates for renewable projects may not be an accurate predictor of completion rates for current renewable projects. The outcomes for current projects will provide additional information and improve the ability to assess the likely future generation mix based on the type of projects in the queue.

While renewables currently make up the majority of both projects and nameplate MW in the queue, historical completion rates and derating factors must be accounted for when evaluating the share of capacity resources that are likely to be contributed by renewables (Table 12-22). Table 12-26 shows the total MW of all projects in the queue as of March 31, 2021, in the status of active, suspended and under construction, by unit type. Table 12-26 also shows the total MW for each fuel type adjusted based on current historical completion rates and for the average solar and wind derates. Of the 20,775.6 MW of combined cycle projects in the queue, 13,660.7 MW (65.8 percent) are expected to go in service based on historical completion rates as of March 31, 2021. Of the 134,968.2 MW of renewable projects in the queue, only 18,847.6 MW (14.0 percent) are expected to go in service based on historical completion rates. Of the 134,968.2 MW of renewable projects in the queue, only 7,506.5 MW (5.6 percent) of capacity resources are expected to go into service, based on both historical completion rates and average derate factors for wind and solar.

Table 12-26 Queue totals for projects (active, suspended and under construction) by unit type adjusted based on current historical completion rates and average solar and wind derates (MW): March 31, 2021³⁸

Unit Type	MW in Queue	Completion Rate Adjusted MW in Queue	Completion Rate and Derate Adjusted MW in Queue
Battery	15,992.5	1,124.1	1,124.1
CC	20,775.6	13,660.7	13,660.7
CT - Natural Gas	5,600.2	3,732.5	3,732.5
CT - Oil	31.0	18.2	18.2
CT - Other	0.0	0.0	0.0
Fuel Cell	3.0	0.9	0.9
Hydro - Pumped Storage	700.0	700.0	700.0
Hydro - Run of River	147.3	61.5	61.5
Nuclear	189.5	71.9	71.9
RICE - Natural Gas	1.3	0.6	0.6
RICE - Oil	0.0	0.0	0.0
RICE - Other	0.0	0.0	0.0
Solar	82,881.4	11,656.1	5,443.4
Solar + Storage	18,968.3	309.1	309.1
Solar + Wind	199.0	0.0	0.0
Steam - Coal	76.0	25.9	25.9
Steam - Natural Gas	11.0	10.0	10.0
Steam - Oil	0.0	0.0	0.0
Steam - Other	0.0	0.0	0.0
Wind	31,962.9	6,119.8	991.4
Wind + Storage	106.3	0.0	0.0
Total	177,645.3	37,491.5	26,150.4

A total of 4,821 projects have been classified as new generation and 1,161 projects have been classified as upgrades. Natural gas, wind, solar and renewable hybrid projects (including solar + storage, solar + wind and wind + storage) have accounted for 4,779 projects (79.9 percent) of all 5,982 generation queue projects to enter the queue since January 1, 1997.

Queue Analysis by Unit Type and Project Classification

Table 12-27 shows the current status of all generation queue projects by unit type and project classification from January 1, 1997, through March 31, 2021. As of March 31, 2021, 5,982 projects, representing 668,740.7 MW, have entered the queue process since its inception. Of those, 967 projects, representing 73,369.0 MW, went into service. Of the projects that entered the queue process, 3,088 projects, representing 417,726.4 MW (62.5 percent of the MW) withdrew prior to completion. Such projects may create barriers to entry for projects that would otherwise be completed by taking up queue positions, increasing interconnection costs and creating uncertainty.

³⁸ Adjustments to totals for derates are applied to the solar and wind fuel types only. Additional derates may apply to hybrid units.

Table 12-27 Status of all generation queue projects: January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																				Total			
		Battery	CC	CT - Natural			CT - Oil	Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural			RICE - Gas	RICE - Oil	RICE - Other	Solar	Solar + Storage	Solar + Wind		Steam - Coal	Steam - Natural Gas	Steam - Oil
In Service	New Generation	22	62	48	10	25	3	0	10	2	10	0	55	166	1	0	8	5	0	4	94	0	525		
	Upgrade	7	102	108	15	5	0	3	19	42	9	2	16	30	0	0	55	10	0	8	11	0	442		
Under Construction	New Generation	1	7	3	0	0	0	0	0	0	1	0	0	28	2	0	0	0	0	4	0	46			
	Upgrade	0	10	15	8	0	1	0	0	1	0	0	0	11	1	0	1	0	0	1	0	49			
Suspended	New Generation	3	5	1	0	0	0	0	0	0	0	0	0	24	1	0	0	0	0	6	1	41			
	Upgrade	0	3	1	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	10			
Withdrawn	New Generation	177	431	28	9	81	26	2	42	9	28	12	16	1,325	63	0	55	1	0	34	446	0	2,785		
	Upgrade	38	96	16	13	13	2	0	5	13	0	2	3	53	1	0	15	0	0	2	31	0	303		
Active	New Generation	174	9	8	1	0	0	2	6	0	0	0	0	936	198	1	0	1	0	88	0	1,424			
	Upgrade	93	16	27	2	1	0	0	2	5	0	0	0	162	27	0	3	2	0	16	1	357			
Total Projects	New Generation	377	514	88	20	106	29	4	58	11	39	12	71	2,479	265	1	63	7	0	38	638	1	4,821		
	Upgrade	138	227	167	38	19	3	3	26	61	9	4	19	261	29	0	74	12	0	10	59	2	1,161		

Table 12-28 shows the totals in Table 12-27 by share of classification as new generation or upgrade. Within a unit type the shares of upgrades add to 100 percent and the shares of new generation add to 100 percent. For example, 73.1 percent of all hydro run of river projects classified as upgrades are currently in service in PJM, 19.2 percent of hydro run of river upgrades were withdrawn and 7.7 percent of hydro run of river upgrades are active in the queue.

Table 12-28 Status of all generation queue projects as a percent of total projects by classification: January 1, 1997 through March 31, 2021

Project Status	Project Classification	Percent of Projects																						Total	
		Battery	CC	CT - Natural			CT - Oil	Other	Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE - Natural			RICE - Gas	RICE - Oil	RICE - Other	Solar	Solar + Storage	Solar + Wind	Steam - Coal	Steam - Natural Gas		Steam - Oil
In Service	New Generation	5.8%	12.1%	54.5%	50.0%	23.6%	10.3%	0.0%	17.2%	18.2%	25.6%	0.0%	77.5%	6.7%	0.4%	0.0%	12.7%	71.4%	0.0%	10.5%	14.7%	0.0%	10.9%		
	Upgrade	5.1%	44.9%	64.7%	39.5%	26.3%	0.0%	100.0%	73.1%	68.9%	100.0%	50.0%	84.2%	11.5%	0.0%	0.0%	74.3%	83.3%	0.0%	80.0%	18.6%	0.0%	38.1%		
Under Construction	New Generation	0.3%	1.4%	3.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.0%	0.0%	1.1%	0.8%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	1.0%			
	Upgrade	0.0%	4.4%	9.0%	21.1%	0.0%	33.3%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%	4.2%	3.4%	0.0%	1.4%	0.0%	0.0%	1.7%	0.0%	4.2%			
Suspended	New Generation	0.8%	1.0%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.9%	100.0%	0.9%			
	Upgrade	0.0%	1.3%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%			
Withdrawn	New Generation	46.9%	83.9%	31.8%	45.0%	76.4%	89.7%	50.0%	72.4%	81.8%	71.8%	100.0%	22.5%	53.4%	23.8%	0.0%	87.3%	14.3%	0.0%	89.5%	69.9%	0.0%	57.8%		
	Upgrade	27.5%	42.3%	9.6%	34.2%	68.4%	66.7%	0.0%	19.2%	21.3%	0.0%	50.0%	15.8%	20.3%	3.4%	0.0%	20.3%	0.0%	0.0%	20.0%	52.5%	0.0%	26.1%		
Active	New Generation	46.2%	1.8%	9.1%	5.0%	0.0%	0.0%	50.0%	10.3%	0.0%	0.0%	0.0%	0.0%	37.8%	74.7%	100.0%	0.0%	14.3%	0.0%	13.8%	0.0%	29.5%			
	Upgrade	67.4%	7.0%	16.2%	5.3%	5.3%	0.0%	0.0%	7.7%	8.2%	0.0%	0.0%	0.0%	62.1%	93.1%	0.0%	4.1%	16.7%	0.0%	0.0%	27.1%	50.0%	30.7%		

Table 12-29 shows the total MW of projects in the PJM generation queue by unit type and project classification. For example, the 446 new generation wind projects that have been withdrawn from the queue as of March 31, 2021, (as shown in Table 12-27) constitute 77,442.0 MW. The 431 new generation combined cycle projects that have been withdrawn in the same time period constitute 215,469.7 MW.

Table 12-29 Status of all generation (MW) in the generation queue: January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																							Total
		Battery	CC	CT -			Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE -				Solar + Storage	Solar + Wind	Steam -			Wind + Storage					
				Natural Gas	Oil	Other					Natural Gas	RICE - Oil	RICE - Other	Solar			Natural Gas	Oil	Other						
In Service	New Generation	223.4	33,703.0	6,664.4	676.5	151.3	1.9	0.0	371.5	1,639.0	156.4	0.0	440.1	2,464.5	1.1	0.0	1,343.0	723.0	0.0	60.9	9,919.6	0.0	58,539.6		
	Upgrade	44.4	6,591.8	2,725.5	127.8	12.3	0.0	390.0	387.6	2,310.8	17.3	27.3	50.7	46.3	0.0	0.0	965.5	225.5	0.0	667.8	238.7	0.0	14,829.3		
Under Construction	New Generation	1.0	6,596.9	259.4	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1,768.7	2.6	0.0	0.0	0.0	0.0	0.0	0.0	760.0	0.0	9,389.9	
	Upgrade	0.0	1,243.4	90.0	13.0	0.0	3.0	0.0	0.0	44.0	0.0	0.0	0.0	253.2	3.2	0.0	36.0	0.0	0.0	0.0	0.0	0.0	1,685.8		
Suspended	New Generation	14.0	4,136.0	675.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,155.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	737.6	90.0	6,908.1	
	Upgrade	0.0	531.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	645.9	
Withdrawn	New Generation	4,186.5	215,469.7	4,281.7	1,721.0	1,244.2	5.5	500.0	2,043.8	8,161.0	479.9	63.9	88.6	40,712.9	7,805.0	0.0	33,511.6	27.0	0.0	1,050.9	77,441.9	0.0	398,795.0		
	Upgrade	841.3	11,590.4	670.6	589.0	72.5	0.9	0.0	105.1	966.0	0.0	13.0	10.0	1,533.4	3.7	0.0	885.0	0.0	0.0	37.1	1,613.4	0.0	18,931.4		
Active	New Generation	13,055.5	6,483.0	2,883.6	14.0	0.0	0.0	700.0	66.3	0.0	0.0	0.0	0.0	73,308.2	17,735.6	199.0	0.0	5.0	0.0	0.0	28,875.3	0.0	143,325.4		
	Upgrade	2,922.0	1,785.3	1,662.2	4.0	0.0	0.0	0.0	81.0	145.5	0.0	0.0	0.0	6,327.2	1,127.0	0.0	40.0	6.0	0.0	0.0	1,590.1	0.0	15,690.3		
Total Projects	New Generation	17,480.3	266,388.6	14,764.1	2,411.5	1,395.6	7.4	1,200.0	2,481.5	9,800.0	637.6	63.9	528.7	119,409.9	25,644.2	199.0	34,854.6	755.0	0.0	1,111.8	117,734.4	90.0	616,958.0		
	Upgrade	3,807.7	21,741.9	5,178.3	733.8	84.8	3.9	390.0	573.7	3,466.3	17.3	40.3	60.7	8,228.7	1,133.9	0.0	1,926.5	231.5	0.0	704.9	3,442.2	16.3	51,782.7		

Table 12-30 shows the MW totals in Table 12-29 by share by classification as new generation or upgrade. Within a unit type the shares of upgrades add to 100 percent and the shares of new generation add to 100 percent. For example, 65.8 percent of wind project MW classified as new generation have been withdrawn from the queue between January 1, 1997, and March 31, 2021.

Table 12-30 Status of all generation queue projects as percent of total MW in project classification: January 1, 1997 through March 31, 2021

Project Status	Project Classification	Percent of Total Projects by Classification																							Total
		Battery	CC	CT -			Fuel Cell	Hydro - Pumped Storage	Hydro - Run of River	Nuclear	RICE -				Solar + Storage	Solar + Wind	Steam -			Wind + Storage					
				Natural Gas	Oil	Other					Natural Gas	RICE - Oil	RICE - Other	Solar			Natural Gas	Oil	Other						
In Service	New Generation	1.3%	12.7%	45.1%	28.1%	10.8%	26.2%	0.0%	15.0%	16.7%	24.5%	0.0%	83.2%	2.1%	0.0%	0.0%	3.9%	95.8%	0.0%	5.5%	8.4%	0.0%	9.5%		
	Upgrade	1.2%	30.3%	52.6%	17.4%	14.5%	0.0%	100.0%	67.6%	66.7%	100.0%	67.7%	83.5%	0.6%	0.0%	0.0%	50.1%	97.4%	0.0%	94.7%	6.9%	0.0%	28.6%		
Under Construction	New Generation	0.0%	2.5%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	1.5%		
	Upgrade	0.0%	5.7%	1.7%	1.8%	0.0%	76.0%	0.0%	0.0%	1.3%	0.0%	0.0%	0.0%	3.1%	0.3%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%		
Suspended	New Generation	0.1%	1.6%	4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	100.0%	1.1%		
	Upgrade	0.0%	2.4%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	1.2%		
Withdrawn	New Generation	23.9%	80.9%	29.0%	71.4%	89.2%	73.8%	41.7%	82.4%	83.3%	75.3%	100.0%	16.8%	34.1%	30.4%	0.0%	96.1%	3.6%	0.0%	94.5%	65.8%	0.0%	64.6%		
	Upgrade	22.1%	53.3%	13.0%	80.3%	85.5%	24.0%	0.0%	18.3%	27.9%	0.0%	32.3%	16.5%	18.6%	0.3%	0.0%	45.9%	0.0%	0.0%	5.3%	46.9%	0.0%	36.6%		
Active	New Generation	74.7%	2.4%	19.5%	0.6%	0.0%	0.0%	58.3%	2.7%	0.0%	0.0%	0.0%	0.0%	61.4%	69.2%	100.0%	0.0%	0.7%	0.0%	0.0%	24.5%	0.0%	23.2%		
	Upgrade	76.7%	8.2%	32.1%	0.5%	0.0%	0.0%	0.0%	14.1%	4.2%	0.0%	0.0%	0.0%	76.9%	99.4%	0.0%	2.1%	2.6%	0.0%	0.0%	46.2%	0.0%	30.3%		

Table 12-31 shows the project MW that entered the PJM generation queue by unit type and year of entry. Since 2016, 77.9 percent of all new projects entering the generation queue have been combined cycle (15.1 percent), wind (17.6 percent) or solar projects (45.2 percent). Prior to 2015, no renewable hybrid units (solar + storage, solar + wind and wind + storage) entered the queue. In the time period from January 1, 2015 through March 31, 2021, 27,081.4 MW have entered the queue.

Table 12-31 Queue project MW by unit type and queue entry year: January 1, 1997 through March 31, 2021

Year	CT -				Hydro -		Hydro -		RICE -				Steam -				Wind +	Total				
	Battery	CC	Gas	CT - Oil	Other	Fuel Cell	Pumped Storage	Run of River	Nuclear	Gas	RICE - Oil	Other	Solar	Solar + Storage	Solar + Wind	Coal			Gas	- Oil	Other	
1997	0.0	4,148.0	321.0	315.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,840.0	
1998	0.0	7,006.0	1,775.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,781.0	
1999	0.0	29,412.7	2,412.1	0.0	10.0	0.0	0.0	196.0	45.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0	0.0	525.0	115.4	0.0	32,763.2	
2000	0.0	21,144.8	493.6	31.5	8.8	0.0	0.0	0.0	95.0	0.0	0.0	1.2	0.0	0.0	37.0	2.5	0.0	0.0	95.6	0.0	21,909.9	
2001	0.0	25,411.7	264.0	0.0	0.0	0.0	0.0	107.0	90.0	0.0	0.0	15.6	0.0	0.0	1,244.6	10.0	0.0	0.0	252.9	0.0	27,395.8	
2002	0.0	4,154.0	11.7	0.0	70.5	0.0	0.0	293.0	236.0	8.0	23.3	4.5	0.0	0.0	1,895.0	0.0	0.0	0.0	790.9	0.0	7,486.9	
2003	0.0	2,361.4	10.0	8.0	0.8	0.0	0.0	2.0	0.0	29.0	0.0	27.5	0.0	0.0	522.0	0.0	0.0	165.0	997.0	0.0	4,122.7	
2004	0.0	3,610.0	43.3	20.0	49.1	0.0	0.0	0.0	1,911.0	0.0	35.5	17.5	0.0	0.0	1,187.0	0.0	0.0	0.0	1,614.7	0.0	8,488.1	
2005	0.0	5,824.6	961.0	281.0	51.4	0.0	340.0	174.2	242.0	21.5	0.0	65.1	0.0	0.0	6,360.0	0.0	0.0	24.0	6,020.0	0.0	20,364.9	
2006	0.0	4,188.1	454.3	607.5	73.1	0.0	0.0	159.0	6,894.0	0.0	0.0	93.0	0.0	0.0	9,586.0	0.0	0.0	258.5	7,650.7	0.0	29,964.2	
2007	0.0	13,944.6	941.2	215.9	149.5	0.0	16.0	161.6	368.0	0.0	0.0	56.5	3.3	0.0	9,078.0	190.0	0.0	50.5	18,525.6	0.0	43,700.6	
2008	121.0	26,001.0	129.7	1,113.0	488.8	0.0	0.0	1,254.5	105.0	6.0	0.0	32.0	66.3	0.0	1,198.0	0.0	0.0	192.3	11,016.1	0.0	41,723.7	
2009	34.0	5,548.4	14.0	66.0	214.2	0.0	0.0	133.9	1,933.8	4.5	16.0	15.2	636.5	0.0	1,273.0	5.5	0.0	148.0	6,672.6	0.0	16,715.6	
2010	72.4	9,185.4	176.0	7.9	117.3	0.0	0.0	132.6	426.0	0.0	2.4	57.8	3,672.6	0.0	64.0	0.0	0.0	173.5	9,803.4	0.0	23,891.3	
2011	24.1	19,744.0	29.5	0.0	174.6	0.0	0.0	30.0	182.0	0.0	14.0	75.3	2,014.0	0.0	357.0	0.0	0.0	49.0	5,576.4	0.0	28,269.9	
2012	142.6	18,014.8	282.1	42.5	48.4	0.0	0.0	11.8	369.0	37.2	0.0	4.0	284.6	0.0	1,837.0	0.0	0.0	143.1	1,529.8	0.0	22,746.8	
2013	217.4	10,493.1	1,201.8	5.0	11.2	0.0	0.0	89.4	102.0	59.7	0.0	1.6	231.7	0.0	158.0	40.0	0.0	44.7	1,407.9	0.0	14,063.4	
2014	246.9	11,704.5	1,532.5	401.0	7.7	0.0	0.0	60.5	0.0	48.0	0.0	17.7	1,590.0	0.0	1,730.5	27.0	0.0	43.1	1,689.7	0.0	19,099.0	
2015	546.9	27,540.8	1,324.5	0.0	0.9	2.3	34.0	0.0	0.0	320.4	13.0	31.4	2,922.9	2.0	47.0	606.5	0.0	0.0	2,160.6	0.0	35,553.0	
2016	111.1	18,802.5	1,392.0	0.0	0.0	3.4	0.0	12.5	50.3	23.5	0.0	38.9	11,665.7	85.6	80.0	77.0	0.0	0.0	3,448.7	16.3	35,807.4	
2017	24.6	5,477.6	701.0	0.0	4.1	2.7	0.0	20.5	39.1	97.1	0.0	33.8	13,656.7	424.9	14.0	17.0	0.0	0.0	5,137.0	90.0	25,740.2	
2018	1,513.7	11,080.1	2,647.4	14.0	0.0	0.0	700.0	2.4	28.1	0.0	0.0	0.8	19,734.1	4,573.9	49.0	0.0	0.0	17,710.4	0.0	58,053.8		
2019	5,843.2	3,332.5	1,572.1	13.0	0.0	3.0	500.0	99.0	0.0	0.0	0.0	0.0	27,416.3	9,596.1	11.0	0.0	0.0	11,585.4	0.0	59,971.6		
2020	11,173.9	0.0	552.6	4.0	0.0	0.0	0.0	80.2	100.0	0.0	0.0	0.0	38,850.0	9,229.9	199.0	11.0	0.0	6,915.9	0.0	67,116.5		
2021	1,216.2	0.0	700.0	0.0	0.0	0.0	0.0	35.3	0.0	0.0	0.0	0.0	4,893.8	2,865.7	0.0	0.0	0.0	460.0	0.0	10,170.9		
Total	21,288.1	288,130.5	19,942.4	3,145.3	1,480.3	11.3	1,590.0	3,055.2	13,266.3	654.9	104.2	589.4	127,638.5	26,778.1	199.0	36,781.1	986.5	0.0	1,816.7	121,176.6	106.3	668,740.7

Combined Cycle Project Analysis

Table 12-32 shows the status of all combined cycle projects by number of projects that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 50 combined cycle projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 24 projects (24.0 percent) are located in the AEP Zone.

Table 12-32 Status of all combined cycle queue projects by zone (number of projects): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																				Total			
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC		
In Service	New Generation	1	4	2	3	2	1	0	2	0	2	0	7	2	0	7	4	0	5	2	4	10	6	0	62
	Upgrade	3	12	7	5	0	5	0	0	0	16	5	0	6	3	0	11	4	4	7	14	0	0	102	
Under Construction	New Generation	0	3	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
	Upgrade	0	4	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	1	0	10	
Suspended	New Generation	0	0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
	Upgrade	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	3	
Withdrawn	New Generation	23	19	45	13	8	14	0	1	2	18	17	3	26	25	0	43	40	34	42	56	2	431		
	Upgrade	7	7	9	3	0	4	0	1	0	11	4	0	7	7	0	3	5	5	8	15	0	96		
Active	New Generation	0	3	1	0	0	3	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	9	
	Upgrade	1	2	4	1	0	2	0	0	0	1	0	0	0	0	0	1	2	0	2	0	0	0	16	
Total Projects	New Generation	24	29	51	19	10	20	1	3	2	26	19	3	33	29	0	48	43	38	52	62	2	514		
	Upgrade	11	25	23	9	0	11	0	1	0	28	10	0	14	11	0	16	11	9	18	30	0	227		

Table 12-33 shows the status of all combined cycle projects by MW that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 20,775.6 MW of combined cycle projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 6,015.0 MW (29.0 percent) are located in the AEP Zone.

Table 12-33 Status of all combined cycle queue projects by zone (MW): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																						Total
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC		
In Service	New Generation	650.0	3,032.0	1,455.0	2,599.0	140.0	600.0	0.0	533.0	0.0	5,828.6	319.2	0.0	1,665.8	2,557.0	0.0	2,665.0	1,900.0	1,560.0	5,750.0	2,448.5	0.0	33,703.0	
	Upgrade	229.0	384.0	790.0	344.0	0.0	633.6	0.0	0.0	0.0	978.0	102.0	0.0	110.0	83.9	0.0	1,008.5	142.3	228.6	712.0	845.9	0.0	6,591.8	
Under Construction	New Generation	0.0	2,579.0	515.0	1,152.0	0.0	2,350.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6,596.9	
	Upgrade	0.0	916.0	149.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	51.6	51.1	0.0	1,243.4	
Suspended	New Generation	0.0	0.0	1,091.0	1,895.0	0.0	0.0	1,150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,136.0	
	Upgrade	0.0	0.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	451.0	0.0	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	531.0	
Withdrawn	New Generation	8,542.4	12,509.5	21,832.1	8,641.0	3,122.1	10,142.0	0.0	134.5	665.0	12,321.0	5,436.4	991.8	13,562.6	13,001.0	0.0	23,340.0	15,951.0	21,308.2	18,917.7	25,044.6	6.9	215,469.7	
	Upgrade	149.4	711.0	874.0	86.0	0.0	1,735.0	0.0	36.0	0.0	780.4	668.0	0.0	378.0	1,742.0	0.0	240.0	1,040.6	229.1	703.0	2,217.9	0.0	11,590.4	
Active	New Generation	0.0	2,200.0	1,270.0	0.0	0.0	1,250.0	0.0	0.0	0.0	1,600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	163.0	0.0	0.0	0.0	6,483.0	
	Upgrade	7.6	320.0	514.0	550.0	0.0	111.7	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	67.0	85.0	0.0	55.0	0.0	0.0	1,785.3	
Total Projects	New Generation	9,192.4	20,320.5	26,163.1	14,287.0	3,262.1	14,342.9	1,150.0	667.5	665.0	19,749.6	5,755.6	991.8	15,228.4	15,558.0	0.0	26,005.0	18,014.0	22,868.2	24,667.7	27,493.1	6.9	266,388.6	
	Upgrade	386.0	2,331.0	2,372.7	980.0	0.0	2,480.3	0.0	36.0	0.0	1,833.4	1,221.0	0.0	523.0	1,900.9	0.0	1,315.5	1,267.9	457.7	1,521.6	3,114.9	0.0	21,741.9	

Combustion Turbine - Natural Gas Project Analysis

Table 12-34 shows the status of all combustion turbine natural gas projects by number of projects that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 55 combustion turbine natural gas projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 14 projects (25.5 percent) are located in the COMED Zone.

Table 12-34 Status of all combustion turbine - natural gas generation queue projects by zone (number of projects): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																						Total
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC		
In Service	New Generation	5	0	6	0	3	0	0	0	0	3	7	0	2	1	0	2	4	2	4	9	0	48	
	Upgrade	4	9	7	2	0	12	5	0	0	28	7	0	4	1	0	4	4	3	4	14	0	108	
Under Construction	New Generation	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	
	Upgrade	0	0	1	2	0	3	0	0	0	0	0	0	1	4	0	0	4	0	0	0	0	15	
Suspended	New Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
	Upgrade	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Withdrawn	New Generation	1	6	0	0	1	1	1	0	0	4	0	1	1	0	0	1	5	0	1	5	0	28	
	Upgrade	2	2	1	1	0	2	2	0	1	3	0	0	0	1	0	0	1	0	0	0	0	16	
Active	New Generation	1	1	0	0	1	1	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	8	
	Upgrade	1	1	2	5	0	9	2	0	1	0	0	0	0	0	0	0	1	5	0	0	0	27	
Total Projects	New Generation	7	7	6	0	5	3	1	0	2	9	7	1	3	1	0	3	11	2	5	15	0	88	
	Upgrade	7	12	12	10	0	26	9	0	2	31	7	0	5	6	0	4	10	8	4	14	0	167	

Table 12-35 shows the status of all combustion turbine natural gas projects by MW that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 5,600.2 MW of combustion turbine natural gas projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 1,138.0 MW (20.3 percent) are located in the Dominion Zone.

Table 12-35 Status of all combustion turbine - natural gas queue projects by zone (MW): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																				Total	
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC
In Service	New Generation	360.7	0.0	1,176.0	0.0	23.0	0.0	0.0	0.0	0.0	1,081.0	1,491.0	0.0	520.0	10.0	0.0	559.0	361.9	5.0	150.9	925.9	0.0	6,664.4
	Upgrade	43.7	208.0	187.7	40.0	0.0	371.0	60.0	0.0	0.0	925.7	86.0	0.0	200.0	34.1	0.0	42.0	28.0	32.0	252.3	215.0	0.0	2,725.5
Under Construction	New Generation	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	219.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	259.4
	Upgrade	0.0	0.0	12.0	5.0	0.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0	12.5	0.0	0.0	0.0	0.0	90.0
Suspended	New Generation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	675.0	0.0	675.0
	Upgrade	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
Withdrawn	New Generation	7.5	1,519.0	0.0	0.0	9.0	10.0	104.0	0.0	0.0	1,069.8	0.0	73.0	2.1	0.0	0.0	0.5	326.8	0.0	19.9	1,140.1	0.0	4,281.7
	Upgrade	165.5	57.1	4.0	25.0	0.0	23.0	104.0	0.0	0.0	57.0	0.0	0.0	0.0	0.0	0.0	0.0	235.0	0.0	0.0	0.0	0.0	670.6
Active	New Generation	230.0	700.0	0.0	0.0	144.6	190.0	0.0	0.0	0.0	1,138.0	0.0	0.0	0.0	0.0	0.0	0.0	481.0	0.0	0.0	0.0	0.0	2,883.6
	Upgrade	0.0	19.0	70.0	528.7	0.0	848.2	43.5	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.0	57.3	0.0	0.0	0.0	1,662.2
Total Projects	New Generation	598.2	2,219.0	1,176.0	0.0	176.6	240.0	104.0	0.0	219.4	3,288.8	1,491.0	73.0	522.1	10.0	0.0	559.5	1,169.7	5.0	170.8	2,741.0	0.0	14,764.1
	Upgrade	209.2	284.1	303.7	598.7	0.0	1,289.2	207.5	0.0	3.5	982.7	86.0	0.0	200.0	47.6	0.0	42.0	367.5	89.3	252.3	215.0	0.0	5,178.3

Wind Project Analysis

Table 12-36 shows the status of all wind generation projects, by number of projects that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 115 wind projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 40 projects (34.8 percent) are located in the COMED Zone.

Table 12-36 Status of all wind generation queue projects by zone (number of projects): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																				Total	
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC
In Service	New Generation	1	17	16	0	0	26	0	0	0	3	0	0	0	0	0	0	23	0	8	0	0	94
	Upgrade	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	11
Under Construction	New Generation	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	Upgrade	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Suspended	New Generation	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	6
	Upgrade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Withdrawn	New Generation	18	106	45	8	0	108	15	0	0	21	11	1	2	0	0	0	64	0	46	1	0	446
	Upgrade	2	2	8	0	0	8	0	0	0	3	0	0	0	0	0	0	6	0	2	0	0	31
Active	New Generation	6	22	5	3	0	30	0	0	0	7	6	0	5	0	0	0	1	0	2	1	0	88
	Upgrade	0	1	0	0	0	10	0	0	0	0	3	0	1	0	0	0	1	0	0	0	0	16
Total Projects	New Generation	25	150	68	11	0	164	15	0	0	32	17	1	7	0	0	0	88	0	58	2	0	638
	Upgrade	2	3	10	0	0	23	0	0	0	3	3	0	1	0	0	0	12	0	2	0	0	59

Table 12-37 shows the status of all wind projects by MW that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 31,962.9 MW of wind projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 8,135.1 MW (25.5 percent) are located in the COMED Zone.

Table 12-37 Status of all wind generation queue projects by zone (MW): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																						Total
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC		
In Service	New Generation	7.5	3,094.6	1,114.6	0.0	0.0	4,088.9	0.0	0.0	0.0	322.5	0.0	0.0	0.0	0.0	0.0	0.0	1,065.0	0.0	226.5	0.0	0.0	9,919.6	
	Upgrade	0.0	0.0	5.0	0.0	0.0	213.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	238.7	
Under Construction	New Generation	0.0	450.0	310.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	760.0	
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Suspended	New Generation	0.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165.3	0.0	0.0	737.6	
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Withdrawn	New Generation	4,643.6	22,191.8	3,472.2	1,295.6	0.0	25,327.3	2,128.0	0.0	0.0	4,988.4	2,968.8	150.3	1,504.0	0.0	0.0	0.0	5,377.0	0.0	3,375.1	20.0	0.0	77,442.0	
	Upgrade	5.0	370.0	119.4	0.0	0.0	755.7	0.0	0.0	0.0	114.0	0.0	0.0	0.0	0.0	0.0	0.0	243.4	0.0	6.0	0.0	0.0	1,613.4	
Active	New Generation	3,441.6	4,015.9	457.0	816.1	0.0	7,649.3	0.0	0.0	0.0	5,116.9	1,859.8	0.0	3,759.2	0.0	0.0	0.0	109.9	0.0	349.6	1,300.0	0.0	28,875.3	
	Upgrade	0.0	16.6	0.0	0.0	0.0	485.8	0.0	0.0	0.0	0.0	477.3	0.0	510.0	0.0	0.0	0.0	100.3	0.0	0.0	0.0	0.0	1,590.1	
Total Projects	New Generation	8,092.7	30,024.3	5,353.8	2,111.7	0.0	37,065.5	2,128.0	0.0	0.0	10,728.1	4,828.6	150.3	5,263.2	0.0	0.0	0.0	6,551.9	0.0	4,116.5	1,320.0	0.0	117,734.4	
	Upgrade	5.0	386.6	124.4	0.0	0.0	1,454.7	0.0	0.0	0.0	114.0	477.3	0.0	510.0	0.0	0.0	0.0	364.2	0.0	6.0	0.0	0.0	3,442.2	

Solar Project Analysis

Table 12-38 shows the status of all solar generation projects by number of projects that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 1,166 solar projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 310 projects (26.6 percent) are located in the Dominion Zone.

Table 12-38 Status of all solar generation queue projects by zone (number of projects): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																						Total
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC		
In Service	New Generation	9	4	8	0	1	1	1	1	0	32	11	0	50	0	0	1	1	1	2	44	0	166	
	Upgrade	1	0	3	0	0	0	0	0	0	5	8	0	9	0	0	0	1	0	3	0	0	30	
Under Construction	New Generation	0	5	1	0	0	0	0	1	0	14	2	0	2	0	0	0	0	0	0	3	0	28	
	Upgrade	0	2	0	0	0	0	0	2	0	5	0	0	0	0	0	0	0	0	0	2	0	11	
Suspended	New Generation	0	3	8	0	0	0	1	1	0	6	0	0	0	1	0	0	4	0	0	0	0	24	
	Upgrade	0	0	0	0	0	0	0	1	0	0	0	0	2	2	0	0	0	0	0	0	0	5	
Withdrawn	New Generation	181	118	89	25	14	40	20	16	1	229	136	13	193	22	1	9	57	21	50	90	0	1,325	
	Upgrade	3	4	3	2	0	6	0	0	0	16	1	0	9	0	0	0	3	3	0	3	0	53	
Active	New Generation	22	171	73	41	2	49	29	4	4	233	45	34	19	30	1	3	99	8	64	5	0	936	
	Upgrade	1	36	13	11	0	5	9	0	1	52	7	1	2	3	0	0	11	0	8	2	0	162	
Total Projects	New Generation	212	301	179	66	17	90	51	22	5	514	194	47	264	53	2	13	161	30	116	142	0	2,479	
	Upgrade	5	42	19	13	0	11	9	3	1	78	16	1	22	5	0	0	15	3	11	7	0	261	

Table 12-39 shows the status of all solar projects by MW that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 82,881.4 MW of solar projects classified as new generation or upgrade currently active, suspended or under construction in the PJM generation queue, 26,162.1 MW (31.6 percent) are located in the AEP Zone.

Table 12-39 Status of all solar generation queue projects by zone (MW): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																				Total	
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC
In Service	New Generation	62.0	14.7	112.3	0.0	1.1	9.0	2.5	0.0	0.0	1,493.0	130.4	0.0	373.4	0.0	0.0	3.3	13.5	2.5	15.0	231.9	0.0	2,464.5
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	46.3
Under Construction	New Generation	0.0	300.0	10.0	0.0	0.0	0.0	0.0	125.0	0.0	1,124.6	170.0	0.0	21.6	0.0	0.0	0.0	0.0	0.0	0.0	17.5	0.0	1,768.7
	Upgrade	0.0	150.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	24.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	253.2
Suspended	New Generation	0.0	30.0	191.8	0.0	0.0	0.0	400.0	70.0	0.0	364.9	0.0	0.0	0.0	35.0	0.0	0.0	63.9	0.0	0.0	0.0	0.0	1,155.6
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	18.6	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.6
Withdrawn	New Generation	2,014.0	7,882.8	2,147.9	1,521.3	112.3	2,748.8	1,173.9	689.4	20.0	12,960.4	2,151.4	723.9	1,602.4	749.7	78.0	78.4	2,354.8	278.0	874.1	551.4	0.0	40,712.9
	Upgrade	170.0	126.0	27.9	62.0	0.0	110.0	0.0	0.0	0.0	988.8	0.0	0.0	23.8	0.0	0.0	0.0	20.0	3.6	0.0	1.3	0.0	1,533.4
Active	New Generation	739.0	22,912.0	3,095.5	3,462.6	30.0	7,471.9	2,603.5	253.9	50.6	21,186.0	1,708.2	3,168.0	229.4	763.1	120.0	45.8	3,439.1	78.9	1,912.3	38.4	0.0	73,308.2
	Upgrade	0.0	2,770.1	289.8	627.7	0.0	185.0	185.5	0.0	8.3	1,625.2	72.0	40.0	0.0	50.0	0.0	0.0	287.5	0.0	186.1	0.0	0.0	6,327.2
Total Projects	New Generation	2,815.0	31,139.5	5,557.5	4,983.9	143.4	10,229.7	4,179.9	1,138.3	70.6	37,128.8	4,160.0	3,891.9	2,226.7	1,547.8	198.0	127.5	5,871.3	359.5	2,801.4	839.2	0.0	119,409.9
	Upgrade	170.0	3,046.1	317.7	689.7	0.0	295.0	185.5	85.0	8.3	2,660.4	72.0	40.0	56.7	90.0	0.0	0.0	307.5	3.6	196.1	5.1	0.0	8,228.7

Renewable Hybrid Project Analysis

Table 12-40 shows the status of all renewable hybrid generation projects (solar + storage, solar + wind and wind + storage) by number of projects that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone.³⁹ Of the 233 renewable hybrid projects currently active, suspended or under construction in the PJM generation queue, 56 projects (24.0 percent) are located in the Dominion Zone.

Table 12-40 Status of all renewable hybrid generation queue projects by zone (number of projects): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Number of Projects																				Total	
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC
In Service	New Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Upgrade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Under Construction	New Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
	Upgrade	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Suspended	New Generation	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2
	Upgrade	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Withdrawn	New Generation	4	10	3	6	0	5	0	0	0	19	0	7	0	0	0	1	0	0	8	0	0	63
	Upgrade	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Active	New Generation	0	39	20	7	0	8	2	0	2	47	2	17	5	11	0	0	16	2	20	1	0	199
	Upgrade	2	4	2	0	0	2	0	0	0	9	0	2	0	1	0	0	2	0	4	0	0	28
Total Projects	New Generation	4	49	23	13	0	13	2	0	2	66	2	24	5	12	0	0	17	2	21	12	0	267
	Upgrade	2	5	3	0	0	2	0	0	0	9	0	2	0	2	0	0	2	0	4	0	0	31

³⁹ PJM does not currently have a definition of a hybrid resource.

Table 12-41 shows the status of all renewable hybrid projects by MW that entered PJM generation queues from January 1, 1997, through March 31, 2021, by zone. Of the 19,273.6 MW of renewable hybrid generation currently active, suspended or under construction in the PJM generation queue, 7,725.7 MW (40.1 percent) are located in the AEP Zone.

Table 12-41 Status of all renewable hybrid generation queue projects by zone (MW): January 1, 1997 through March 31, 2021

Project Status	Project Classification	Project MW																				Total		
		ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUO	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG		REC	
In Service	New Generation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Under Construction	New Generation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	2.6
	Upgrade	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
Suspended	New Generation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	90.0	0.0	0.0	190.0
	Upgrade	0.0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
Withdrawn	New Generation	14.5	3,360.8	280.0	509.9	0.0	629.9	0.0	0.0	0.0	1,860.0	0.0	960.0	0.0	0.0	0.0	0.0	160.0	0.0	0.0	29.9	0.0	0.0	7,805.0
	Upgrade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
Active	New Generation	0.0	7,002.5	1,465.3	270.9	0.0	1,618.9	80.0	0.0	37.5	3,650.8	130.0	1,957.0	180.0	82.1	0.0	0.0	697.2	562.5	180.0	20.0	0.0	0.0	17,934.6
	Upgrade	93.0	720.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1,127.0
Total Projects	New Generation	14.5	10,363.3	1,745.3	780.8	0.0	2,248.8	80.0	0.0	37.5	5,510.8	130.0	2,917.0	180.0	182.1	0.0	0.0	857.2	562.5	270.0	53.5	0.0	0.0	25,933.2
	Upgrade	93.0	723.2	16.3	0.0	0.0	20.0	0.0	0.0	0.0	94.0	0.0	100.0	0.0	3.7	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1,150.2

Relationship Between Project Developer and Transmission Owner

A transmission owner (TO) is an “entity that owns, leases or otherwise has a possessory interest in facilities used for the transmission of electric energy in interstate commerce under the tariff.”⁴⁰ Where the transmission owner is a vertically integrated company that also owns generation, there is a potential conflict of interest when the transmission owner evaluates the interconnection requirements of new generation which is a competitor to the generation or transmission of the parent company and when the transmission owner evaluates the interconnection requirements of new generation which is part of the same company as the transmission owner. There is also a potential conflict of interest when the transmission owner evaluates the interconnection requirements of a nonincumbent transmission developer which is a competitor of the transmission owner. The MMU recommends outsourcing interconnection studies to an independent party to avoid potential conflicts of interest.

Table 12-42 shows the relationship between the project developer and transmission owner for all project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and unit type. A project where the developer is affiliated with the transmission owner is classified as related. A project where the developer is not affiliated with the transmission owner is classified as unrelated. For example, 36.0 MW of combined cycle generation projects that have entered the PJM generation queue in the DUKE Zone were projects developed by Duke Energy or subsidiaries of Duke Energy, the transmission owner for the DUKE Zone. These project MW are classified as related. There have been 667.5 MW of combined cycle projects that have entered the PJM generation queue in the DUKE Zone by developers not affiliated with Duke Energy. These project MW are classified as unrelated.

Of the 668,740.7 MW that have entered the queue during the time period of January 1, 1997, through March 31, 2021, 68,949.5 MW (10.3 percent) have been submitted by transmission owners building in their own service territory. PSEG is the transmission owner with the highest percentage of affiliates building in

⁴⁰ See OATT § 1 (Transmission Owner).

their own service territory. Of the 38,947.0 MW that entered the queue in the PSEG Zone during the time period of January 1, 1997, through March 31, 2021, 14,287.3 MW (36.7 percent) have been submitted by PSEG or one of their affiliated companies.

Table 12-42 Relationship between project developer and transmission owner for all interconnection queue projects MW by unit type: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	Number of Projects	MW by Unit Type																				Total		
				CT - Natural		Hydro - Pumped			RICE - Natural			RICE - Other			Solar + Storage			Steam - Natural			Wind + Storage					
				Battery	CC	Gas	Oil	Other	Cell	Storage	Run of River	Nuclear	Gas	- Oil	Other	Solar	Storage	Wind	Coal	Gas	Steam - Oil	Steam - Other	Wind		Storage	
AEP	AEP	Related	49	16.0	678.0	0.0	0.0	0.0	0.0	0.0	34.0	2.4	214.0	0.0	0.0	0.0	247.7	0.0	0.0	3,918.0	90.0	0.0	0.0	0.0	0.0	5,200.1
		Unrelated	775	4,074.0	21,973.5	2,503.1	7.5	127.3	0.0	0.0	453.6	0.0	12.0	0.0	75.4	33,937.9	11,086.5	0.0	10,399.0	0.0	0.0	452.0	30,410.9	0.0	0.0	115,512.6
AES	DAY	Related	13	20.0	0.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5	0.0	0.0	1,347.5	0.0	0.0	0.0	0.0	0.0	0.0	1,427.0
		Unrelated	91	289.9	1,150.0	273.5	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4,343.9	80.0	0.0	0.0	0.0	0.0	0.0	2,128.0	0.0	0.0	8,277.2
DUQ	DUQ	Related	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	38	75.0	665.0	222.9	40.0	19.2	0.0	0.0	191.4	1,879.0	0.0	0.0	0.0	78.9	37.5	0.0	2,810.0	0.0	0.0	0.0	0.0	0.0	0.0	6,018.9
DOM	DOM	Related	143	350.0	12,338.5	2,045.7	100.0	0.0	0.0	340.0	0.0	1,944.0	0.0	0.0	60.0	3,266.3	17.0	0.0	301.0	0.0	0.0	4.0	2,786.0	0.0	0.0	23,552.5
		Unrelated	815	4,721.2	9,244.5	2,225.8	0.5	227.3	0.0	0.0	35.0	0.0	0.0	10.0	119.4	36,523.0	5,587.8	0.0	20.0	0.0	0.0	316.3	8,056.1	0.0	0.0	67,086.9
DUKE	DUKE	Related	10	27.3	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	106.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	169.7
		Unrelated	34	140.4	667.5	0.0	0.0	0.0	0.0	0.0	112.0	0.0	0.0	0.0	4.8	1,116.9	0.0	0.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	2,161.6
EKPC	EKPC	Related	2	0.0	821.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	821.8
		Unrelated	81	96.3	170.0	73.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,931.9	3,017.0	0.0	0.0	0.0	0.0	0.0	150.3	0.0	0.0	7,438.5
Exelon	ACEC	Related	5	0.0	730.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	738.3
		Unrelated	352	914.0	8,848.4	807.4	388.0	20.7	2.8	0.0	0.0	0.0	2.0	5.0	10.3	2,976.7	107.5	0.0	15.0	5.5	0.0	10.0	8,097.7	0.0	0.0	22,211.0
	BGE	Related	15	22.5	250.0	10.0	0.0	0.0	0.0	0.0	0.0	108.5	0.0	0.0	8.5	20.0	0.0	0.0	10.0	101.0	0.0	0.0	0.0	0.0	0.0	530.5
		Unrelated	66	836.6	3,012.1	166.6	18.0	133.0	0.0	0.0	0.4	3,280.0	1.3	0.0	0.0	123.4	0.0	0.0	0.0	2.5	0.0	25.0	0.0	0.0	0.0	7,598.9
	COMED	Related	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,185.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,194.0
		Unrelated	462	2,673.6	16,823.2	1,529.2	42.0	65.2	0.0	0.0	22.7	0.0	35.0	0.0	67.7	10,515.7	2,069.8	199.0	1,926.0	91.0	0.0	90.0	38,520.1	0.0	0.0	74,670.2
	DPL	Related	8	1.0	1,365.0	351.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,724.4
		Unrelated	339	837.5	5,611.6	1,226.0	600.9	42.6	0.0	0.0	0.0	0.0	0.0	0.0	84.6	4,224.6	130.0	0.0	653.0	15.0	0.0	65.0	5,305.9	0.0	0.0	18,796.7
	PECO	Related	33	40.0	6,965.0	5.0	89.5	0.0	0.0	0.0	265.0	437.8	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	7,809.3
		Unrelated	86	25.3	20,355.5	596.5	2.0	15.0	0.0	0.0	0.0	0.0	0.0	17.0	3.7	127.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21,142.5
	PEPCO	Related	1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
		Unrelated	107	20.0	23,325.9	94.3	34.0	9.0	0.0	0.0	0.0	1,640.0	32.0	0.0	3.5	363.1	562.5	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	26,090.3
First Energy	APS	Related	4	0.0	1,453.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,710.0	0.0	0.0	0.0	0.0	0.0	0.0	3,163.0
		Unrelated	492	818.7	27,082.8	1,479.7	0.0	84.4	0.0	0.0	623.3	0.0	140.0	53.8	25.4	5,875.2	1,745.3	0.0	4,092.0	0.0	0.0	184.4	5,478.2	16.3	0.0	47,699.4
	ATSI	Related	6	0.0	1,678.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,694.0
		Unrelated	165	546.4	13,589.0	598.7	10.5	166.4	0.0	0.0	0.0	0.0	59.7	0.0	6.9	5,673.6	780.8	0.0	0.0	16.5	0.0	0.0	2,111.7	0.0	0.0	23,560.2
	JCPLC	Related	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0
		Unrelated	425	1,462.0	15,751.4	722.1	0.0	4.8	0.6	0.0	31.6	0.0	0.6	0.0	12.8	2,271.4	180.0	0.0	0.0	0.0	0.0	30.0	5,773.2	0.0	0.0	26,240.5
	MEC	Related	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	165	619.9	17,458.9	57.6	1,204.4	52.1	0.0	0.0	0.0	93.0	0.0	8.0	23.2	1,637.8	185.8	0.0	0.0	0.0	0.0	84.0	0.0	0.0	0.0	21,424.7
	PE	Related	4	0.0	534.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,860.0	0.0	0.0	0.0	0.0	0.0	0.0	2,399.0
		Unrelated	444	940.2	18,747.9	1,532.2	0.0	214.4	3.0	16.0	46.3	0.0	341.8	8.0	14.8	6,178.8	857.2	0.0	561.0	590.0	0.0	525.0	6,916.1	0.0	0.0	37,492.4
OVEC	OVEC	Related	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.0
PPL	PPL	Related	22	0.0	2,261.0	0.0	0.0	0.0	0.0	0.0	109.0	1,600.0	0.0	0.0	0.0	124.8	0.0	0.0	111.0	0.0	0.0	0.0	0.0	0.0	0.0	4,205.8
		Unrelated	361	719.8	23,928.3	423.1	8.0	234.5	0.0	1,200.0	142.6	488.0	19.9	2.4	44.7	2,872.7	280.0	0.0	6,896.6	0.0	0.0	31.0	4,122.5	90.0	0.0	41,504.2
PSEG	PSEG	Related	109	0.0	11,836.1	1,818.1	0.0	0.0	0.0	0.0	0.0	381.0	0.0	0.0	0.0	180.4	3.7	0.0	24.0	44.0	0.0	0.0	0.0	0.0	0.0	14,287.3
		Unrelated	237	999.5	18,771.9	1,137.9	600.0	62.5	4.9	0.0	1,000.0	0.0	10.6	0.0	13.7	663.9	49.9	0.0	25.0	0.0	0.0	1,320.0	0.0	0.0	24,659.8	
Con Ed	REC	Related	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Unrelated	2	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	
Total		Related	443	477.8	40,946.4	4,272.8	189.5	0.0	0.0	374.0	396.4	5,886.3	0.0	0.0	68.5	4,003.7	20.7	0.0	9,288.5	235.0	0.0	4.0	2,786.0	0.0	0.0	68,949.5
		Unrelated	5539	20,810.3	247,184.1	15,669.6	2,955.8	1,480.3	11.3	1,216.0	2,658.8	7,380.0	654.9	104.2	520.9	123,634.8	26,757.4	199.0	27,492.6	751.5	0.0	1,812.7	118,390.6	106.3	0.0	599,791.1

Combined Cycle Project Developer and Transmission Owner Relationships

Table 12-43 shows the relationship between the project developer and transmission owner for all combined cycle project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and project status. Of the 48,135.1 combined cycle project MW that have achieved in service or under construction status during this time period, 9,294.6 MW (19.3 percent) have been developed by transmission owners building in their own service territory. EKPC is the transmission owner with the highest percentage of affiliates building combined cycle projects in their own service territory. Of the 991.8 MW that entered the queue in the EKPC Zone during the time period of January 1, 1997, through March 31, 2021, 821.8 MW (82.9 percent) have been submitted by EKPC or one of their affiliated companies.

Table 12-43 Relationship between project developer and transmission owner for all combined cycle project MW in the queue: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	MW by Project Status					Total
			Active	In Service	Under Construction	Suspended	Withdrawn	
AEP	AEP	Related	0.0	678.0	0.0	0.0	0.0	678.0
		Unrelated	2,520.0	2,738.0	3,495.0	0.0	13,220.5	21,973.5
AES	DAY	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	1,150.0	0.0	1,150.0
DUQ	DUQ	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	665.0	665.0
DOM	DOM	Related	75.0	4,762.5	0.0	0.0	7,501.0	12,338.5
		Unrelated	1,600.0	2,044.1	0.0	0.0	5,600.4	9,244.5
DUKE	DUKE	Related	0.0	0.0	0.0	0.0	36.0	36.0
		Unrelated	0.0	533.0	0.0	0.0	134.5	667.5
EKPC	EKPC	Related	0.0	0.0	0.0	0.0	821.8	821.8
		Unrelated	0.0	0.0	0.0	0.0	170.0	170.0
Exelon	ACEC	Related	0.0	0.0	0.0	0.0	730.0	730.0
		Unrelated	7.6	879.0	0.0	0.0	7,961.8	8,848.4
	BGE	Related	0.0	130.0	0.0	0.0	120.0	250.0
		Unrelated	0.0	10.0	0.0	0.0	3,002.1	3,012.1
COMED	Related	0.0	0.0	0.0	0.0	0.0	0.0	
	Unrelated	1,361.7	1,233.6	2,350.9	0.0	11,877.0	16,823.2	
DPL	DPL	Related	0.0	60.0	0.0	0.0	1,305.0	1,365.0
		Unrelated	0.0	361.2	0.0	451.0	4,799.4	5,611.6
PECO	PECO	Related	0.0	0.0	0.0	0.0	6,965.0	6,965.0
		Unrelated	67.0	3,673.5	0.0	0.0	16,615.0	20,355.5
PEPCO	PEPCO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	1,788.6	0.0	0.0	21,537.3	23,325.9
First Energy	APS	Related	0.0	525.0	0.0	0.0	928.0	1,453.0
		Unrelated	1,784.0	1,720.0	664.7	1,136.0	21,778.1	27,082.8
	ATSI	Related	0.0	0.0	0.0	0.0	1,678.0	1,678.0
		Unrelated	550.0	2,943.0	1,152.0	1,895.0	7,049.0	13,589.0
JCPLC	Related	0.0	0.0	0.0	0.0	0.0	0.0	
	Unrelated	0.0	1,775.8	0.0	35.0	13,940.6	15,751.4	
MEC	Related	0.0	0.0	0.0	0.0	0.0	0.0	
	Unrelated	0.0	2,640.9	75.0	0.0	14,743.0	17,458.9	
PE	Related	0.0	0.0	0.0	0.0	534.0	534.0	
	Unrelated	248.0	2,042.3	0.0	0.0	16,457.6	18,747.9	
OVEC	OVEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PPL	PPL	Related	0.0	600.0	0.0	0.0	1,661.0	2,261.0
		Unrelated	55.0	5,862.0	51.6	0.0	17,959.7	23,928.3
PSEG	PSEG	Related	0.0	2,488.0	51.1	0.0	9,297.0	11,836.1
		Unrelated	0.0	806.4	0.0	0.0	17,965.5	18,771.9
Con Ed	REC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	6.9	6.9
Total	Total	Related	75.0	9,243.5	51.1	0.0	31,576.8	40,946.4
		Unrelated	8,193.3	31,051.3	7,789.2	4,667.0	195,483.2	247,184.1

Combustion Turbine – Natural Gas Project Developer and Transmission Owner Relationships

Table 12-44 shows the relationship between the project developer and transmission owner for all CT – natural gas project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and project status. Of the 9,739.3 CT – natural gas project MW that have achieved in service or under construction status during this time period, 2,145.0 (22.0 percent) have been developed by Transmission Owners building in their own service territory. PSEG is the transmission owner with the highest percentage of affiliates building CT – natural gas projects in their own service territory. Of the 2,956.0 MW that entered the queue in the PSEG Zone during the time period of January 1, 1997, through March 31, 2021, 1,818.1 MW (61.5 percent) have been submitted by PSEG or one of their affiliated companies.

Table 12-44 Relationship between project developer and transmission owner for all CT – natural gas project MW in the queue: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	MW by Project Status					Total
			Active	In Service	Under Construction	Suspended	Withdrawn	
AEP	AEP	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	719.0	208.0	0.0	0.0	1,576.1	2,503.1
AES	DAY	Related	0.0	38.0	0.0	0.0	0.0	38.0
		Unrelated	43.5	22.0	0.0	0.0	208.0	273.5
DUQ	DUQ	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	3.5	0.0	219.4	0.0	0.0	222.9
DOM	DOM	Related	1,138.0	824.0	0.0	0.0	83.7	2,045.7
		Unrelated	0.0	1,182.7	0.0	0.0	1,043.1	2,225.8
DUKE	DUKE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
EKPC	EKPC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	73.0	73.0
Exelon	ACEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	230.0	404.4	0.0	0.0	173.0	807.4
	BGE	Related	0.0	10.0	0.0	0.0	0.0	10.0
		Unrelated	144.6	13.0	0.0	0.0	9.0	166.6
	COMED	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	1,038.2	371.0	87.0	0.0	33.0	1,529.2
	DPL	Related	0.0	351.0	0.0	0.0	0.0	351.0
		Unrelated	0.0	1,226.0	0.0	0.0	0.0	1,226.0
	PECO	Related	0.0	5.0	0.0	0.0	0.0	5.0
		Unrelated	0.0	596.0	0.0	0.0	0.5	596.5
	PEPCO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	57.3	37.0	0.0	0.0	0.0	94.3
First Energy	APS	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	70.0	1,363.7	12.0	30.0	4.0	1,479.7
	ATSI	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	528.7	40.0	5.0	0.0	25.0	598.7
	JCPLC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	720.0	0.0	0.0	2.1	722.1
	MEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	44.1	13.5	0.0	0.0	57.6
	PE	Related	0.0	5.0	0.0	0.0	0.0	5.0
		Unrelated	573.0	384.9	12.5	0.0	561.8	1,532.2
OVEC	OVEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PPL	PPL	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	403.2	0.0	0.0	19.9	423.1
PSEG	PSEG	Related	0.0	912.0	0.0	0.0	906.1	1,818.1
		Unrelated	0.0	228.9	0.0	675.0	234.0	1,137.9
Con Ed	REC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
Total		Related	1,138.0	2,145.0	0.0	0.0	989.8	4,272.8
		Unrelated	3,407.8	7,244.9	349.4	705.0	3,962.5	15,669.6

Wind Project Developer and Transmission Owner Relationships

Table 12-45 shows the relationship between the project developer and transmission owner for all wind project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and project status. Of the 10,918.3 wind project MW that have achieved in service or under construction status during this time period, 12.0 MW (0.1 percent) have been developed by transmission owners building in their own service territory. Dominion is the transmission owner with the highest percentage of affiliates building wind projects in their own service territory. Of the 10,842.1 MW that entered the queue in the Dominion Zone during the time period of January 1, 1997, through March 31, 2021, 2,786.0 MW (25.7 percent) have been submitted by Dominion or one of their affiliated companies.

Table 12-45 Relationship between project developer and transmission owner for all wind project MW in the queue: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	MW by Project Status					Total
			Active	In Service	Under Construction	Suspended	Withdrawn	
AEP	AEP	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	4,032.6	3,094.6	450.0	272.0	22,561.8	30,410.9
AES	DAY	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	2,128.0	2,128.0
DUQ	DUQ	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
DOM	DOM	Related	2,640.0	12.0	0.0	0.0	134.0	2,786.0
		Unrelated	2,476.9	310.5	0.0	300.3	4,968.4	8,056.1
DUKE	DUKE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
EKPC	EKPC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	150.3	150.3
Exelon	ACEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	3,441.6	7.5	0.0	0.0	4,648.6	8,097.7
	BGE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
COMED	Related	0.0	0.0	0.0	0.0	0.0	0.0	
	Unrelated	8,135.1	4,302.1	0.0	0.0	26,082.9	38,520.1	
DPL	DPL	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	2,337.1	0.0	0.0	0.0	2,968.8	5,305.9
PECO	PECO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PEPCO	PEPCO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
First Energy	APS	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	457.0	1,119.6	310.0	0.0	3,591.6	5,478.2
	ATSI	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	816.1	0.0	0.0	0.0	1,295.6	2,111.7
JCPLC	Related	0.0	0.0	0.0	0.0	0.0	0.0	
	Unrelated	4,269.2	0.0	0.0	0.0	1,504.0	5,773.2	
MEC	MEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PE	PE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	210.2	1,085.5	0.0	0.0	5,620.3	6,916.1
OVEC	OVEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PPL	PPL	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	349.6	226.5	0.0	165.3	3,381.1	4,122.5
PSEG	PSEG	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	1,300.0	0.0	0.0	0.0	20.0	1,320.0
Con Ed	REC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
Total		Related	2,640.0	12.0	0.0	0.0	134.0	2,786.0
		Unrelated	27,825.3	10,146.3	760.0	737.6	78,921.4	118,390.6

Solar Project Developer and Transmission Owner Relationships

Table 12-46 shows the relationship between the project developer and transmission owner for all solar project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and project status. Of the 4,532.7 solar project MW that have achieved in service or under construction status during this time period, 1,223.1 MW (27.0 percent) have been developed by transmission owners building in their own service territory. PSEG is the transmission owner with the highest percentage of affiliates building solar projects in their own service territory. Of the 844.3 MW that entered the queue in the PSEG Zone during the time period of January 1, 1997, through March 31, 2021, 180.4 MW (21.4 percent) have been submitted by PSEG or one of their affiliated companies.

Table 12-46 Relationship between project developer and transmission owner for all solar project MW in the queue: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	MW by Project Status					Total
			Active	In Service	Under Construction	Suspended	Withdrawn	
AEP	AEP	Related	48.0	14.7	20.0	10.0	155.0	247.7
		Unrelated	25,634.1	0.0	430.0	20.0	7,853.8	33,937.9
AES	DAY	Related	0.0	0.0	0.0	0.0	21.5	21.5
		Unrelated	2,789.0	2.5	0.0	400.0	1,152.4	4,343.9
DUQ	DUQ	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	58.9	0.0	0.0	0.0	20.0	78.9
DOM	DOM	Related	1,981.9	726.4	306.1	0.0	251.9	3,266.3
		Unrelated	20,829.3	788.6	842.9	364.9	13,697.3	36,523.0
DUKE	DUKE	Related	50.0	0.0	0.0	0.0	56.4	106.4
		Unrelated	203.9	0.0	200.0	80.0	633.0	1,116.9
EKPC	EKPC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	3,208.0	0.0	0.0	0.0	723.9	3,931.9
Exelon	ACEC	Related	0.0	0.0	0.0	0.0	8.3	8.3
		Unrelated	739.0	62.0	0.0	0.0	2,175.8	2,976.7
	BGE	Related	0.0	0.0	0.0	0.0	20.0	20.0
		Unrelated	30.0	1.1	0.0	0.0	92.3	123.4
	COMED	Related	0.0	9.0	0.0	0.0	0.0	9.0
		Unrelated	7,656.9	0.0	0.0	0.0	2,858.8	10,515.7
	DPL	Related	0.0	7.4	0.0	0.0	0.0	7.4
		Unrelated	1,780.2	123.0	170.0	0.0	2,151.4	4,224.6
	PECO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	45.8	3.3	0.0	0.0	78.4	127.5
	PEPCO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	78.9	2.5	0.0	0.0	281.6	363.1
First Energy	APS	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	3,385.3	112.3	10.0	191.8	2,175.8	5,875.2
	ATSI	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	4,090.3	0.0	0.0	0.0	1,583.3	5,673.6
	JCPLC	Related	0.0	0.0	0.0	0.0	12.0	12.0
		Unrelated	229.4	387.7	21.6	18.6	1,614.2	2,271.4
	MEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	813.1	0.0	0.0	75.0	749.7	1,637.8
	PE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	3,726.6	13.5	0.0	63.9	2,374.8	6,178.8
OVEC	OVEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	120.0	0.0	0.0	0.0	78.0	198.0
PPL	PPL	Related	124.8	0.0	0.0	0.0	0.0	124.8
		Unrelated	1,973.7	25.0	0.0	0.0	874.1	2,872.7
PSEG	PSEG	Related	0.0	134.3	5.2	0.0	40.9	180.4
		Unrelated	38.4	97.6	16.1	0.0	511.8	663.9
Con Ed	REC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
Total		Related	2,204.6	891.8	331.3	10.0	566.0	4,003.7
		Unrelated	77,430.7	1,619.0	1,690.6	1,214.2	41,680.4	123,634.8

Renewable Hybrid Project Developer and Transmission Owner Relationships

Table 12-47 shows the relationship between the project developer and transmission owner for all renewable hybrid project MW that have entered the PJM generation queue from January 1, 1997, through March 31, 2021, by transmission owner and project status. Of the 6.8 renewable hybrid project MW that have achieved in service or under construction status during this time period, 3.7 MW (53.9 percent) have been developed by transmission owners building in their own service territory. PSEG is the transmission owner with the highest percentage of affiliates building hybrid projects in their own service territory. Of the 53.6 MW that entered the queue in the PSEG Zone during the time period of January 1, 1997, through March 31, 2021, 3.7 MW (6.9 percent) have been submitted by PSEG or one of their affiliated companies.

Table 12-47 Relationship between project developer and transmission owner for all hybrid project MW in the queue: March 31, 2021

Parent Company	Transmission Owner	Related to Developer	MW by Project Status					Total
			Active	In Service	Under Construction	Suspended	Withdrawn	
AEP	AEP	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	7,722.5	0.0	3.2	0.0	3,360.8	11,086.5
AES	DAY	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	80.0	0.0	0.0	0.0	0.0	80.0
DUQ	DUQ	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	37.5	0.0	0.0	0.0	0.0	37.5
DOM	DOM	Related	17.0	0.0	0.0	0.0	0.0	17.0
		Unrelated	3,727.8	0.0	0.0	0.0	1,860.0	5,587.8
DUKE	DUKE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
EKPC	EKPC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	2,057.0	0.0	0.0	0.0	960.0	3,017.0
Exelon	ACEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	93.0	0.0	0.0	0.0	14.5	107.5
	BGE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
	COMED	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	1,638.9	0.0	0.0	0.0	629.9	2,268.8
	DPL	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	130.0	0.0	0.0	0.0	0.0	130.0
	PECO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
	PEPCO	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	562.5	0.0	0.0	0.0	0.0	562.5
First Energy	APS	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	1,465.3	0.0	0.0	16.3	280.0	1,761.6
	ATSI	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	270.9	0.0	0.0	0.0	509.9	780.8
	JCPLC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	180.0	0.0	0.0	0.0	0.0	180.0
	MEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	82.1	0.0	0.0	100.0	3.7	185.8
	PE	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	697.2	0.0	0.0	0.0	160.0	857.2
OVEC	OVEC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
PPL	PPL	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	280.0	0.0	0.0	90.0	0.0	370.0
PSEG	PSEG	Related	0.0	1.1	2.6	0.0	0.0	3.7
		Unrelated	20.0	0.0	0.0	0.0	29.9	49.9
Con Ed	REC	Related	0.0	0.0	0.0	0.0	0.0	0.0
		Unrelated	0.0	0.0	0.0	0.0	0.0	0.0
Total		Related	17.0	1.1	2.6	0.0	0.0	20.7
		Unrelated	19,044.6	0.0	3.2	206.3	7,808.7	27,062.7

Regional Transmission Expansion Plan (RTEP)⁴¹

The PJM RTEP process is designed to identify needed transmission system additions and improvements to continue to provide reliable service throughout the RTO. The objective of the RTEP process is to provide PJM with an optimal set of solutions necessary to solve reliability issues, operational performance issues and transmission constraints.

The RTEP process initially considered only factors such as load growth and the generation interconnection requests in its development of the 15 year plan. Currently, the RTEP process includes a broader range of inputs including the effects of public policy, market efficiency, interregional coordination and the effects of aging infrastructure.

RTEP Process

The PJM RTEP process is a 24 month planning process that identifies reliability issues for the next 15 year period. This 24 month planning process includes a process to build power flow models that represent the expected future system topology, studies to identify issues, stakeholder input and PJM Board of Manager approvals. The 24 month planning process is made up of overlapping 18 month planning cycles to identify and develop shorter lead time transmission upgrades and one 24 month planning cycle to provide sufficient time for the identification and development of longer lead time transmission upgrades that may be required to satisfy planning criteria.

Market Efficiency Process

PJM's Regional Transmission Expansion Plan (RTEP) process includes a market efficiency analysis. The stated purpose of the market efficiency analysis is: to determine which reliability based enhancements have economic benefit if accelerated; to identify new transmission enhancements that result in economic benefits; and to identify economic benefits associated with modification to existing RTEP reliability based enhancements that when modified would relieve one or more economic constraints. PJM identifies the economic benefit of proposed transmission projects based on production cost

analyses.⁴² PJM presents the RTEP market efficiency enhancements to the PJM Board, along with stakeholder input, for Board approval.

To be recommended to the PJM Board of Managers for approval, the relative benefits and costs of the economic based enhancement or expansion of the proposed project must reduce congestion on one or more constraints by at least one dollar, meet a benefit/cost ratio threshold of at least 1.25:1 and have an independent cost review, performed by PJM, if expected costs are over \$50 million. PJM provides the review of a project with a projected cost of over \$50 million using its own staff or outside consultants that are hired to assist in the review. PJM presents its findings to the TEAC where PJM's findings are reviewed by the stakeholders. While stakeholders can comment on the findings, PJM makes the final decision about what costs will be used for the purpose of calculating the Benefit/Cost ratio for the project. The benefit/cost ratio is the ratio of the present value of the total annual benefit for 15 years to the present value of the total annual cost for the first 15 years of the life of the enhancement or expansion.

The market efficiency process is comprised of a 12 month cycle and a 24 month cycle, both of which begin and end on the calendar year. The 12 month cycle is used for analysis of modifications and accelerations to approved RTEP projects only. The 24 month cycle is used for analysis of new economic transmission projects for years five through 15. This long-term proposal window takes place concurrently with the long-term proposal window for reliability projects.

PJM's first market efficiency analysis was performed in 2013, prior to Order 1000. The 2013 window was open from August 12, 2013, through September 26, 2013. This window accepted proposals to address historical congestion on 25 identified flowgates. PJM received 17 proposals from six entities. One project was approved by the PJM Board.

The first market efficiency cycle conducted under Order 1000 was performed during the 2014/2015 RTEP long term window. The 2014/2015 long term

⁴¹ The material in this section is based in part on the PJM Manual 14B: PJM Region Transmission Planning Process. See PJM. "PJM Manual 14B: PJM Region Transmission Planning Process," Rev. 48 (October 1, 2020).

⁴² See PJM. "PJM Regional Transmission Expansion Plan: 2019," (February 29, 2020) <<https://www.pjm.com/-/media/library/reports-notices/2019-rtep/2019-rtep-book-1.ashx>>.

window was open from November 1, 2014, through February 28, 2015. This window accepted proposals to address historical congestion on 12 identified flowgates. PJM received 93 proposals from 19 entities. Thirteen projects were approved by the PJM Board.

The second market efficiency cycle was performed during the 2016/2017 RTEP long term window. The 2016/2017 long term window was open from November 1, 2016, through February 28, 2017. This window accepted proposals to address historical congestion on four identified flowgates. PJM received 96 proposals from 20 entities. Four projects were approved by the PJM Board.

PJM also held an addendum 2016/2017 long term window. This 2016/2017 1A long term window was open from September 14, 2017, through September 28, 2017. This window accepted proposals to address historical congestion on one identified flowgate. PJM received three proposals from two entities. One project was approved by the PJM Board.

The fourth market efficiency cycle was performed for the 2018/2019 RTEP long term window. The 2018/2019 long term window was open from November 2, 2018, through March 15, 2019. This window accepted proposals to address historical congestion on one internal and three interregional flowgates. PJM received 33 proposals from 10 entities. One project was approved by the PJM Board to address the historical congestion on the internal flowgate, and one project was approved by the PJM Board to address the historical congestion on one of the interregional flowgates.⁴³

The Benefit/Cost Evaluation

For an RTEP project to be recommended to the PJM Board of Managers for approval as a market efficiency project, the relative benefits and costs of the economic based enhancement or expansion must meet a benefit/cost ratio threshold of at least 1.25:1.

The total benefit of a project is calculated as the sum of the net present value of calculated energy market benefits and calculated reliability pricing model

⁴³ No proposals effectively resolved the congestion on two of the three identified interregional market efficiency flowgates. One proposal received provisional approval by the PJM Board, pending approval by the MISO Board.

(RPM) benefits for a 15 year period, starting with the projected in service date of the project. PJM measures benefits as reductions in estimated load charges and production costs in the energy market and reductions in estimated load capacity payments and in system capacity costs in the capacity market, but does not weight increases and decreases in benefits equally. The method for calculating energy market benefits and reliability pricing model benefits depends on whether the project is regional or subregional. A regional project is any project rated at or above 230 kV. A subregional project is any project rated at less than 230 kv.

The energy market benefit analysis uses an energy market simulation tool that produces an hourly least-cost, security constrained market solution, including total operational costs, hourly LMPs, bus specific injections and bus specific withdrawals for each modeled year with and without the proposed RTEP project. Using the output from the model, PJM calculates changes in energy production costs and load energy payments.

The definition of the energy benefit analysis depends on whether the project is regional or subregional. For a regional project, the energy benefit for each modeled year is equal to 50 percent of the change in system wide total system energy production costs with and without the project plus 50 percent of the change in zonal load payments with and without the project, including only those zones where the project reduced the load payments. For subregional projects, the calculation of benefits for each modeled year ignores any impact on system wide energy production costs and is instead based only the change in zonal load energy payments with and without the project, but including only those zones where the project reduced the load energy payments.

In both the regional and subregional analysis, changes in zonal load energy payments are netted against changes in the estimated value of any Auction Revenue Rights (ARR) that sink in that zone for purposes of determining whether a zone benefits from a proposed RTEP project. Estimated ARR credits are calculated for each simulated year using the most recent planning year's actual ARR MW combined with FTR prices assumed to be equal to the market simulation's CLMP differences between ARR source and sink points. The value

of the ARR rights with and without the RTEP project is evaluated based on changes in modeled CLMPs on the latest allocation of ARR rights. ARR MW allocations are not adjusted to reflect any potential changes in ARR allocations which may be allowed by the RTEP upgrade and the value of the ARRs are assumed to match the forecasted CLMP differences on the ARR paths.

The Reliability Pricing Model (RPM) Benefit analysis is conducted using the RPM solution software, with and without the proposed RTEP project, using a set of estimated capacity offers.

The definition of the benefit in the RPM benefit analysis depends on whether the project is regional or subregional. For a regional project, the RPM benefit for each modeled year is equal to 50 percent of the change in system wide total system capacity payments with and without the project plus 50 percent of the change in zonal capacity payments with and without the project, including only those zones where the project reduced the capacity payments. For subregional projects, the reliability pricing model benefits for each modeled year ignores any impact on system wide total capacity payments and is equal to the change in zonal capacity payments with and without the project, including only those zones where the project reduced the capacity payments.

The difference in the benefits calculation used in the regional and subregional cost benefit threshold tests is related to how the direct costs of the transmission projects are allocated for approved regional and subregional projects. The costs of an approved regional project are allocated so that 50 percent of the total costs are allocated on a system wide load ratio share basis and the remaining 50 percent of the total costs are allocated to zones with projected energy market benefits and reliability pricing model benefits in proportion to those projected positive benefits. The costs of an approved subregional project are allocated so that the total costs of the project is allocated to zones with projected energy market benefits and reliability pricing model benefits in proportion to those projected positive benefits.

There are significant issues with PJM's benefit/cost analysis. The current rules governing benefit/cost analysis of competing transmission projects do not accurately measure the relative costs and benefits of transmission projects. The current rules do not account for the fact that the benefits of projects are uncertain and highly sensitive to the modeling assumptions used. The current rules explicitly ignore the increased zonal load costs that a project may create. The current rules do not account for the fact that the project costs are nonbinding estimates, are not subject to cost caps and may significantly exceed the estimated costs. These flaws have contributed to PJM approving market efficiency projects with forecasted benefits that do not exceed the forecasted costs.

The recent introduction of storage as transmission assets (SATA) raises a number of additional concerns about PJM's benefit/cost analysis. PJM's benefit/cost analysis uses a 15 year forecast for purposes of evaluating benefits and costs of traditional transmission assets with an expected useful life of 50 years or more. Using the same 15 year horizon does not make sense for SATA resources with an expected useful life of 10 years or less, depending on use. Using a 15 year benefit horizon will exaggerate the forecasted benefit stream relative to the stream of benefits that could be produced over the expected useful life relative to traditional transmission assets. Further, the rules for how to account for the actual, and forecasted, revenues and charges for operating the SATA to provide transmission load relief have not been established. Without clear rules on how to allocate operational revenues and costs it is impossible to develop forecasted benefits and/or costs of a SATA project.

The broader issue is that the market efficiency project approach explicitly allows transmission projects to compete against future generation projects, but without allowing the generation projects to compete. Projecting speculative transmission related benefits for 15 years based on the existing generation fleet and existing patterns of congestion eliminates the potential for new generation to respond to market signals. The market efficiency process allows assets built under the cost of service regulatory paradigm to displace generation assets built under the competitive market paradigm. The MMU recommends that the market efficiency process be eliminated.

The Transource Project

The Transource Project (Project 9A) is an example of a PJM approved market efficiency project that passed PJM's 1.25 benefit/cost threshold test despite having benefits, if accurately calculated, that were less than forecasted costs. This project also illustrates the risks of ignoring potential cost increases given that the costs included in the benefit/cost calculation are nonbinding estimates. The Transource Project was proposed in PJM's 2014/2015 RTEP long term window. PJM's 2014/2015 RTEP long term window was the first market efficiency cycle under Order 1000. The 2014/2015 long term window was open from November 1, 2014, through February 28, 2015. This window accepted proposals to address historical congestion on 12 identified flowgates. The AP South Interface was one of the 12 identified flow gates listed in the 2014/15 RTEP Long Term Proposal Window Problem Statement.

A total of 41 market efficiency projects were proposed to address congestion on the AP South Transmission Interface. Transource Energy LLC, together with Dominion High Voltage, submitted a proposal referenced by PJM as Project 9A (or IEC or the Transource project) to address AP South related congestion.

Project 9A was considered a subregional project based on its voltage level, meaning that changes in forecasted system costs were not considered for purposes of estimating the benefit/cost ratios. Instead, only reductions in zonal load costs were considered as a benefit of the project. Any increases in zonal load costs were ignored in the analysis.

The initial study had a benefit to cost ratio of 2.48, with a capital cost of \$340.6 million. The sum of the positive (energy cost reductions) effects was \$1,188.07 million. The sum of negative effects (energy cost increases) was \$851.67 million. The net actual benefit of the project in the study was therefore \$336.40 million, not the \$1,188.07 used in the study. Using the total benefits (positive and negative) to compare to the net present value of costs, the benefit to cost ratio was 0.70, not 2.48. The project should have been rejected on those grounds.

Subsequent studies of the 9A project have reduced its benefit/cost ratio as a result of increased costs, decreased congestion on the AP South Interface since 2014 and a reduction in peak load forecasts since 2015. The most recent study produced by PJM in 2019 using simulations for years 2017, 2021, 2024 and 2027 had a benefit cost ratio of 2.10 with a capital cost of \$383.63 million. The sum of the positive (energy cost reductions) effects was \$855.19 million, a reduction of \$322 million (28.0 percent) from the initial study. The sum of negative effects (energy cost increases) was \$827.34 million, a reduction of \$27.86 million (3.3 percent) from the results of the initial study. The net actual benefit of the project in the 2019 study was \$27.85 million, not the \$1,188.07 from the initial study. Using the total benefits (positive and negative) to compare to the net present value of costs in the 2019 analysis, the benefit to cost ratio was 0.07, not 2.10. The project should have been rejected on those grounds.

PJM MISO Interregional Market Efficiency Process (IMEP)

PJM and MISO developed a process to facilitate the construction of interregional projects in response to the Commission's concerns about interregional coordination along the PJM-MISO seam. This process, called the Interregional Market Efficiency Process (IMEP), operates on a two year study schedule and is designed to address forward looking congestion. To qualify as an IMEP project, the project must be evaluated in a joint study process, qualify as an economic transmission enhancement in both PJM and MISO transmission expansion models and meet specific IMEP cost benefit criteria.⁴⁴ The allocation of costs to each RTO for IMEPs will be in proportion to the benefits received.

While the IMEP process is a joint effort, PJM and MISO perform their own analysis of benefits to their own system and each uses a different modeling approach and a different metric for determining the benefits of a proposed project. PJM makes use of the benefit/cost analysis used for its own internal market efficiency projects which will, by definition, overstate project benefits

⁴⁴ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C." (December 11, 2008) <<http://www.pjm.com/directory/merged-tariffs/miso-joa.pdf>>.

by ignoring areas where energy costs are increased. MISO, on the other hand, measures benefits as changes in projected system wide production cost caused by the project. The use of different approaches to measuring benefits is an issue when studying potential benefits of projects in a joint effort, and when using the defined benefits to allocate the costs of IMEP projects to each RTO. PJM's approach will over allocate the costs of IMEP projects to PJM members.

PJM and MISO conducted a two year interregional market efficiency project study in 2018/2019 and included the investigation of forward looking congestion on three market to market flowgates. Proposals were received during the 2018/2019 long term window, which was open from November 2, 2018, through March 15, 2019. PJM and MISO received 10 proposals from seven entities. As a result of this analysis, the RTOs recommended one IMEP project, the Bosserman to Trail Creek 138 kV Project.⁴⁵ The approved project has an in service cost of \$24.7 million, and counting only PJM positive zonal benefits, a total present value of projected benefits of \$69.2 million. Ignoring PJM zones with negative benefits (increased costs to load) the project has a calculated PJM benefit/cost ratio of 2.63. MISO, using both positive and negative zonal effects, calculated the projected benefits of the project to be \$8.4 million. Based on the proportion of the calculated benefits, PJM is to be allocated 89.1 percent (\$23.4 million) of the project costs and MISO is to be allocated 10.9 percent (\$2.9 million) of the interregional costs. The PJM board approved the recommended project in December 2019. The MISO board approved the recommended project in September 2020.

Using a rational measure of benefits and costs, the Bosserman to Trail Creek 138 kV Project should not have been approved. Including the projected positive and negative benefits of the project to all PJM zones, the projected total benefits of the project drops from \$69.2 million to -\$68.1 million dollars. PJM analysis shows benefits to only one zone of \$69.2 million, with the negative effect on all other zones of -\$137.3 million. The resulting benefit/cost ratio would be -2.59. Even including the net MISO benefit of \$8.4 million, the total projected benefit of the project would still be a -\$59.7 million dollars. Allocating the costs of the project based on the proportion of total regional

⁴⁵ Analysis showed that no projects met the B/C criteria on two of the identified flowgates.

benefit (-\$68.1 million to PJM and \$8.4 million to MISO) would have allocated 100 percent of the cost to MISO, resulting in a benefit/cost ratio of 0.32 to MISO, and a rejection of the project by MISO.

PJM and MISO are currently in the second year of the two year 2020/2021 IMEP cycle. The RTOs are currently coordinating the development of their regional models.

PJM MISO Targeted Market Efficiency Process (TMEP)

PJM and MISO developed the Targeted Market Efficiency Process (TMEP) to facilitate the resolution of historic congestion issues that could be addressed through small, quick implementation projects. The TMEP process operates on a 12 month study schedule. To qualify as a TMEP project, the project must have an estimated in service date by the third summer peak season from the year the project was approved, have an estimated cost of less than \$20 million and must have estimated benefits, based on the projected congestion cost relief over a four year period, that exceed the expected installed capacity cost of the proposed project.^{46 47}

The benefit of a proposed TMEP project is calculated as the value of eliminating congestion on the affected constraint over a four year period. PJM and MISO calculate the estimated value of eliminating congestion by calculating the average congestion for the two prior years prior and multiplying by four.

The allocation of costs to each RTO for an approved TMEP project will be in proportion to the benefits received by that RTO.⁴⁸ The proportion of benefits is calculated using the average shadow price of the constraint times the dfax to affected downstream buses times MW of load at the buses, which is effectively the proportion of congestion paid by the RTO. Within an RTO, the RTO's share of the cost of the approved project is allocated to each transmission control area in proportion to the benefits received by each transmission control area.

⁴⁶ See "Joint Operating Agreement Between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, LLC," (December 11, 2008) <<http://www.pjm.com/directory/merged-tariffs/miso-joa.pdf>>.

⁴⁷ On November 2, 2017, PJM submitted a compliance filing including additional revisions to the MISO-PJM JOA to include stakeholder feedback in the TMEP project selection process. See *PJM Interconnection, LLC*, Docket No. ER17-718-000, et al. (November 2, 2017).

⁴⁸ See *PJM Interconnection, LLC*, Docket No. ER17-729-000 (December 30, 2016).

The first Targeted Market Efficiency Process (TMEP) analysis occurred in 2017 and included the investigation of historical congestion on an initial set of 50 market to market flowgates. The causes of congestion on these flowgates were analyzed. If the historical congestion was a result of outages, or if the congestion was expected to be mitigated by planned upgrades already included in the PJM RTEP or MISO MTEP, then the flowgate was eliminated from consideration in the TMEP process. As a result of this analysis, potential short term upgrades were identified for 13 of the initial 50 flowgates. PJM and MISO conducted a market efficiency and power flow analysis to determine the potential to eliminate the identified congestion on the 13 flowgates and recommended five TMEP projects. The five projects address \$59.0 million in historical congestion, with a calculated TMEP benefit of \$99.6 million. The projects have a total cost of \$20.0 million, with a 5.0 average benefit/cost ratio. PJM and MISO presented the five recommended projects to their boards in December 2017, and both boards approved all five projects.⁴⁹

The second Targeted Market Efficiency Process analysis occurred in 2018 and included the investigation of historical congestion on an initial set of 61 market to market flowgates. As a result of this analysis, potential short term upgrades were identified for 20 of the initial 61 flowgates. PJM and MISO conducted a market efficiency and power flow analysis to determine the potential to eliminate the identified congestion on the 20 flowgates and recommended two TMEP projects. The two projects address \$25.0 million in historical congestion, with a calculated TMEP benefit of \$31.9 million. The projects have a total cost of \$4.5 million, with a 7.1 average benefit/cost ratio. PJM and MISO presented the two recommended projects to their boards in December 2018, and both boards approved the projects.⁵⁰

With only one additional year of historical information, and the fact that many of the same constraints were evaluated in the 2018 TMEP process, PJM and MISO did not conduct a TMEP study in 2019.

⁴⁹ See PJM. "MISO PJM IPSAC" (January 12, 2018) <<http://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20180112/20180112-ipsac-presentation.ashx>>.

⁵⁰ See PJM. "MISO PJM IPSAC" (January 18, 2019) <<https://www.pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/20190118/20190118-ipsac-presentation.ashx>>.

As a result of decreases in M2M congestion and the addition of transmission upgrades already in process that affect the top congested historical M2M flowgates, PJM and MISO did not conduct a TMEP study in 2020.

The PJM and MISO TMEP process for measuring the projected benefits of a TMEP transmission projects is flawed. The current rules incorrectly count congestion as a cost to load without accounting for how the congestion dollars are or are not returned to the load through the ARRs and FTRs. The benefit of a TMEP transmission upgrade should be the expected difference in the total cost of energy before and after the upgrade to all affected load. This measurement would include the change in expected LMP of all affected load before and after the upgrade, times the MW of load, plus the change in congestion dollars returned to the affected load before and after the upgrade. Congestion revenue returned to load is not a cost to the load, it is a credit against the overpayment of load payments relative to generation credits caused by the transmission constraint. Ignoring the return of congestion from ARRs/FTRs overstates the potential benefits of eliminating congestion through the TMEP upgrades, and ignores the value of smaller upgrades that may not eliminate a constraint, but may reduce the average cost of energy for load.

Supplemental Transmission Projects

Supplemental projects are asserted to be "transmission expansions or enhancements that are not required for compliance with PJM criteria and are not state public policy projects according to the PJM Operating Agreement. These projects are used as inputs to RTEP models, but are not required for reliability, economic efficiency or operational performance criteria, as determined by PJM."⁵¹ Attachment M-3 of the PJM OATT defines the process that Transmission Owners (TO) must follow in adding Supplemental Projects in their local plan.

The M-3 Process requires TOs to present the criteria, assumptions and models that they will use to plan and identify Supplemental Projects on a yearly basis. The criteria identified for Supplemental Projects are very broad and include: **equipment material condition, performance and risk, operational flexibility**

⁵¹ See PJM. Planning. "Transmission Construction Status," (Accessed on March 31, 2021) <<http://www.pjm.com/planning/rtep-upgrades-status/construct-status.aspx>>.

and efficiency, infrastructure resilience, customer service or other, as well as asset management.

While the identification of the criteria violations and solutions are reviewed, and stakeholders have the opportunity to comment, the solution that is submitted in the Local Plan is the Transmission Owner's decision. PJM conducts a do no harm analysis to ensure the Supplemental Projects do not negatively affect the reliability of the system. Supplemental Projects are ultimately included in PJM's Regional Transmission Expansion Plan and are allocated 100 percent to the zone in which the transmission facilities are located. Supplemental Projects may displace projects that would have otherwise been implemented through the RTEP process.

Supplemental projects are currently exempt from the Order No. 1000 competitive process.⁵² Transmission owners have a clear incentive to increase investments in rate base given that transmission owners are paid for these projects on a cost of service basis.

Figure 12-5 shows the latest cost estimate of all baseline and supplemental projects by expected in service year. FERC Order No. 890 was issued on February 16, 2007, and implemented in PJM starting in 2008. Order No. 890 required Transmission Providers to participate in a coordinated, open and transparent planning process. Prior to the implementation of Order No. 890, there were transmission projects planned by transmission owners and included in the PJM planning models, that were not included in the totals shown in Figure 12-5, Table 12-48 and Table 12-49 because PJM did not track or report such projects. There has been a significant increase in supplemental projects coincident with the implementation of Order No. 890 starting in 2008 and the competitive planning process introduced by FERC Order No. 1000 starting in 2011.

Figure 12-5 Cost estimate of baseline and supplemental projects by expected in service year: January 1, 1998 through March 31, 2021

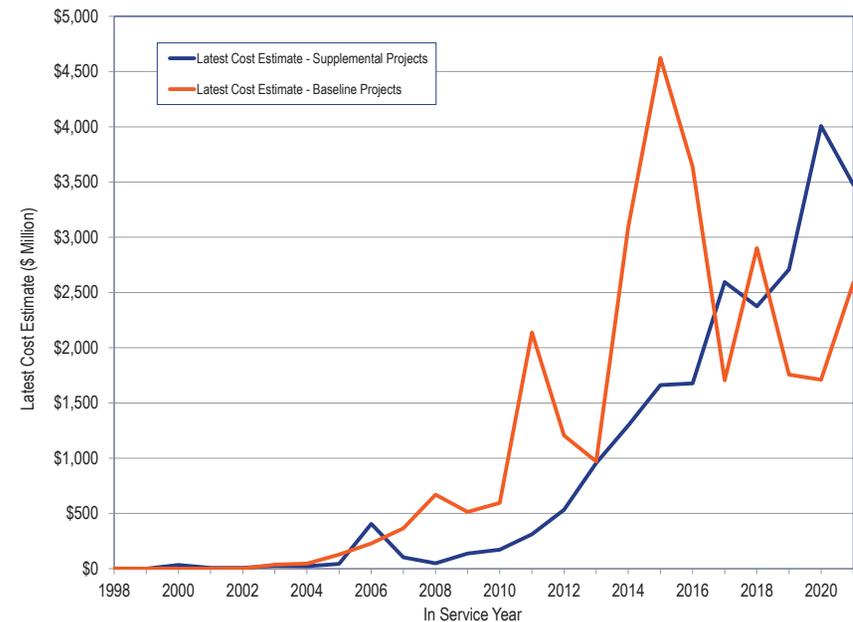


Table 12-48 shows the number of supplemental projects by expected in service year for each transmission zone. The average number of supplemental projects in each expected in service year increased by 795.0 percent, from 20 for years 1998 through 2007 (pre Order No. 890) to 179 for years 2008 through 2021 (post Order No. 890).

⁵² The FERC accepted tariff provisions that exclude supplemental projects from competition in the RTEP. 162 FERC ¶ 61,129 (2018), *reh'g denied*, 164 FERC ¶ 61,217 (2018).

Table 12-48 Number of supplemental projects by expected in service year and zone: 1998 through 2040

Year	ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC	Total
1998	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
1999	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
2000	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	11
2001	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	14
2002	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10
2003	4	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	2	0	0	0	0	16
2004	5	0	10	0	0	10	0	0	0	0	12	0	2	0	0	0	0	0	0	2	0	41
2005	4	2	8	0	0	4	0	0	0	1	14	0	1	0	0	1	2	0	0	2	0	39
2006	4	2	5	0	0	6	0	0	0	0	9	0	1	0	0	0	1	0	2	1	0	31
2007	2	1	5	0	4	5	0	0	4	0	7	0	0	0	0	0	2	0	1	6	0	37
2008	4	0	15	0	1	6	0	0	1	7	4	0	0	1	0	0	0	0	3	1	0	43
2009	3	1	6	0	1	8	0	0	3	3	5	0	0	0	0	5	1	0	1	2	0	39
2010	0	6	7	0	3	4	0	0	6	3	0	0	1	2	0	2	0	0	3	5	0	42
2011	0	8	8	0	0	2	0	0	5	2	0	0	1	0	0	4	0	0	6	4	0	40
2012	0	5	6	4	1	2	0	7	3	16	1	0	2	0	0	1	0	0	5	11	0	64
2013	5	21	4	5	0	11	0	6	4	13	1	0	1	1	0	1	0	1	14	19	0	107
2014	3	32	2	8	2	14	0	5	6	18	3	2	2	0	0	1	2	0	9	18	0	127
2015	4	16	2	9	1	37	0	8	4	17	5	4	2	0	0	1	0	4	7	24	0	145
2016	6	17	4	17	0	26	0	6	2	13	4	2	0	1	0	3	2	3	12	30	0	148
2017	8	107	3	26	1	23	0	3	8	31	11	5	0	3	0	0	3	1	23	44	0	300
2018	10	143	3	13	1	20	0	14	3	22	6	4	0	0	0	2	0	1	20	26	0	288
2019	3	157	4	30	6	14	2	16	1	33	8	5	3	14	0	1	15	0	15	27	0	354
2020	5	136	4	33	9	12	5	13	2	26	2	6	10	18	0	2	34	1	15	21	0	354
2021	2	204	3	33	2	4	7	15	1	29	2	6	12	50	5	6	34	0	23	22	0	460
2022	5	224	6	33	2	7	3	2	1	16	5	0	14	41	0	4	49	3	28	26	0	469
2023	6	136	0	12	0	1	14	7	1	10	5	2	1	14	0	3	31	0	16	26	0	285
2024	4	66	0	8	0	4	5	2	0	3	2	1	5	20	0	0	17	2	13	13	0	165
2025	3	65	1	6	3	0	0	0	0	20	5	0	0	22	0	0	18	0	6	0	0	149
2026	4	19	0	0	7	1	0	1	0	0	0	0	1	0	0	0	0	0	14	0	0	47
2027	0	18	0	3	1	0	0	2	2	0	0	0	0	0	0	0	1	0	26	0	0	53
2028	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	3
2029	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	6
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2031	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	94	1,386	106	241	49	221	36	107	58	283	161	37	59	187	5	37	215	16	267	330	0	3,895

Table 12-49 shows the latest cost estimate of supplemental projects by expected in service year for each transmission zone. The average cost of supplemental projects in each expected in service year increased by 2,312.9 percent, from \$65.0 million for years 1998 through 2007 (pre Order No. 890) to \$1,568.4 million for years 2008 through 2021 (post Order No. 890).

Table 12-49 Latest cost estimate by expected in service year and zone (\$ millions): 1998 through 2040

Year	ACEC	AEP	APS	ATSI	BGE	COMED	DAY	DUKE	DUQ	DOM	DPL	EKPC	JCPLC	MEC	OVEC	PECO	PE	PEPCO	PPL	PSEG	REC	Total
1998	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1.67	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1.67
1999	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.77	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.77
2000	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$32.94	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$32.94
2001	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6.79	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6.79
2002	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$7.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$7.00
2003	\$8.32	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$8.77	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$9.60	\$0.00	\$0.00	\$0.00	\$0.00	\$26.69
2004	\$4.45	\$0.00	\$9.99	\$0.00	\$0.00	\$0.82	\$0.00	\$0.00	\$0.00	\$0.00	\$7.32	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$22.58
2005	\$4.06	\$14.66	\$10.11	\$0.00	\$0.00	\$2.57	\$0.00	\$0.00	\$0.00	\$0.02	\$10.98	\$0.00	\$0.00	\$0.00	\$0.00	\$0.50	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$42.90
2006	\$4.03	\$309.70	\$0.93	\$0.00	\$0.00	\$48.92	\$0.00	\$0.00	\$0.00	\$0.00	\$11.62	\$0.00	\$6.00	\$0.00	\$0.00	\$0.00	\$1.50	\$0.00	\$4.63	\$18.80	\$0.00	\$406.13
2007	\$1.12	\$2.06	\$9.85	\$0.00	\$37.61	\$4.65	\$0.00	\$0.00	\$31.75	\$0.00	\$12.93	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.34	\$0.00	\$0.34	\$2.28	\$102.59
2008	\$2.84	\$0.00	\$12.03	\$0.00	\$0.45	\$7.61	\$0.00	\$0.00	\$7.00	\$14.01	\$2.77	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1.59	\$0.00	\$0.00	\$48.30
2009	\$0.77	\$0.90	\$12.22	\$0.00	\$5.00	\$21.11	\$0.00	\$0.00	\$19.60	\$2.12	\$7.35	\$0.00	\$0.00	\$0.00	\$0.00	\$48.10	\$2.73	\$0.00	\$0.16	\$17.60	\$0.00	\$137.66
2010	\$0.00	\$34.36	\$12.13	\$0.00	\$18.90	\$1.38	\$0.00	\$0.00	\$34.45	\$14.98	\$0.00	\$0.00	\$0.03	\$4.58	\$0.00	\$31.80	\$0.00	\$0.00	\$1.86	\$17.72	\$0.00	\$172.19
2011	\$0.00	\$37.60	\$9.30	\$0.00	\$0.00	\$1.00	\$0.00	\$0.00	\$16.72	\$85.67	\$0.00	\$0.00	\$1.16	\$0.00	\$0.00	\$113.30	\$0.00	\$0.00	\$11.87	\$34.60	\$0.00	\$311.22
2012	\$0.00	\$46.00	\$5.12	\$0.35	\$2.20	\$12.60	\$0.00	\$26.06	\$11.60	\$165.74	\$0.99	\$0.00	\$6.61	\$0.00	\$0.00	\$12.60	\$0.00	\$0.00	\$19.66	\$223.01	\$0.00	\$532.54
2013	\$3.15	\$134.93	\$1.10	\$33.68	\$0.00	\$59.25	\$0.00	\$9.93	\$79.10	\$25.03	\$0.99	\$0.00	\$0.05	\$4.10	\$0.00	\$22.50	\$0.00	\$2.40	\$76.70	\$503.72	\$0.00	\$956.63
2014	\$15.53	\$568.00	\$5.97	\$58.70	\$21.20	\$60.37	\$0.00	\$2.43	\$14.90	\$88.61	\$5.95	\$0.38	\$5.60	\$0.00	\$0.00	\$13.30	\$1.30	\$0.00	\$33.47	\$401.11	\$0.00	\$1,296.82
2015	\$3.73	\$237.67	\$3.80	\$21.90	\$2.00	\$376.00	\$0.00	\$14.12	\$4.53	\$113.53	\$13.06	\$1.56	\$0.30	\$0.00	\$0.00	\$33.80	\$0.00	\$42.50	\$50.17	\$743.91	\$0.00	\$1,662.58
2016	\$74.54	\$84.13	\$18.40	\$182.70	\$0.00	\$308.15	\$0.00	\$15.13	\$26.95	\$40.68	\$26.60	\$0.25	\$0.00	\$2.37	\$0.00	\$86.40	\$0.40	\$7.80	\$59.20	\$744.18	\$0.00	\$1,677.88
2017	\$66.28	\$648.74	\$8.60	\$164.45	\$0.09	\$145.97	\$0.00	\$64.31	\$3.62	\$104.25	\$92.29	\$2.21	\$0.00	\$14.70	\$0.00	\$0.00	\$8.30	\$12.00	\$264.88	\$994.43	\$0.00	\$2,595.12
2018	\$66.55	\$817.94	\$14.60	\$42.12	\$4.08	\$80.94	\$0.00	\$69.80	\$3.13	\$162.94	\$68.94	\$10.87	\$0.00	\$0.00	\$0.00	\$47.60	\$0.00	\$156.00	\$197.34	\$631.25	\$0.00	\$2,374.10
2019	\$64.30	\$1,158.43	\$11.97	\$190.40	\$150.25	\$90.19	\$0.30	\$98.59	\$0.30	\$90.14	\$33.55	\$23.67	\$0.90	\$62.30	\$0.00	\$2.00	\$75.80	\$0.00	\$298.00	\$356.41	\$0.00	\$2,707.50
2020	\$59.58	\$992.86	\$0.30	\$112.78	\$65.81	\$78.09	\$13.66	\$71.54	\$7.20	\$253.38	\$39.50	\$25.61	\$2.60	\$23.70	\$0.00	\$1.60	\$74.50	\$102.70	\$196.99	\$1,884.38	\$0.00	\$4,006.78
2021	\$17.60	\$1,524.74	\$2.70	\$238.08	\$29.70	\$137.80	\$31.40	\$173.00	\$18.10	\$75.77	\$6.70	\$29.18	\$39.00	\$194.30	\$4.40	\$31.70	\$148.39	\$0.00	\$254.43	\$520.75	\$0.00	\$3,477.74
2022	\$186.66	\$1,660.06	\$7.48	\$269.92	\$244.30	\$98.40	\$10.35	\$21.46	\$45.00	\$217.70	\$67.90	\$0.00	\$48.50	\$105.76	\$0.00	\$0.00	\$114.30	\$737.50	\$362.25	\$934.55	\$0.00	\$5,132.09
2023	\$88.30	\$1,402.18	\$0.00	\$141.06	\$0.00	\$1.00	\$54.15	\$54.79	\$0.00	\$56.80	\$39.50	\$20.49	\$6.80	\$80.80	\$0.00	\$201.80	\$40.70	\$0.00	\$253.44	\$855.60	\$0.00	\$3,297.41
2024	\$38.74	\$753.76	\$0.00	\$107.50	\$0.00	\$212.40	\$61.60	\$17.64	\$0.00	\$42.42	\$39.70	\$15.42	\$38.50	\$147.90	\$0.00	\$0.00	\$24.50	\$38.50	\$237.10	\$292.50	\$0.00	\$2,068.18
2025	\$30.39	\$515.60	\$60.00	\$199.70	\$144.10	\$0.00	\$0.00	\$0.00	\$0.00	\$267.77	\$51.93	\$0.00	\$0.00	\$134.70	\$0.00	\$0.00	\$46.60	\$0.00	\$127.00	\$0.00	\$0.00	\$1,577.79
2026	\$64.00	\$201.10	\$0.00	\$0.00	\$336.00	\$67.00	\$0.00	\$4.70	\$0.00	\$0.00	\$0.00	\$0.00	\$16.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$387.05	\$0.00	\$0.00	\$1,075.85
2027	\$0.00	\$250.20	\$0.00	\$389.30	\$118.00	\$0.00	\$0.00	\$32.57	\$160.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$138.00	\$0.00	\$582.41	\$0.00	\$0.00	\$1,670.48
2028	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$30.40	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$51.00	\$0.00	\$0.00	\$81.40
2029	\$0.00	\$0.00	\$0.00	\$0.00	\$231.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$96.60	\$0.00	\$0.00	\$327.60
2030	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$91.90	\$0.00	\$0.00	\$91.90
2031	\$0.00	\$0.00	\$0.00	\$80.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$80.00
2032	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2033	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2034	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$200.00	\$0.00	\$0.00	\$0.00	\$0.00	\$200.00
2035	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2036	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2037	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2038	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2039	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2040	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total	\$804.94	\$11,395.62	\$216.60	\$2,232.64	\$1,410.69	\$1,816.22	\$171.46	\$676.07	\$514.35	\$1,821.56	\$598.51	\$129.64	\$172.05	\$775.21	\$4.40	\$647.00	\$886.62	\$1,099.40	\$3,660.04	\$9,176.80	\$0.00	\$38,209.82

The MMU recommends, to increase the role of competition, that the exemption of supplemental from the Order No. 1000 competitive process be terminated.

End of Life Transmission Projects

An end of life transmission project is a project submitted for the purpose of replacing existing infrastructure that is at, or is approaching, the end of its useful life. Under the current process, end of life transmission projects are not subject to the RTEP open window process and have become a form of supplemental project that is exempt from competition under the existing rules.⁵³

The MMU recommends, to increase the role of competition, that the exemption of end of life projects from the Order No. 1000 competitive process be terminated and that end of life transmission projects be included in the RTEP process and should be subject to a transparent, robust and clearly defined mechanism to permit competition to build such projects.

Competitive Planning Process Exclusions

There are several project types that are currently exempt from the competitive planning process. These project types include:

- **Immediate Need Exclusion.** Due to the immediate need of the violation (3 years or less), the timing required for an RTEP proposal window is defined to be infeasible and such projects are excluded from competition. As a result, the local Transmission Owner is the Designated Entity.⁵⁴ On October 17, 2019, the Commission issued an Order Instituting Section 206 Proceedings to determine if RTOs have implemented the exemption in a manner consistent with the Commission's directives under Order 1000.⁵⁵ Some supplemental projects are in this category.
- **Below 200kV.** Due to the lower voltage level of the identified violation(s), the driver(s) for this project are excluded from competition. As a result, the local Transmission Owner is the Designated Entity.⁵⁶ Some supplemental projects are in this category.

⁵³ In recent decisions addressing competing proposals on end of life projects, the Commission accepted a transmission owner proposal excluding end of life projects from competition in the RTEP process, 172 FERC ¶ 61,136 (2020), *reh'g denied*, 173 FERC ¶ 61,225 (2020), and rejected a proposal from PJM stakeholders that would have included end of life projects in competition in the RTEP process, 173 FERC ¶ 61,242 (2020).

⁵⁴ See OA Schedule 6 § 1.5.8(m).

⁵⁵ 169 FERC ¶ 61,054 (2019).

⁵⁶ See OA Schedule 6 § 1.5.8(n).

- **Substation Equipment.** Due to identification of the limiting element(s) as substation equipment, such projects are excluded from competition. As a result, the local Transmission Owner is the Designated Entity.⁵⁷ Some supplemental projects are in this category.

While the PJM Operating Agreement defines who will be the Designated Entity for projects that are excluded from the competitive planning process, neither the PJM Operating Agreement nor the various commission orders on transmission competition prohibit PJM from permitting competition to provide financing for such projects. The MMU recommends that rules be implemented to permit competition to provide financing for transmission projects. This competition could reduce the cost of capital for transmission projects and significantly reduce total costs to customers. In addition, the criteria for and need for all exclusions from the competitive process should be reviewed. There does not appear to be any market reason to exclude transmission projects from competition for any of these exclusion categories.

Comparative Cost Framework

The MMU recommended that rules be implemented to require that project cost caps on new transmission projects be part of the evaluation of competing projects. On May 24, 2018, the PJM Markets and Reliability Committee (MRC) approved a motion that required PJM, with input from the MMU, to develop a comparative cost framework to evaluate the quality and effectiveness of binding cost containment proposals versus proposals without cost containment provisions. On March 20, 2020, the Commission approved PJM's filing to amend the PJM Operating Agreement to incorporate this requirement.⁵⁸

The 2020 RTEP Window 1 was the first open window that received cost capping proposals to be evaluated under the comparative cost framework. The analysis performed under the new process was insufficient and did not follow the process defined in the PJM manual.⁵⁹ The existing proposal templates do not provide enough information to adequately perform a financial analysis. The MMU recommends that PJM modify the project proposal templates to

⁵⁷ See OA Schedule 6 § 1.5.8(p).

⁵⁸ 170 FERC ¶ 61,243 (2020).

⁵⁹ See PJM, "PJM Manual 14F: Competitive Planning Process," Rev. 5 (April 10, 2020).

include data necessary to perform a detailed project lifetime financial analysis. The required data includes, but is not limited to: capital expenditure; capital structure; return on equity; cost of debt; tax assumptions; ongoing capital expenditures; ongoing maintenance; and expected life.

Storage As A Transmission Asset (SATA)

The PJM Planning Committee is currently considering whether storage devices should be included in the RTEP process as transmission assets.⁶⁰

Transmission and generation have, and have always had, a symbiotic relationship in the provision of wholesale power. Transmission needs generation to function and generation needs transmission to function. Transmission can substitute for generation at the margin and generation can substitute for transmission at the margin. This relationship has always been a relatively unexamined area in the design of competitive wholesale power markets. For example, there is little if any explicit consideration of the impact of transmission planning on competitive generation investment in RTO/ISO market rules. Improvement is needed in these areas. Introducing confusion about what assets are classified as generation and what assets are classified as transmission frustrates potential reform and undermines the competitive markets.

On July 22, 2020, through the supplemental planning process, American Electric Power Service Corporation (AEP) filed, on behalf of Kentucky Power Company (Kentucky Power), a Petition for Declaratory Order seeking confirmation that its Middle Creek energy storage project is eligible for cost-of-service recovery through AEP's formula rates.⁶¹ AEP's Middle Creek energy storage project was a proposed battery storage device that would discharge energy to serve retail load at the Middle Creek substation in the event of a transmission outage. On December 21, 2020, the Commission ruled that the Middle Creek energy storage project did not perform a transmission function, and was ineligible to recover its costs through formula rates.⁶²

⁶⁰ See PJM, "Storage As A Transmission Asset: Problem / Opportunity Statement," <<https://pjm.com/-/media/committees-groups/committees/pc/2020/20200605-special/20200605-item-02a-storage-as-a-transmission-asset-problem-statement-clean.ashx>>.

⁶¹ See AEP, Docket No. EL20-58 (July 22, 2020).

⁶² 173 FERC ¶ 61,264 (2020).

Storage devices like batteries that are defined to be part of PJM markets should not be treated as transmission assets. The MMU recommends that storage resources not be includable as transmission assets for any reason.

Board Authorized Transmission Upgrades

The Transmission Expansion Advisory Committee (TEAC) regularly reviews internal and external proposals to improve transmission reliability throughout PJM. These proposals, which include reliability baseline, network, market efficiency and targeted market efficiency projects, as well as scope changes and project cancellations, but exclude supplemental and end of life projects, are periodically presented to the PJM Board of Managers for authorization.⁶³

An RTEP project can be approved by the PJM Board if the project ensures compliance with NERC, regional and local transmission owner planning criteria or to address market efficiency congestion relief. These projects are considered Baseline Projects. PJM Board approved RTEP projects that are necessary to allow new generation to interconnect reliably are considered Network Projects.

In the first three months of 2021, the PJM Board approved a net change of \$349.8 million in transmission upgrades. As of March 31, 2021, the PJM Board had approved \$38.2 billion in transmission system enhancements since 1999. On February 22, 2021, the PJM Board of Managers authorized an additional \$349.8 million in transmission upgrades and additions.

Qualifying Transmission Upgrades (QTU)

A Qualifying Transmission Upgrade (QTU) is an upgrade to the transmission system that increases the Capacity Emergency Transfer Limit (CETL) into an LDA and can be offered into capacity auctions as capacity. Once a QTU is in service, the upgrade is eligible to continue to offer the approved incremental import capability into future RPM Auctions.

If a QTU that was cleared in a Base Residual Auction (BRA) or Incremental Auction (IA) is not completed by the start of the Delivery Year, the submitting

⁶³ Supplemental Projects, including the end of life subset of supplemental projects, do not require PJM Board of Managers authorization.

party is required to provide replacement capacity. Once a QTU is in service, the upgrade is eligible to continue to offer the approved incremental import capability into future RPM Auctions. As of March 31, 2021, no QTUs have cleared a BRA or IA.

Cost Allocation

In response to complaints against PJM RTEP Baseline Upgrade Filings in 2014 that included cost allocations for \$1.5 billion in baseline transmission enhancements and expansions, on November 24, 2015, FERC issued an order directing investigation of “whether there is a definable category of reliability projects within PJM for which the solution-based DFAX cost allocation method may not be just and reasonable, such as projects addressing reliability violations that are not related to flow on the planned transmission facility, and whether an alternative just and reasonable *ex ante* cost allocation method could be established for any such category of projects.”⁶⁴ FERC convened a technical conference on January 12, 2016, to address the complaints in multiple proceedings and to address these two core issues.⁶⁵

The issues identified in the complaints and at the technical conference included: whether the solutions based allocation method is appropriate for upgrades not related to transmission overload issues; whether the solutions based allocation method correctly identifies all the beneficiaries of the upgrades; whether it is reasonable to allocate a level of costs to a merchant transmission project that could force bankruptcy; and whether the significant shifts in allocation that result from use of the 0.01 distribution factor cutoff are appropriate.

On February 20, 2020, the Commission issued an Order denying rehearing requests.⁶⁶ The Commission found that PJM’s solution based dfax method for regional cost allocation, including the 0.01 distribution cutoff factor, is just and reasonable.

It is clear that the allocation issues are difficult. Nonetheless, the allocation methods affect the efficiency of the markets and the incentives for merchant

transmission owners to compete to build new transmission. The MMU recommends a comprehensive review of the ways in which the solution based dfax is implemented. The goal for such a process would be to ensure that the most rational and efficient approach to implementing the solution based dfax method is used in PJM. Such an approach should allocate costs consistent with benefits and appropriately calibrate the incentives for investment in new transmission capability. No replacement approach should be approved until all potential alternatives, including the status quo, are thoroughly reviewed.

As an example, the use of the arbitrary 0.01 distribution factor cutoff can result in large and inappropriate shifts in cost allocation. If the intent of the use of the 0.01 cutoff is to help eliminate small, arbitrary cost allocations to geographically distant areas, this could be achieved by adding a threshold for a minimum usage impact on the line. The MMU recommends consideration of changing the minimum distribution factor in the allocation from 0.01 to 0.00 and adding a threshold minimum impact on the load on the line based on a complete analysis of the intent of the allocation and the impacts of the allocation.

Transmission Line Ratings

Transmission line ratings, and more broadly transmission facility ratings, are the metric for the ability of transmission lines to transmit power from one point to another. Transmission line ratings have significant and frequently underappreciated impacts on competitive wholesale power markets like PJM. These include direct impacts on energy and capacity prices, the frequency and level of congestion in the day-ahead and real-time energy market, day-ahead nodal price differences and the associated value of FTRs, locational price differences in the capacity market, the need to invest in additional transmission capacity, the need to invest in additional generation capacity, the location of new power plants, and the interconnection costs for new power plants. The impact of transmission facility ratings on markets is a function both of the line ratings directly and the use of those ratings by the RTO/ISO.

⁶⁴ 153 FERC ¶ 61,245 at P 35 (2015).

⁶⁵ See Docket Nos. EL15-18-000 (ConEd), EL15-67-000 (Linden), and EL15-95-000 (Artificial Island).

⁶⁶ 170 FERC ¶ 61,122 (2020).

Congestion payments by load result when lower cost generation is not available to meet all the load in an area as a result of limits on the transmission system. When higher cost local generation is needed to meet part of the local load because of transmission limits, 100 percent of the local load pays the higher price while only the local generation receives the higher price. The difference between what the load pays and generators receive is congestion. Since 2008, congestion costs in PJM have ranged from \$0.5 billion to \$2.05 billion per year. Congestion costs were significantly higher during extreme winter weather conditions such as January 2014, when the congestion costs in PJM were \$825.1 million for one month.⁶⁷

LMP may, at times, be set by transmission penalty factors. When a transmission constraint is binding and there are no generation alternatives to resolve the constraint, system operators may allow the transmission limit to be violated. When this occurs, the shadow price of the constraint is set by transmission penalty factors. The shadow price directly affects the LMP. Transmission penalty factors are administratively determined and can be thought of as a form of locational scarcity pricing. Transmission penalty factors were fully implemented in PJM pricing effective February 1, 2019.

Transmission line ratings can result in short term, significant increases in prices as a result of the application of transmission penalty factors. For example, violation of a transmission constraint, meaning that the flow exceeds the line limit, could result in a \$2,000 per MWh price. As the power flows approach their rated limits, PJM dispatchers may reduce the limits.⁶⁸ Violation of these reduced line ratings results in penalty factors setting prices. In 2019, there were 152,675 transmission constraint intervals in the real-time market with a non-zero shadow price. For nearly five percent of these transmission constraints, the line limit was violated, meaning the flow exceeded the facility limit and prices were set by transmission penalty factors. In 2019, the average shadow price of transmission constraints when the line limit was violated was

nearly 15 times higher than when transmission constraint was binding at its limit.⁶⁹

Capacity market prices separate locally when transmission capability into Locational Deliverable Areas (LDA) is not adequate to meet the LDA capacity requirement with the lowest cost capacity. The available transmission capability into LDAs is defined as the Capacity Emergency Transfer Limit (CETL). Higher cost LDAs are the equivalent in the capacity market of congestion in the energy market. Load in the higher cost LDAs pay more for capacity than those in lower cost LDAs. For example, the clearing price for the BGE LDA in the 2021/2022 Base Residual Auction was \$200.30 per MW-day. The clearing price for the EMAAC LDA was \$165.73 per MW-day.⁷⁰

Transmission line ratings for a given transmission facility vary by the duration of the power flow, by ambient temperatures, by wind speed and by other conditions. Transmission lines can operate with higher loads for shorter periods of time. This is significant when a contingency is expected to last for only a short period. The transmission line rating can mean the difference between substantial congestion costs and no congestion costs. The transmission line rating can mean the difference between a transmission penalty factor and no penalty factor.

In PJM, transmission owners use a range of ratings by duration.⁷¹ PJM requires transmission owners to provide thermal ratings under normal operating conditions, long term emergency operating conditions, short term emergency operating conditions and the extreme load dump conditions. But there is no requirement that the ratings differ for these operating conditions. PJM typically uses normal line ratings for precontingency (base case) constraints and long term emergency line ratings (four hours) for contingency constraints. PJM requires transmission owners to provide temperature based line ratings separately for night and day times. The temperature ranges from 32 degree Fahrenheit or below to 95 degree Fahrenheit or above in nine degree increments. But there is no requirement that the ratings differ

⁶⁷ See the *2018 State of the Market Report for PJM*, Volume II, Section 11: Congestion and Marginal Losses.

⁶⁸ See "Transmission Constraint Control Logic and Penalty Factors," presented at May 10, 2018 meeting of the Markets Implementation Committee Special Session Transmission Constraint Penalty Factors at p14. <<https://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special/20180510-item-03-transmission-constraint-penalty-factor-education.aspx>>.

⁶⁹ See the *2019 State of the Market Report for PJM*, Volume II, Section 3: Energy Market.

⁷⁰ See the "Analysis of the 2021/2022 RPM Base Residual Auction," <https://www.monitoringanalytics.com/reports/Reports/2018/IMM_Analysis_of_the_20212022_RPM_BRA_Revised_20180824.pdf> (August 24, 2018).

⁷¹ See "PJM Manual 3: Transmission Operations," Rev. 58 (November 19, 2020) § 2.1.1, at p 28.

for these operating condition temperatures. In PJM, transmission owners are responsible for developing their own methods to compute line ratings subject to a range of NERC guidelines and requirements. PJM does not review or verify the accuracy of transmission owners' methods to compute line ratings. In PJM, transmission owners have substantial discretion in the approach to line ratings.⁷²

Given the significant impact of transmission line ratings on all aspects of wholesale power markets, ensuring and improving the accuracy and transparency of line ratings is essential. Line ratings should incorporate ambient temperature conditions, wind speed and other relevant operating conditions. PJM real-time prices are calculated every five minutes for thousands of nodes. PJM prices are extremely sensitive to transmission line ratings. For consistency with the dynamic nature of wholesale power markets, line ratings should be updated in real time to reflect real time conditions and to help ensure that real-time prices are based on actual current line ratings. The ongoing analysis of dynamic line ratings is a promising area that should be pursued.

The MMU recommends that all PJM transmission owners use the same methods to define line ratings, subject to NERC standards and guidelines, subject to review by NERC and approval by FERC. The same facilities should have the same basic ratings under the same operating conditions regardless of the transmission owner. Transmission owner discretion should be minimized or eliminated. The line rating methods should be based on the basic engineering facts of the transmission system components and reflect the impact of actual operating conditions on the ratings of transmission facilities, including ambient temperatures and wind speed when relevant.⁷³ The line rating methods should be public and fully transparent.

The MMU recommends that PJM routinely review all transmission facility ratings and any changes to those ratings to ensure that the normal, emergency

⁷² PJM presentation to the Planning Committee (PC) (May 3, 2018) "Transmission Owner Ratings Development and Reporting in PJM" ("There are no requirements for PJM to approve or verify a TO's ratings or do any kind of consistency check.") at 24.

⁷³ See "Transmission Owner Ratings Development and Reporting in PJM," presented at May 3, 2018 meeting of the Planning Committee. <<https://www.pjm.com/-/media/committees-groups/committees/pc/20180503/20180503-item-13-to-ratings-process-and-reporting.ashx>>.

and load dump ratings used in modeling the transmission system are accurate and reflect standard ratings practice.⁷⁴ All line rating changes and the detailed reasons for those changes should be public and fully transparent.

Transmission Facility Outages

Scheduling Transmission Facility Outage Requests

A transmission facility is designated as reportable by PJM if a change in its status can affect a transmission constraint on any Monitored Transmission Facility or could impede free flowing ties within the PJM RTO and/or adjacent areas.⁷⁵ When a reportable transmission facility needs to be taken out of service, the transmission owner is required to submit an outage request as early as possible.⁷⁶ The specific timeline is shown in Table 12-51.⁷⁷

Transmission outages have significant impacts on PJM markets, including impacts on FTR auctions, on congestion, and on expected market outcomes in the day-ahead and real-time markets. The efficient functioning of the markets depends on clear, enforceable rules governing transmission outages.

The outage data for the FTR market are for outages scheduled to occur in the 2019/2020 planning period and the first 10 months of the 2020/2021 planning period, regardless of when they were initially submitted.⁷⁸ The outage data for the day-ahead market are for outages scheduled to occur from January 2015 through March 2021.

Transmission outages are categorized by duration: greater than 30 calendar days; less than or equal to 30 calendar days; greater than five calendar days; less than or equal to five calendar days.⁷⁹ Table 12-50 shows that 77.2 percent of requested outages were planned for less than or equal to five days and 8.4 percent of requested outages were planned for greater than 30 days in the first 10 months of the 2020/2021 planning period. Table 12-50 also shows that

⁷⁴ See the 2018 State of the Market Report for PJM, Volume II, Section 2: Recommendations.

⁷⁵ If a transmission facility is not modeled in the PJM EMS or the facility is not expected to significantly impact PJM system security or congestion management, it is not reportable. See PJM, "Manual 3: Transmission Operations," Rev. 58 (November 19, 2020).

⁷⁶ See PJM, "Manual 3: Transmission Operations," Rev. 58 (November 19, 2020).

⁷⁷ See PJM, "Manual 3: Transmission Operations," Rev. 58 (November 19, 2020).

⁷⁸ The hotline tickets, EMS tripping tickets or test outage tickets were excluded. The analysis includes only the transmission outage tickets submitted by PJM companies which are currently active.

⁷⁹ *Id.* at 70.

77.8 percent of the requested outages were planned for less than or equal to five days and 7.8 percent of requested outages were planned for greater than 30 days in the 2019/2020 planning period.

Table 12-50 Transmission facility outage request summary by planned duration: June 2019 through March 2021

Planned Duration (Days)	2019/2020 (12 months)		2020/2021 (10 months)	
	Outage Requests	Percent of Total	Outage Requests	Percent of Total
<=5	16,609	77.8%	12,765	77.2%
>5 <=30	3,077	14.4%	2,383	14.4%
>30	1,676	7.8%	1,394	8.4%
Total	21,362	100.0%	16,542	100.0%

After receiving a transmission facility outage request from a TO, PJM assigns a received status to the request based on its submission date and outage planned duration. The received status can be On Time or Late, as defined in Table 12-51.⁸⁰

The purpose of the rules defined in Table 12-51 is to require the TOs to submit transmission facility outages prior to the Financial Transmission Right (FTR) auctions so that market participants have complete information about market conditions on which to base their FTR bids and PJM can accurately model market conditions.⁸¹

Table 12-51 Transmission facility outage request received status definition

Planned Duration (Calendar Days)	Request Submitted	Received Status
<=5	Before the first of the month one month prior to the starting month of the outage	On Time
	After or on the first of the month one month prior to the starting month of the outage	Late
> 5 <=30	Before the first of the month six months prior to the starting month of the outage	On Time
	After or on the first of the month six months prior to the starting month of the outage	Late
>30	The earlier of 1) February 1, 2) the first of the month six months prior to the starting month of the outage	On Time
	After or on the earlier of 1) February 1, 2) the first of the month six months prior to the starting month of the outage	Late

Table 12-52 shows a summary of requests by received status. In the first 10 months of the 2020/2021 planning period, 42.7 percent of outage requests received were late. In the 2019/2020 planning period, 44.4 percent of outage requests received were late.

Table 12-52 Transmission facility outage request summary by received status: June 2019 through March 2021

Planned Duration (Days)	2019/2020 (12 months)				2020/2021 (10 months)			
	On Time	Late	Total	Percent Late	On Time	Late	Total	Percent Late
<=5	9,570	7,039	16,609	42.4%	7,618	5,147	12,765	40.3%
>5 <=30	1,640	1,437	3,077	46.7%	1,280	1,103	2,383	46.3%
>30	663	1,013	1,676	60.4%	580	814	1,394	58.4%
Total	11,873	9,489	21,362	44.4%	9,478	7,064	16,542	42.7%

Once received, PJM processes outage requests in priority order: emergency transmission outage request; transmission outage request submitted on time; and transmission outage request submitted late. Transmission outage requests that are submitted late may be approved if the outage does not affect the reliability of PJM or cause congestion in the system.⁸²

⁸⁰ See PJM, "Manual 3: Transmission Operations," Rev. 58 (Nov. 19, 2020).

⁸¹ See "Report of PJM Interconnection, LLC on Transmission Oversight Procedures," Docket No. EL01-122-000 (November 2, 2001).

⁸² See PJM, "Manual 3: Transmission Operations," Rev. 58 (Nov. 19, 2020). The following language was removed from Manual 3 Rev. 50: PJM retains the right to deny all jobs submitted after 8 a.m. three days prior to the requested start date unless the request is an emergency job or an exception request (i.e. a generator tripped and the Transmission Owner is taking advantage of a situation that was not available before the unit trip).

Outages with emergency status will be approved even if submitted late after PJM determines that the outage does not result in Emergency Procedures. PJM cancels or withholds approval of any outage that results in Emergency Procedures.⁸³ Table 12-53 is a summary of outage requests by emergency status. Of all outage requests scheduled to occur in the first 10 months of the 2020/2021 planning period, 12.7 percent were for emergency outages. Of all outage requests scheduled to occur in the 2019/2020 planning period, 12.2 percent were for emergency outages.

Table 12-53 Transmission facility outage request summary by emergency: June 2019 through March 2021

Planned Duration (Days)	2019/2020 (12 months)				2020/2021 (10 months)			
	Emergency	Non Emergency	Total	Percent Emergency	Emergency	Non Emergency	Total	Percent Emergency
<=5	1,952	14,657	16,609	11.8%	1,520	11,245	12,765	11.9%
>5 <=30	402	2,675	3,077	13.1%	372	2,011	2,383	15.6%
>30	262	1,414	1,676	15.6%	213	1,181	1,394	15.3%
Total	2,616	18,746	21,362	12.2%	2,105	14,437	16,542	12.7%

PJM will approve all transmission outage requests that are submitted on time and do not jeopardize the reliability of the PJM system. PJM will approve all transmission outage requests that are submitted late and are not expected to cause congestion on the PJM system and do not jeopardize the reliability of the PJM system. Each outage is studied and if it is expected to cause a constraint to exceed a limit, PJM will flag the outage ticket as “congestion expected.”⁸⁴

After PJM determines that a late request may cause congestion, PJM informs the transmission owner of solutions available to eliminate the congestion. For example, if a generator planned or maintenance outage request is contributing to the congestion, PJM can request that the generation owner defer the outage. If no solutions are available, PJM may require the transmission owner to reschedule or cancel the outage.

Table 12-54 is a summary of outage requests by congestion status. Of all outage requests submitted to occur in the first 10 months of the 2020/2021 planning period, 6.3 percent were expected to cause congestion. Of all the outage requests that were expected to cause congestion, 2.0 percent (21 out of 1,045) were denied by PJM in the first 10 months of the 2020/2021 planning period and 19.8 percent (207 out of 1,045) were cancelled (Table 12-56). Of all outage requests submitted to occur in the 2019/2020 planning period, 6.5 percent were expected to cause congestion. Of all the outage requests that were expected to cause congestion, 2.1 percent (29 out of 1,399) were denied by PJM in the 2019/2020 planning period and 21.7 percent (304 out of 1,399) were cancelled (Table 12-56).

Table 12-54 Transmission facility outage request summary by congestion: June 2019 through March 2021

Planned Duration (Days)	2019/2020 (12 months)				2020/2021 (10 months)			
	Congestion Expected	No Congestion Expected	Total	Percent Congestion Expected	Congestion Expected	No Congestion Expected	Total	Percent Congestion Expected
<=5	976	15,633	16,609	5.9%	749	12,016	12,765	5.9%
>5 <=30	267	2,810	3,077	8.7%	198	2,185	2,383	8.3%
>30	156	1,520	1,676	9.3%	98	1,296	1,394	7.0%
Total	1,399	19,963	21,362	6.5%	1,045	15,497	16,542	6.3%

⁸³ PJM, “Manual 3: Transmission Operations,” Rev. 58 (Nov. 19, 2020).

⁸⁴ PJM added this definition to Manual 38 in February 2017. PJM, “Manual 38: Operations Planning,” Rev. 14 (Jan. 27, 2021).

Table 12-55 shows the outage requests summary by received status, congestion status and emergency status. In the first 10 months of the 2020/2021 planning period, 30.1 percent of requests were submitted late and were nonemergency while 1.1 percent of requests (178 out of 16,542) were late, nonemergency, and expected to cause congestion. In the 2019/2020 planning period, 32.3 percent of request were submitted late and were nonemergency while 1.1 percent of requests (238 out of 21,362) were late, nonemergency, and expected to cause congestion.

Table 12-55 Transmission facility outage request summary by received status, emergency and congestion: June 2019 through March 2021

		2019/2020 (12 months)				2020/2021 (10 months)			
Received Status		Congestion		Percent of Total	Congestion		Percent of Total		
		Expected	No Expected		Expected	No Expected			
Late	Emergency	68	2,517	2,585	12.1%	63	2,015	2,078	12.6%
	Non Emergency	238	6,666	6,904	32.3%	178	4,808	4,986	30.1%
On Time	Emergency	4	27	31	0.1%	1	26	27	0.2%
	Non Emergency	1,089	10,753	11,842	55.4%	803	8,648	9,451	57.1%
Total		1,399	19,963	21,362	100.0%	1,045	15,497	16,542	100.0%

Once PJM processes an outage request, the outage request is labelled as Submitted, Received, Denied, Approved, Cancelled by Company, PJM Admin Closure, Revised, Active or Complete according to the processed stage of a request.⁸⁵ Table 12-56 shows the detailed process status for outage requests only for the outage requests that are expected to cause congestion. Status Submitted and status Received are in the In Process category and status Cancelled by Company and status PJM Admin Closure are in the Cancelled category in Table 12-56. Table 12-56 shows that of all the outage requests that were expected to cause congestion, 2.0 percent (21 out of 1,045) were denied by PJM in the first 10 months of the 2020/2021 planning period, 67.1 percent were complete and 19.8 percent (207 out of 1,045) were cancelled. Of all the outage requests that were expected to cause congestion, 2.1 percent (29 out of 1,399) were denied by PJM in the 2019/2020 planning period, 70.0 percent were complete and 21.7 percent (304 out of 1,399) were cancelled.

Table 12-56 Transmission facility outage requests status summary: June 2019 through March 2021

		2019/2020 (12 months)					2020/2021 (10 months)						
Received Status		Congestion			Percent Complete	Congestion			Percent Complete				
		Cancelled	Complete	In Process		Denied	Expected	In Process		Denied			
Late	Emergency	6	61	0	1	68	89.7%	4	57	1	1	63	90.5%
	Non Emergency	37	185	7	8	238	77.7%	33	121	14	8	178	68.0%
On Time	Emergency	1	3	0	0	4	75.0%	0	0	1	0	1	0.0%
	Non Emergency	260	730	77	20	1,089	67.0%	170	523	86	12	803	65.1%
Total		304	979	84	29	1,399	70.0%	207	701	102	21	1,045	67.1%

There are clear rules defined for assigning On Time or Late status for submitted outage requests in both the PJM tariff and PJM manuals.⁸⁶ However, the On Time or Late status only affects the priority that PJM assigns for processing the outage request. Table 12-56 shows that in the 2019/2020 planning period, 238 nonemergency outage requests were submitted late and expected to cause congestion. The expected impact on congestion is the basis for PJM's treatment of

⁸⁵ See PJM Markets & Operations, PJM Tools "Outage Information," <<http://www.pjm.com/markets-and-operations/etools/oasis/system-information/outage-info.aspx>> (2019).

⁸⁶ OA Schedule 1 § 1.9.2.

late outage requests. But there is no rule or clear definition of this congestion analysis in the PJM manuals. The MMU recommends that PJM draft a clear definition of the congestion analysis required for transmission outage requests to include in Manual 3 after appropriate review.

Rescheduling Transmission Facility Outage Requests

A TO can reschedule or cancel an outage after initial submission. Table 12-57 is a summary of all the outage requests planned for the 2019/2020 planning period and the first 10 months of the 2020/2021 planning period which were approved and then cancelled or rescheduled by TOs at least once. If an outage request was submitted, approved and subsequently rescheduled at least once, the outage request will be counted as Approved and Rescheduled. If an outage request was submitted, approved and subsequently cancelled at least once, the outage request will be counted as Approved and Cancelled. In the first 10 months of the 2020/2021 planning period, 29.7 percent of transmission outage requests were approved by PJM and then rescheduled by the TOs, and 12.0 percent of the transmission outages were approved by PJM and subsequently cancelled by the TOs. In the 2019/2020 planning period, 31.8 percent of transmission outage requests were approved by PJM and then rescheduled by the TO, and 11.4 percent of the transmission outages were approved by PJM and subsequently cancelled by the TO.

Table 12-57 Rescheduled and cancelled transmission outage request summary: June 2019 through March 2021

Planned Duration (Days)	2019/2020 (12 months)					2020/2021 (10 months)				
	Outage Requests	Approved and Rescheduled	Approved and Rescheduled	Approved and Cancelled	Approved and Cancelled	Outage Requests	Approved and Rescheduled	Approved and Rescheduled	Approved and Cancelled	Approved and Cancelled
<=5	16,609	3,879	23.4%	2,163	13.0%	12,765	2,821	22.1%	1,758	13.8%
>5 <=30	3,077	1,826	59.3%	188	6.1%	2,383	1,302	54.6%	152	6.4%
>30	1,676	1,095	65.3%	81	4.8%	1,394	793	56.9%	68	4.9%
Total	21,362	6,800	31.8%	2,432	11.4%	16,542	4,916	29.7%	1,978	12.0%

If a requested outage is determined to be late and TO reschedules the outage, the outage will be reevaluated by PJM again as On Time or Late.

A transmission outage ticket with duration of five days or less with an On Time status can retain its On Time status if the outage is rescheduled within the original scheduled month.⁸⁷ This rule allows a TO to reschedule within the same month with very little notice.

A transmission outage ticket with a duration exceeding five days with an On Time status can retain its On Time status if the outage is rescheduled to a future month, and the revision is submitted by the first of the month prior to the revised month in which the outage will occur.⁸⁸ This rescheduling rule is much less strict than the rule that applies to the first submission of outage requests with similar duration. When first submitted, the outage request with a duration exceeding five days needs to be submitted before the first of the month six months prior to the month in which the outage was expected to occur. The rescheduling rule allows TOs to avoid the timing requirements associated with outages exceeding five days.

The MMU recommends that PJM reevaluate all transmission outage tickets as On Time or Late as if they were new requests when an outage is rescheduled and apply the standard rules for late submissions to any such outages.

⁸⁷ PJM, "Manual 3: Transmission Operations," Rev. 58 (Nov. 19, 2020).

⁸⁸ *Id.*

Long Duration Transmission Facility Outage Requests

PJM rules (Table 12-51) define a transmission outage request as On Time or Late based on the planned outage duration and the time of submission. The rule has stricter submission requirements for transmission outage requests planned for longer than 30 days. In order to avoid the stricter submission requirement, some transmission owners divided the duration of outage requests longer than 30 days into shorter segments for the same equipment and submitted one request for each segment. The MMU recommends that PJM not permit transmission owners to divide long duration outages into smaller segments to avoid complying with the requirements for long duration outages.

More than one outage request can be submitted for the same transmission equipment. In order to accurately present the results, Table 12-58 shows equipment outages by the equipment instead of by outage request.

Table 12-58 shows that there were 10,728 transmission equipment planned outages in the first 10 months of the 2020/2021 planning period, of which 1,395 or 13.0 percent were longer than 30 days, and of which 169 or 1.6 percent were scheduled longer than 30 days when the duration of all the outage requests are combined for the same equipment.

Table 12-58 Transmission equipment outage summary: June 2019 through March 2021

Planned Duration (Days)	Divided into Shorter Periods	2019/2020 (12 months)		2020/2021 (10 months)	
		Count of Equipment with Planned Outages	Percent of Total	Count of Equipment with Planned Outages	Percent of Total
> 30	No	1,474	11.2%	1,226	11.4%
	Yes	229	1.7%	169	1.6%
<= 30		11,427	87.0%	9,333	87.0%
Total		13,130	100.0%	10,728	100.0%

Table 12-59 shows the details of long duration (> 30 days) outages when combining the duration of the outage requests for the same equipment.⁸⁹ The actual duration of scheduled outages would be longer than 30 days if the

⁸⁹ A transmission facility is modeled as equipment in the EMS model. Equipment has three identifiers: location (B1), voltage level (B2) and equipment name (B3). The types of equipment include, for example, lines, transformers, and capacitors. There can be multiple outage requests associated with the same equipment.

duration of the outage requests was appropriately combined for the same equipment. An effective duration was calculated for each piece of equipment by subtracting the start date of the earliest outage request from the end date of the latest outage request of the equipment. In the first 10 months of the 2020/2021 planning period, within effective duration greater than a month and shorter than two months, there were 24 outages with a combined duration longer than 30 days.

Table 12-59 Transmission equipment outages by effective duration: June 2019 through March 2021

Effective Duration of Outage	2019/2020 (12 months)		2020/2021 (10 months)	
	Count of Equipment with Planned Outages	Percent of Total	Count of Equipment with Planned Outages	Percent of Total
<=31	3	1.3%	2	1.2%
>31 <=62	27	11.8%	24	14.2%
>62 <=93	21	9.2%	20	11.8%
>93	178	77.7%	123	72.8%
Total	229	100.0%	169	100.0%

Transmission Facility Outage Analysis for the FTR Market

Transmission facility outages affect the price and quantity outcomes of FTR Auctions. The purpose of the rules governing outage reporting is to ensure that outages are known with enough lead time prior to FTR Auctions so that market participants can understand market conditions and PJM can accurately model market conditions.

There are Long Term, Annual and Monthly Balance of Planning Period auctions in the FTR Market. For each type of auction, PJM includes a set of outages to be modeled.

Annual FTR Market

The Annual FTR Market includes the Annual ARR Allocation and the Annual FTR Auction. When determining transmission outages to be modeled in the simultaneous feasibility test used in the Annual FTR Market, PJM considers

all outages with planned duration longer than or equal to two weeks as an initial list. Then PJM may exercise significant discretion in selecting outages to be modeled in the final model. PJM posts the final FTR outage list to the FTR web page usually at least one week before the auction bidding opening day.⁹⁰

In the first 10 months of the 2020/2021 planning period, 310 outage requests were included in the annual FTR market outage list and 16,232 outage requests were not included.⁹¹ In the 2019/2020 planning period, 289 outage requests were included in the annual FTR market outage list and 21,073 outage requests were not included. Table 12-60, Table 12-61, Table 12-62 and Table 12-63 show the summary information on the modeled outage requests and Table 12-64 and Table 12-65 show the summary information on outages that were not included in the Annual FTR Market.

Table 12-60 shows that 27.2 percent of the outage requests modeled in the Annual FTR Market for the first 10 months of the 2020/2021 planning period had a planned duration of less than two weeks and that 16.1 percent of the outage requests (50 out of 310) modeled in the Annual FTR Market for the planning period were submitted late according to outage submission rules. It also shows that 15.2 percent of the outage requests modeled in the Annual FTR Market for the 2019/2020 planning period had a planned duration of less than two weeks and that 17.0 percent of the outage requests (49 out of 289) modeled in the Annual FTR Market for the planning period were submitted late according to outage submission rules.

Table 12-60 Annual FTR market modeled transmission facility outage requests by received status: June 2019 through March 2021

Planned Duration	2019/2020 (12 months)				2020/2021 (10 months)			
	On Time	Late	Total	Percent of Total	On Time	Late	Total	Percent of Total
<2 weeks	35	9	44	15.2%	75	11	86	27.7%
>=2 weeks & <2 months	84	10	94	32.5%	80	13	93	30.0%
>=2 months	121	30	151	52.2%	105	26	131	42.3%
Total	240	49	289	100.0%	260	50	310	100.0%

⁹⁰ PJM Financial Transmission Rights, "Annual ARR Allocation and FTR Auction Transmission Outage Modeling," <<https://www.pjm.com/-/media/markets-ops/ftr/annual-ftr-auction/2018-2019/2018-2019-annual-outage-modeling.aspx?la=en>> (April 5, 2018). There is no documentation on the deadline for when modeling outages should be posted on the PJM website.

⁹¹ PJM's treatment of transmission outages in the FTR models is discussed in the 2020 State of the Market Report for PJM: Section 13: FTRs and ARRs: Supply and Demand.

Table 12-61 shows the annual FTR market modeled outage requests summary by emergency status and received status. Two of the annual FTR market modeled outages expected to occur in the first 10 months of the 2020/2021 planning period were emergency outages. Two of the modeled outages expected to occur in the 2019/2020 planning period were emergency outages.

Table 12-61 Annual FTR market modeled transmission facility outage requests by emergency and received status: June 2019 through March 2021

Received Status	Planned Duration	2019/2020 (12 months)				2020/2021 (10 months)			
		Emergency	Non Emergency	Total	Percent Non Emergency	Emergency	Non Emergency	Total	Percent Non Emergency
On Time	<2 weeks	0	35	35	100.0%	0	75	75	100.0%
	>=2 weeks & <2 months	0	84	84	100.0%	0	80	80	100.0%
	>=2 months	0	121	121	100.0%	0	105	105	100.0%
	Total	0	240	240	100.0%	0	260	260	100.0%
Late	<2 weeks	0	9	9	100.0%	2	9	11	81.8%
	>=2 weeks & <2 months	0	10	10	100.0%	0	13	13	100.0%
	>=2 months	2	28	30	93.3%	0	26	26	100.0%
	Total	2	47	49	95.9%	2	48	50	96.0%

PJM determines expected congestion for both On Time and Late outage requests. A Late outage request may be denied or cancelled if it is expected to cause congestion. Table 12-62 shows a summary of requests by expected congestion and received status. Of all the annual FTR market modeled outages expected to occur in the first 10 months of the 2020/2021 planning period and submitted late, 8.0 (4 out of 50) was expected to cause congestion. Overall, of all the annual FTR market modeled outages expected to occur in the 2019/2020 planning period and submitted late, 10.2 percent (5 out of 49) were expected to cause congestion.

Table 12-62 Annual FTR market modeled transmission facility outage requests by congestion and received status: June 2019 through March 2021

Received Status	Planned Duration	2019/2020 (12 months)				2020/2021 (10 months)			
		Congestion Expected	No Congestion Expected	Total	Percent Congestion Expected	Congestion Expected	No Congestion Expected	Total	Percent Congestion Expected
On Time	<2 weeks	11	24	35	31.4%	18	57	75	24.0%
	>=2 weeks & <2 months	24	60	84	28.6%	16	64	80	20.0%
	>=2 months	23	98	121	19.0%	19	86	105	18.1%
	Total	58	182	240	24.2%	53	207	260	20.4%
Late	<2 weeks	2	7	9	22.2%	2	9	11	18.2%
	>=2 weeks & <2 months	2	8	10	20.0%	1	12	13	7.7%
	>=2 months	1	29	30	3.3%	1	25	26	3.8%
	Total	5	44	49	10.2%	4	46	50	8.0%

Table 12-63 shows that 22.6 percent of outage requests modeled in the annual FTR market for the first 10 months of the 2020/2021 planning period and with a duration of two weeks or longer but shorter than two months were cancelled after the FTR auction was open, compared to 28.7 percent for the 2019/2020 planning period. Table 12-63 also shows that 17.6 percent of outages requests modeled in the Annual FTR Market for the first 10 months of the 2020/2021 planning period and with a duration of two months or longer were cancelled, compared to 22.5 percent for the 2019/2020 planning period.

Table 12-63 Annual FTR market modeled transmission facility outage requests by processed status: June 2019 through March 2021

Planned Duration	Processed Status	2019/2020 (12 months)		2020/2021 (10 months)	
		2019/2020	Percent	Outage Requests	Percent
<2 weeks	In Progress	7	15.9%	5	5.8%
	Denied	0	0.0%	1	1.2%
	Approved	0	0.0%	1	1.2%
	Cancelled	7	15.9%	26	30.2%
	Active	0	0.0%	0	0.0%
	Completed	30	68.2%	53	61.6%
	Total	44	100.0%	86	100.0%
>=2 weeks & <2 months	In Progress	15	16.0%	10	10.8%
	Denied	0	0.0%	0	0.0%
	Approved	0	0.0%	1	1.1%
	Cancelled	27	28.7%	21	22.6%
	Active	0	0.0%	1	1.1%
	Completed	52	55.3%	60	64.5%
	Total	94	100.0%	93	100.0%
>=2 months	In Progress	24	15.9%	17	13.0%
	Denied	0	0.0%	2	1.5%
	Approved	0	0.0%	1	0.8%
	Cancelled	34	22.5%	23	17.6%
	Active	4	2.6%	31	23.7%
	Completed	89	58.9%	57	43.5%
	Total	151	100.0%	131	100.0%
Total Cancelled		68	23.5%	70	22.6%
Grand Total		289		310	

More outage requests were not modeled in the Annual FTR Market than were modeled in the Annual FTR Market. In the first 10 months of the 2020/2021 planning period, 310 outage requests were modeled and 16,232 outage requests were not modeled in the Annual FTR Market. In the 2019/2020 planning period, 289 outage requests were modeled and 21,073 outage requests were not modeled in the Annual FTR Market.

Table 12-64 shows that 6.6 percent of outage requests not modeled in the Annual FTR Auction with duration longer than or equal to two months, labeled On Time according to the rules, were submitted or rescheduled after the Annual FTR Auction bidding opening date for the first 10 months of the 2020/2021 planning period compared to 15.3 percent in the 2019/2020 planning period.

Table 12-64 Transmission facility outage requests not modeled in Annual FTR Auction: June 2019 through March 2021

Planned Duration	2019/2020 (12 months)						2020/2021 (10 months)					
	On Time			Late			On Time			Late		
	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After
<2 weeks	1,684	8,696	83.8%	238	7,660	97.0%	1,902	6,257	76.7%	210	5,580	96.4%
>=2 weeks & <2 months	618	413	40.1%	150	823	84.6%	659	187	22.1%	132	649	83.1%
>=2 months	188	34	15.3%	221	348	61.2%	199	14	6.6%	185	258	58.2%
Total	2,490	9,143	78.6%	609	8,831	93.5%	2,760	6,458	70.1%	527	6,487	92.5%

Table 12-65 shows that 81.8 percent of late outage requests which were not modeled in the Annual FTR Auction with duration longer than or equal to two months and submitted after the Annual FTR Auction bidding opening date were approved and completed in the first 10 months of the 2020/2021 planning period. It also shows that 85.7 percent of late outage requests which were not modeled in the Annual FTR Auction with duration longer than or equal to two months and submitted after the Annual FTR Auction bidding opening date were approved and completed in the 2019/2020 planning period.

Table 12-65 Late transmission facility outage requests: June 2019 through March 2021

Planned Duration	2019/2020 (12 months)			2020/2021 (10 months)		
	Completed Outages	Total	Percent Complete	Completed Outages	Total	Percent Complete
<2 weeks	6,593	7,660	86.1%	4,794	5,580	85.9%
>=2 weeks & <2 months	705	823	85.7%	531	649	81.8%
>=2 months	301	348	86.5%	152	258	58.9%
Total	7,599	8,831	86.0%	5,477	6,487	84.4%

Although the definition of late outages was developed in order to prevent outages for the planning period being submitted after the opening of bidding in the Annual FTR Auction, the rules have not functioned effectively because the rule has no direct connection to the date on which bidding opens for the Annual FTR Auction. By requiring all long-duration transmission outages to be submitted before February 1, PJM outage submission rules only prevent long-duration transmission outages from being submitted late. The rule does not

address the situation in which long-duration transmission outages are submitted on time, but are rescheduled so that they are late. There is no rule to address the situation in which short-duration outages (duration <= 5 days) are submitted on time, but are changed to long-duration transmission outages after the outages are approved and active. The Annual FTR Auction model may consider transmission outages planned for longer than two weeks but less than two months. Those outages not

only include long duration outages but also include outages shorter than 30 days. In those cases, PJM outage submission rules failed to prevent those transmission outages from being submitted late. The MMU recommends that PJM modify the rules to eliminate the approval of outage requests submitted or rescheduled after the opening of bidding in the Annual FTR Auction.

Monthly FTR Market

When determining transmission outages to be modeled in the Monthly Balance of Planning Period FTR Auction, PJM considers all outages with planned duration longer than five days and may consider outages with planned durations less than or equal to five days. PJM exercises significant discretion in selecting outages to be modeled. PJM posts an FTR outage list to the FTR webpage usually at least one week before the auction bidding opening day.⁹² Table 12-66 and Table 12-67 show the summary information on outage requests modeled in the Monthly Balance of Planning Period FTR Auction and Table 12-68 and Table 12-69 show the summary information on outage requests not modeled in the Monthly Balance of Planning Period FTR Auction.

Table 12-66 shows that on average, 30.0 percent of the outage requests modeled in the Monthly Balance of Planning Period FTR Auction were submitted late according to outage submission rules in the first 10 months of the 2020/2021

⁹² PJM Financial Transmission Rights, "2015/2016 Monthly FTR Auction Transmission Outage Modeling," <<http://www.pjm.com/-/media/markets-ops/fttr-allocation/monthly-fttr-auctions/2015-2016-monthly-transmission-outages-that-may-cause-infeasibilities.ashx?la=en>> (December 9, 2015).

planning period. On average, 32.4 percent of the outage requests modeled in the Monthly Balance of Planning Period FTR Auction were submitted late according to outage submission rules in the 2019/2020 planning period.

Table 12-66 Monthly Balance of Planning Period FTR Auction modeled transmission facility outage requests by received status: June 2019 through March 2021

Month	2019/2020			2020/2021				
	On Time	Late	Total	Percent Late	On Time	Late	Total	Percent Late
Jun	162	115	277	41.5%	215	101	316	32.0%
Jul	92	96	188	51.1%	96	71	167	42.5%
Aug	131	86	217	39.6%	118	81	199	40.7%
Sep	379	147	526	27.9%	468	140	608	23.0%
Oct	533	183	716	25.6%	596	176	772	22.8%
Nov	431	163	594	27.4%	486	185	671	27.6%
Dec	311	146	457	31.9%	324	130	454	28.6%
Jan	189	86	275	31.3%	224	64	288	22.2%
Feb	223	93	316	29.4%	211	116	327	35.5%
Mar	428	141	569	24.8%	429	142	571	24.9%
Apr	461	181	642	28.2%				
May	391	167	558	29.9%				
Average	311	134	445	32.4%	317	121	437	30.0%

Table 12-67 shows that on average, 17.3 percent of outage requests modeled in the Monthly Balance of Planning Period FTR Auction were cancelled in the first 10 months of the 2020/2021 planning period. On average, 19.7 percent of outage requests modeled in the Monthly Balance of Planning Period FTR Auction were cancelled in the 2019/2020 planning period.

Table 12-67 Monthly Balance of Planning Period FTR Auction modeled transmission facility outage requests by processed status: June 2019 through March 2021

Planning Year	Month	In Process	Denied	Approved	Cancelled	Revised	Active	Complete	Total	Percent Cancelled
2019/2020	Jun	17	2	2	47	0	82	127	277	17.0%
	Jul	13	4	0	45	0	72	54	188	23.9%
	Aug	14	5	0	37	0	79	82	217	17.1%
	Sep	58	2	25	93	0	178	170	526	17.7%
	Oct	65	2	13	131	1	200	304	716	18.3%
	Nov	30	1	11	120	0	173	259	594	20.2%
	Dec	27	4	8	86	1	74	257	457	18.8%
	Jan	21	0	9	52	0	95	98	275	18.9%
	Feb	37	0	8	51	0	111	109	316	16.1%
	Mar	55	0	13	130	0	160	211	569	22.8%
	Apr	54	0	12	148	0	177	251	642	23.1%
	May	26	2	10	111	1	126	282	558	19.9%
	Avg	35	2	9	88	0	127	184	445	19.7%
2020/2021	Jun	27	5	7	48	1	75	153	316	15.2%
	Jul	9	16	4	22	0	73	43	167	13.2%
	Aug	22	2	4	26	0	71	74	199	13.1%
	Sep	65	0	19	114	0	195	215	608	18.8%
	Oct	67	4	17	161	2	208	313	772	20.9%
	Nov	52	1	42	151	0	160	265	671	22.5%
	Dec	31	1	7	97	0	75	243	454	21.4%
	Jan	39	1	6	46	0	79	117	288	16.0%
	Feb	36	0	11	52	0	115	113	327	15.9%
	Mar	73	0	11	92	0	175	220	571	16.1%
	Avg	42	3	13	81	0	123	176	437	17.3%

Table 12-68 shows that on average, 9.4 percent of outage requests not modeled in the Monthly Balance of Planning Period FTR Auction, labeled On Time according to the rules, were submitted after the monthly FTR auction bidding opening dates in the first 10 months of the 2020/2021 planning period, compared to 9.1 percent in the 2019/2020 planning period. On average, 66.1 percent of outage requests not modeled in the Monthly Balance of Planning Period FTR Auction, labeled Late according to the rules, were submitted after the Monthly Balance of Planning Period FTR Auction bidding opening dates in the first 10 months of the 2020/2021 planning period, compared to 66.1 percent in the 2019/2020 planning period.

Table 12-68 Transmission facility outage requests that are not modeled in Monthly Balance of Planning Period FTR Auction: June 2019 through March 2021

	2019/2020						2020/2021					
	On Time			Late			On Time			Late		
	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After	Before Bidding Opening Date	After Bidding Opening Date	Percent After
Jun	673	86	11.3%	347	694	66.7%	799	104	11.5%	332	791	70.4%
Jul	391	64	14.1%	268	729	73.1%	430	90	17.3%	271	605	69.1%
Aug	357	44	11.0%	300	640	68.1%	438	74	14.5%	262	617	70.2%
Sep	894	124	12.2%	318	661	67.5%	1,062	86	7.5%	273	640	70.1%
Oct	1,110	120	9.8%	388	929	70.5%	1,192	70	5.5%	363	616	62.9%
Nov	1,000	63	5.9%	457	659	59.1%	964	71	6.9%	354	580	62.1%
Dec	737	63	7.9%	328	636	66.0%	739	67	8.3%	390	587	60.1%
Jan	580	37	6.0%	292	572	66.2%	606	73	10.8%	277	455	62.2%
Feb	645	51	7.3%	280	603	68.3%	593	47	7.3%	278	572	67.3%
Mar	1,318	98	6.9%	333	702	67.8%	1,365	62	4.3%	309	623	66.8%
Apr	1,502	178	10.6%	448	693	60.7%						
May	1,267	87	6.4%	484	702	59.2%						
Avg	873	85	9.1%	354	685	66.1%	819	74	9.4%	311	609	66.1%

Table 12-69 shows that on average, 70.9 percent of late outage requests which were not modeled in the Monthly Balance of Planning Period FTR Auction, submitted after the Monthly Balance of Planning Period FTR Auction bidding opening dates, were approved and complete in the first 10 months of the 2020/2021 planning period, compared to 71.8 percent in the 2019/2020 planning period.

Table 12-69 Late transmission facility outage requests: June 2019 through March 2021

	2019/2020			2020/2021		
	Completed Outages	Total	Percent Complete	Completed Outages	Total	Percent Complete
Jun	528	694	76.1%	574	791	72.6%
Jul	489	729	67.1%	436	605	72.1%
Aug	500	640	78.1%	447	617	72.4%
Sep	455	661	68.8%	436	640	68.1%
Oct	616	929	66.3%	419	616	68.0%
Nov	472	659	71.6%	392	580	67.6%
Dec	469	636	73.7%	440	587	75.0%
Jan	441	572	77.1%	341	455	74.9%
Feb	475	603	78.8%	390	572	68.2%
Mar	461	702	65.7%	440	623	70.6%
Apr	480	693	69.3%			
May	518	702	73.8%			
Avg	492	685	71.8%	432	609	70.9%

Transmission Facility Outage Analysis in the Day-Ahead Energy Market

Transmission facility outages also affect the energy market. Just as with the FTR market, it is critical that outages that affect the operating day are known prior to the submission of offers in the day-ahead energy market so that market participants can understand market conditions and PJM can accurately model market conditions in the day-ahead market. PJM requires transmission owners to submit changes to outages scheduled for the next two days no later than 09:30 am.⁹³

There are three relevant time periods for the analysis of the impact of transmission outages on the energy market: before the day-ahead market is

closed; when the day-ahead market save cases are created; and during the operating day. The list of approved or active outage requests before the day-ahead market is closed is available to market participants. The day-ahead market model uses outages included in the day-ahead market save cases as an input. The outages that actually occurred during the operating day are the outages that affect the real-time market. If the three sets of outages are the same, there is no potential impact on markets. If the three sets of outages differ, there is a potential negative impact on markets. For example, if the list of outages before the day-ahead market was closed was different from the list of outages that included in the day-ahead market save cases, the day-ahead market participant would have inconsistent outage information as what day-ahead market model used.

For example for the operating day of May 5, 2018, Figure 12-6 shows that: there were 443 approved or active outages seen by market participants before the day-ahead market was closed; there were 329 outage requests included in the day-ahead market model; there were 315 outage requests included in both sets of outage; there were 128 outage requests approved or active before the day-ahead market was closed but not included as inputs in day-ahead market model; and there were 14 outage requests included in day-ahead market model but not available to market participants prior to the day-ahead market.

⁹³ PJM, "Manual 3: Transmission Operations," Rev. 58 (Jan. 19, 2020).

Figure 12-6 Illustration of day-ahead market analysis: May 5, 2018

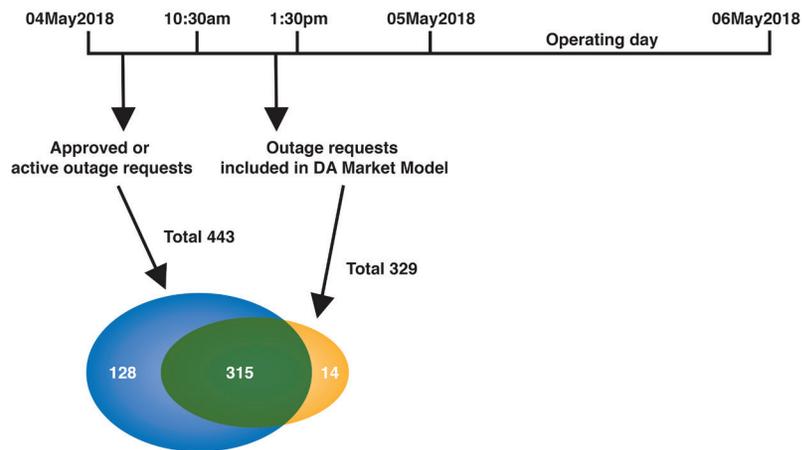


Figure 12-7 compares the weekly average number of active or approved outages available to market participants prior to the close of the day-ahead market with the outages included as inputs to the day-ahead market by PJM.

Figure 12-7 Approved or active outage requests: January 2015 through March 2021

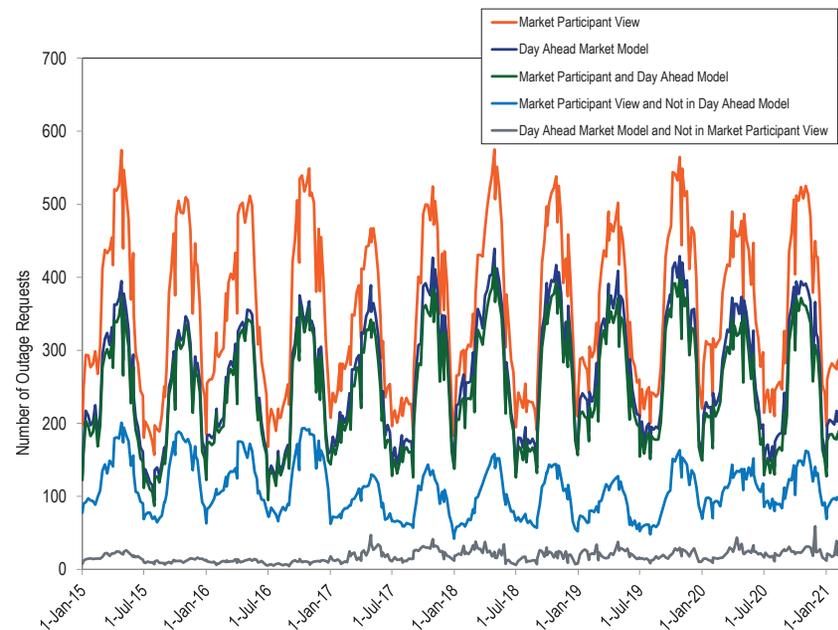


Figure 12-8 compares the weekly average number of outages included as inputs to the day-ahead market by PJM with the outages that actually occurred during the operating day.

Figure 12-8 Day-ahead market model outages: January 2015 through March 2021

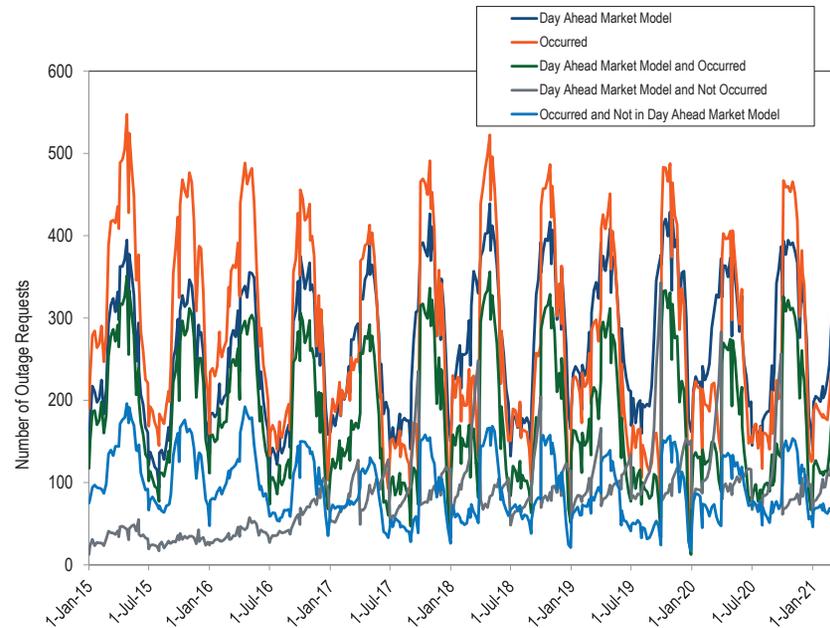


Figure 12-9 compares the weekly average number of active or approved outages available to market participants prior to the close of the day-ahead market with the outages that actually occurred during the operating day.

Figure 12-9 Approved or active outage requests: January 2015 through March 2021

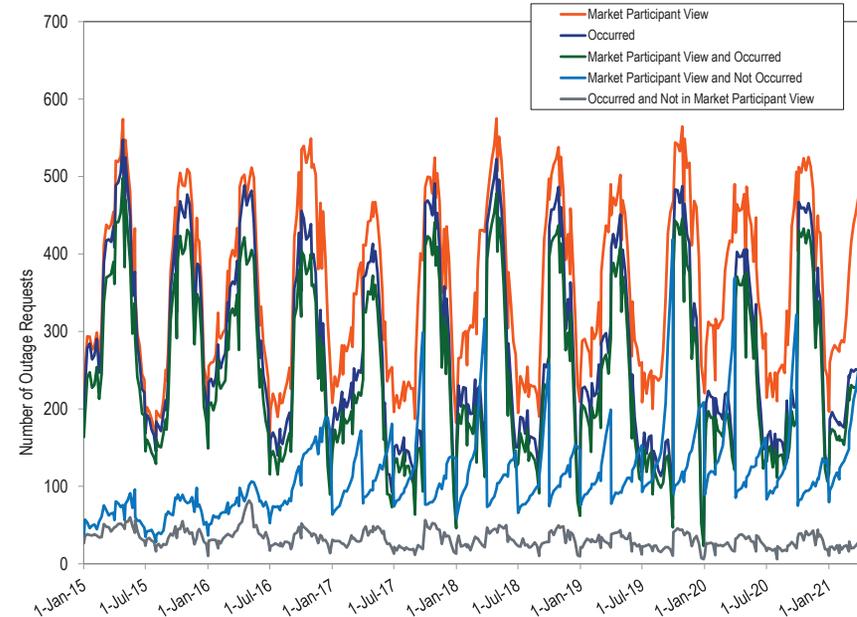


Figure 12-7, Figure 12-8, and Figure 12-9 show that on a weekly average basis, the active or approved outages available to day-ahead market participants, the outages included as inputs in the day-ahead market model and the outages that actually occurred in real time are not consistent. The active or approved outages available to day-ahead market participants are more consistent with the outages that actually occurred in real time than with the outages included in the day-ahead market model.

Financial Transmission and Auction Revenue Rights

In an LMP market, the lowest cost generation is dispatched to meet the load, but when there are transmission constraints, load pays the high local price for all generation, including the low cost generation serving part of that load. The low cost generation receives payment only for its low local price and does not receive the payment made by load for the output of the low cost generation at the high local price. The result is that load pays the correct local price but pays too much in total for energy because it is paying more for the low cost generation than the low cost generation receives. Load pays the difference between the high local price and the low local price of the low cost generation. That payment is appropriately not made to the low cost generation which is paid its LMP. In an LMP market, load pays more than generation receives. FTRs are the mechanism for returning those excess payments to load. But the current FTR mechanism in PJM does not and cannot return all the excess payments to load. The FTR mechanism in PJM needs a significant redesign in order to achieve that objective. The FTR mechanism has become unduly complicated and has deviated significantly from its original purpose. Return of all the excess payments to load would result in a perfect hedge against congestion. The current FTR mechanism has significantly attenuated the value of the FTR/ARR design as a hedge against congestion for load.

The FTR mechanism should be a simple accounting method for assigning congestion rights to load. But PJM has had to add increasingly complex rules and regularly intervene in the FTR mechanism because the PJM FTR design has moved further and further from these economic fundamentals. Some market participants have profited in various ways from these design flaws and those market participants now strongly defend the current design.

When the lowest cost generation is remote from load centers, the physical transmission system permits that lowest cost generation to be delivered to load, subject to transmission limits. This was true prior to the introduction of LMP markets and continues to be true in LMP markets. Prior to the introduction of LMP markets, payment for the delivery of low cost generation to load was

based both on intrazonal generation and intrazonal transmission, both under cost of service rates, and on contracts with specific remote generation outside the local zone and the associated point to point transmission contracts. In both cases, customers paid for the physical rights associated with the transmission system used to provide for the delivery of low cost generation to load. There was no congestion revenue because customers paid only the actual cost of the low cost generation. Most generation was intrazonal and the transmission system used to deliver the related energy to intrazonal load was also intrazonal.

After the introduction of LMP markets, financial transmission rights (FTRs) were introduced, effective April 1, 1999, for the real-time market and June 1, 2000, for the combined day-ahead and balancing (real-time) markets. FTRs permitted the loads, which pay for the transmission system, to continue to receive the benefits of access to either local or remote low cost generation by returning congestion to the load.¹ FTRs and the associated congestion revenues were directly provided to load in recognition of the fact that, as a result of LMP, load was required to pay more for low cost generation than is paid to low cost generation. But there was a flaw built in from the very beginning of the FTR design that had no significant impact initially but which was ultimately the source of all the issues with the FTR mechanism. That flaw was the idea that congestion was based on contract paths in a network system rather than a result of the actual operation of the complex network. The flaw was especially ironic given that most load was served by intrazonal generation subject to cost of service regulation rather than contracts with extrazonal generation. That flaw was inconsistent with the most basic logic of LMP and the resultant fissure has continued to widen. The origin of FTRs was the recognition that the way to hold load harmless from making the excess payments created by the LMP system was to return the excess payments to load. The rights to congestion belong to load. If implemented correctly, FTRs would be the financial equivalent of firm transmission service for load. If implemented correctly, FTRs would be a perfect hedge against congestion for load. The result of the current FTR mechanism is a significant reduction in the value of FTRs as a hedge for load.

¹ See 81 FERC ¶ 61,257 at 62,241 (1997).

The notion that FTRs exist in order to provide a hedge for generation is a fallacy. In an LMP system, the basic incentive structure for generation derives from the fact that generation is paid the LMP at the generator bus. If generation were to be guaranteed a price at a distant constrained load bus rather than at the generation bus, there would be no incentive for generation to locate where it is needed on the system. In addition, the payment of the price at the generator bus is fundamental to the logic of locational marginal pricing which produces local prices equal to the marginal value of generation at every point. There is no logical or theoretical basis in locational marginal pricing for the assertion that generation at low price nodes is underpaid and should be paid more from congestion dollars. Generation does not pay congestion. Some generation receives a price lower than the system marginal price (SMP) and some generation receives a price greater than SMP but that does not mean that generation is paying congestion. It means that generation is being paid an LMP that is higher or lower than the system load-weighted average LMP. If a generating unit wants a hedge, it may enter into an arm's length transaction with a willing counter party as a hedge. That is the way hedges work in markets. That is not the purpose of FTRs.

In an LMP system, the only way to ensure that load receives the benefits associated with the use of the transmission system to deliver low cost energy is to use FTRs, or an equivalent mechanism, to pay back to load the difference between the total load payments and the total generation revenues. FTRs were the mechanism selected in PJM to offset the congestion costs that load pays in an LMP market. Congestion revenues are the source of the funds to pay FTRs. Congestion revenues are assigned to the load that paid them through FTRs.² The only way to ensure that load receives the benefits associated with the use of the transmission system to deliver low cost energy is to ensure that all congestion revenues are returned to load or, more precisely, that the rights to all congestion revenues are assigned to load. In order to do that, congestion must be defined correctly based on the operation of the network and not on arbitrary contract paths.

² See *id.* at 62, 259–62, 260 & n. 123.

Effective April 1, 1999, when FTRs were introduced with the LMP market, there was a real-time market but no day-ahead market, and FTRs returned real-time congestion revenue to load. Effective June 1, 2000, the day-ahead market was introduced and FTRs returned total congestion including day-ahead and balancing (real-time) congestion to load. Congestion, in PJM's two settlement market, is the sum of day ahead and balancing congestion. Effective June 1, 2003, PJM replaced the direct allocation of FTRs to load with an allocation of Auction Revenue Rights (ARRs). Under the ARR construct, the load still owns the rights to congestion revenue, but the ARR construct allows load to either claim the FTRs directly (through a process called self scheduling), or to sell the rights to congestion revenue in the FTR auction in exchange for a revenue stream based on the auction clearing prices of the FTRs. Under the ARR construct, the right to all congestion revenues should belong to load. All congestion surplus should be assigned to load. But the actual implementation produces a very different result.

ARRs were an add on concept, defined based on a misunderstanding of FTRs, which had its roots in the assignment of congestion to load using contract paths (generation to load paths) rather than on the calculation of congestion actually paid. ARRs used assumed contract paths to assign congestion to load. The use of contract paths for ARRs was a more critical mistake than using contract paths for FTRs because contract paths did not and do not account for all congestion. The use of contract paths led to the mistaken conclusion that some congestion did not belong to load and could be sold to FTR buyers. The ARR concept, as it is currently implemented, does not allow the FTR sellers, load, to establish a price at which they are willing to sell, but forces load to accept whatever prices buyers are willing to pay. The revenue from the sale of congestion rights is not even paid in full to ARR holders. Sellers are required to return some of the cleared auction revenue to FTR buyers when FTR profits are not adequate. So called surplus revenue is paid to FTR holders to ensure payment despite the fact that willing FTR buyers paid the revenues in the auction for the rights to an uncertain level of congestion.

The use of generation to load contract paths rather than the direct calculation of congestion led to an increased divergence between the congestion on

the generation to load contract paths and total congestion. This divergence between actual network use and historic contract paths was exacerbated as new zones were added with their own historic generation to load contract paths and as significant numbers of generating units retired and new units were added.³ Rather than understanding that the divergence resulted from the fact that a contract path based approach did not correctly calculate congestion in a network system, especially as the system grew significantly, the issue was characterized as the existence of excess capacity on the transmission system. But congestion was never about capacity on the transmission system. Prior to the introduction of ARRs, the so called excess congestion that exceeded the congestion on the defined contract paths was returned to load, regardless of its source. There is no such thing as excess congestion. The overlay of ARRs on the FTR concept did not change the fundamental logic of congestion, but permitted the introduction of a system in which the divergence was formally created between the amount of congestion paid by load and the amount of congestion returned to load. Congestion belongs to the load, by definition. The introduction of ARRs based on a contract path fiction undermined the assignment of all congestion rights to load.

The contract path fiction is also the source of the incorrect definition of the product that is bought and sold as FTRs, the available supply of the product and the price paid to the buyers of the product. The product is defined as the difference in congestion prices across specific transmission contract paths. The difference in congestion prices across contract paths is not congestion and is not equal to congestion revenues. The quantity of the product made available for sale in the FTR auctions is defined as system capability, meaning the capacity of the transmission system to deliver power. But system capability is not congestion and system capability is not the difference in congestion prices across transmission contract paths nor the potential for such difference. The definition of ARRs based on contract paths led to the mistaken idea that some transmission system capacity was used by ARRs but some was not and that both the ARR capability and the excess capacity was available for sale as FTRs. This fundamental confusion in the design of the market is the source of

³ For a comprehensive report on capacity retirements and capacity additions in PJM, see: "2020 PJM Generation Capacity and Funding Sources: 2007/2008 through 2021/2022," (September 15, 2020) available at <http://www.monitoringanalytics.com/reports/Reports/2020/Constraint_Based_Congestion_Calculations_20200722.pdf>.

so called revenue shortfalls, of the redesign of the market to exclude balancing congestion, and of the need for PJM to intervene in the market. PJM has had to regularly intervene in the market because the market as designed cannot reach equilibrium based on the economic fundamentals. The product, the quantity of the product and the price of the product are all incorrectly defined.

The ARR/FTR design does not serve as an efficient mechanism for returning congestion to load, as a result of an FTR design that was flawed from its introduction and as a result of various distortions added to the design since its introduction. The distortions include the definition of target allocations based on day-ahead congestion only, the fact that ARR holders cannot set the sale price for congestion revenue rights, the return of market revenues to FTR buyers when profit targets are not met, the failure to assign all FTR auction revenues to ARR holders, the differences between modeled and actual system capability, the definition and allocation of surplus, and the numerous cross subsidies among participants. The fundamental distortion was the assignment of the rights to congestion revenue based on specific generation to load transmission contract paths. This approach retained the contract path based view of congestion rooted in physical transmission rights and inconsistent with the role of FTRs in a nodal, network system with locational marginal pricing.

The cumulative offset by ARRs for the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period, using the rules effective for each planning period, was 74.1 percent. Load has been underpaid by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period.

The overall underassignment of congestion to load includes dramatically different results by zone. Load in some zones receives congestion revenues well in excess of the congestion they pay while the reverse is true for other zones.

If the original PJM FTR approach had been designed to return congestion revenues to load without use of the generation to load contract paths, and

if the distortions subsequently introduced into the FTR design had not been added, many of the subsequent issues with the FTR design and complex redesigns would have been avoided. PJM would not have had to repeatedly intervene in the functioning of the FTR system in an effort to meet the artificial and incorrectly defined goal of revenue adequacy. The design should simply have provided for the return of all congestion revenues to load. The design should have also provided for the ability of load to sell the rights to congestion revenue. That sale could be organized as an FTR auction with the product and the price clearly defined. Now is a good time to address the issues of the FTR design and to return the design to its original purpose. This would eliminate much of the complexity associated with ARRs and FTRs and eliminate unnecessary controversy about the appropriate recipients of congestion revenues.

The *2021 Quarterly State of the Market Report for PJM: January through March* focuses on the 2020/2021 Monthly Balance of Planning Period FTR Auctions, specifically covering January 1, 2021, through March 31, 2021.

Table 13–1 The FTR/ARR markets results were partially competitive

Market Element	Evaluation	Market Design
Market Structure	Competitive	
Participant Behavior	Partially Competitive	
Market Performance	Partially Competitive	Flawed

- Market structure was evaluated as competitive. The ownership of FTR obligations is unconcentrated for the individual years of the 2020/2023 Long Term FTR Auction, the 2020/2021 Annual FTR Auction and each period of the Monthly Balance of Planning Period Auctions. The ownership of FTR options is moderately or highly concentrated for every Monthly FTR Auction period and moderately concentrated for the 2020/2021 Annual FTR Auction. Ownership of FTRs is disproportionately (75.4 percent) by financial participants. The ownership of ARRs is unconcentrated.
- Participant behavior was evaluated as partially competitive as a result of the behavior of GreenHat Energy, LLC. ARR holders who are the sellers of FTRs are not permitted to participate in the market clearing.
- Market performance was evaluated as partially competitive because of the flaws in the market design. Sellers, the ARR holders, cannot set a sale price. Buyers can reclaim some of their purchase price after the market clears if the product does not meet a profitability target. The market resulted in a substantial shortfall in congestion payments to load and significant and unsupportable disparities among zones in the share of congestion returned to load. FTR purchases by financial entities remain persistently profitable in part as a result of the flaws in the market design.
- Market design was evaluated as flawed because there are significant and fundamental flaws with the basic ARR/FTR design. The FTR auction market is not actually a market because the sellers have no independent role in the process. ARR holders cannot determine the price at which they are willing to sell rights to congestion revenue. Buyers have the ability to reclaim some of the price paid for FTRs after the market clears. The market design is not an efficient or effective way to ensure that the rights to all congestion revenues are assigned to load. The product sold to FTR buyers is incorrectly defined as target allocations rather than a share of congestion revenue. ARR holders' rights to congestion revenues are not correctly defined because the contract path based assignment of congestion rights is inadequate and incorrect. Ongoing PJM subjective intervention in the FTR market that affects market fundamentals is also an issue and a symptom of the fundamental flaws in the design. The product, the quantity of the product and the price of the product are all incorrectly defined.
- The fact that load is not able to define its willingness to sell FTRs or the prices at which it is willing to sell FTRs and the fact that sellers are required to return some of the cleared auction revenue to FTR buyers when FTR profits are not adequate, means that the FTR design does not actually function as a market and is evidence of basic flaws in the market design.

Overview

Auction Revenue Rights

Market Structure

- **ARR Ownership.** In the 2020/2021 planning period ARRs were allocated to 1,392 individual participants, held by 131 parent companies. ARR ownership for the 2020/2021 planning period was unconcentrated with an HHI of 851.

Market Behavior

- **Self Scheduled FTRs.** For the 2020/2021 planning period, 25.4 percent of eligible ARRs were self scheduled as FTRs.

Market Performance

- **ARRs as an Offset to Congestion.** ARRs have not served as an effective mechanism to return all congestion revenues to load. For the first 10 months of the 2020/2021 planning period, ARRs offset only 45.8 percent of total congestion. Congestion payments by load in some zones were more than offset and congestion payments in some zones were less than offset. Load has been underpaid congestion revenues by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period. The cumulative offset for that period was 74.1 percent of total congestion.
- **Revenue Adequacy.** For the first 10 months of the 2020/2021 planning period, the ARR target allocations, which are based on the nodal price differences from the Annual FTR Auction, were \$514.8 million, while PJM collected \$688.7 million from the combined Long Term, Annual and Monthly Balance of Planning Period FTR Auctions, making ARRs revenue adequate. For the 2019/2020 planning period, the ARR target allocations were \$752.2 million while PJM collected \$982.0 million from the combined Annual and Monthly Balance of Planning Period FTR Auctions.

- **Residual ARRs.** Residual ARRs are only available on contract paths prorated in Stage 1 of the annual ARR allocation, are only effective for single, whole months and cannot be self scheduled. Residual ARR clearing prices are based on monthly FTR auction clearing prices. Residual ARRs with negative target allocations are not allocated to participants. Instead they are removed and the model is rerun.

In the first 10 months of the 2020/2021 planning period, PJM allocated a total of 20,616.0 MW of residual ARRs with a total target allocation of \$9.4 million, down from 22,090.7 MW, with a total target allocation of \$11.1 million, in the first 10 months of the 2019/2020 planning period.

- **ARR Reassignment for Retail Load Switching.** There were 27,387 MW of ARRs associated with \$373,700 of revenue that were reassigned in the first 10 months of the 2020/2021 planning period. There were 29,509 MW of ARRs associated with \$583.6 of revenue that were reassigned for the same time frame of the 2019/2020 planning period.

Financial Transmission Rights

Market Design

- **Monthly Balance of Planning Period FTR Auctions.** The design of the Monthly Balance of Planning Period FTR Auctions was changed effective with the 2020/2021 planning period. The new design includes auctions for each remaining month in the planning period. The prior design included auctions for the next three individual months plus remaining quarters.

Market Structure

- **Patterns of Ownership.** For the Monthly Balance of Planning Period Auctions, financial entities purchased 88.6 percent of prevailing flow and 92.2 percent of counter flow FTRs for January through March, 2021. Financial entities owned 78.4 percent of all prevailing and counter flow FTRs, including 71.5 percent of all prevailing flow FTRs and 85.9 percent of all counter flow FTRs during the period from January through March 2021. Self scheduled FTRs account for 1.9 percent of all FTRs held.

- **Market Concentration.** For prevailing flow obligation FTRs in the Monthly Balance of Planning Period Auctions for the first 10 months of the 2020/2021 planning period, all market periods were unconcentrated. For counter flow obligation FTRs for the first 10 months of the 2020/2021 planning period, two periods were moderately concentrated and all others were unconcentrated. All periods were highly concentrated for FTR options. FTR options in the Annual FTR Auction were moderately concentrated.

Market Behavior

- **Sell Offers.** In a given auction, market participants can sell FTRs acquired in preceding auctions or preceding rounds of auctions. In the Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning period, total participant FTR sell offers were 15,507,661 MW.
- **Buy Bids.** The total FTR buy bids from the Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning period were 33,157,407 MW.
- **FTR Forfeitures.** Total FTR forfeitures were \$4.0 million for the first 10 months of the 2020/2021 planning period.
- **Credit.** There were five collateral defaults in 2021. There were 5 payment defaults in 2021 not involving GreenHat Energy, LLC for a total of \$1.8 million. GreenHat Energy accrued payment defaults of \$1.1 million in 2021 for a total of \$163.0 million in defaults to date, which will continue to accrue through May 2021, including the auction liquidation costs.⁴ In addition, PJM added the settlement fee and claimant payee funds to the default allocation, resulting in allocations of \$12.5 million and \$5.0 million for a total of \$180.5 million.

⁴ See the 2019 Quarterly State of the Market Report for PJM: January through June for a more complete explanation of credit issues that occurred in 2019.

Market Performance

- **Quantity.** In the first 10 months of the 2020/2021 planning period, Monthly Balance of Planning Period FTR Auctions cleared 5,271,196 (15.9 percent) of FTR buy bids and 2,579,029 MW (16.6 percent) of FTR sell offers. For the first 10 months of the 2019/2020 planning period, Monthly Balance of Planning Period FTR Auctions cleared 3,548,585 (19.2 percent) of FTR buy bids and 1,457,284 MW (20.5 percent) of FTR sell offers.
- **Price.** The weighted average buy bid cleared FTR price in the Monthly Balance of Planning Period FTR Auctions for all periods of the first 10 months of the 2020/2021 planning period was \$0.14 per MWh.
- **Revenue.** The Monthly Balance of Planning Period FTR Auctions resulted in net revenue of \$39.0 million in the first 10 months of the 2020/2021 planning period, down from \$51.2 million for the same time period in the 2019/2020 planning period.
- **Revenue Adequacy.** FTRs were paid at 98.8 percent of the target allocation level for the first 10 months of the 2020/2021 planning period, including distribution of the current surplus revenue.
- **Profitability.** FTR profitability is the difference between the revenue received directly from holding an FTR plus any revenue from the sale of an FTR, and the cost of the FTR. In the first 10 months of 2020/2021 planning period, physical entities made \$70.8 million in profits on FTRs purchased directly (not self scheduled), up from \$56.8 million in losses for the same time period in the 2019/2020 planning period and financial entities made \$211.0 million in profits, up from \$9.5 million in losses for the same time period in the 2019/2020 planning period.

Markets Timeline

Any PJM member can participate in the Long Term FTR Auction, the Annual FTR Auction and the Monthly Balance of Planning Period FTR Auctions.

Table 13-2 shows the date of first availability and final closing date for all annual ARR and FTR products.

Table 13-2 Annual FTR product dates

Auction	Initial Open Date	Final Close Date
2021/2024 Long Term	6/2/2020	3/2021
2019/2020 ARR	3/2/2020	4/3/2020
2019/2020 Annual	4/7/2020	5/4/2020

Recommendations

Market Design

ARR

- The MMU recommends that the ARR/FTR design be modified to ensure that the rights to all congestion revenues are assigned to load. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that all historical generation to load paths be eliminated as a basis for assigning ARRs. The MMU recommends that the current design be replaced with a network design in which the rights to actual congestion are assigned directly to load by node. (Priority: High. First reported 2015. Status: Partially adopted.)
- The MMU recommends that, under the current FTR design, the rights to all congestion revenue be allocated as ARRs prior to sale as FTRs. Reductions for outages and increased system capability should be reserved for ARRs rather than sold in the Long Term FTR Auction. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that IARRs be eliminated from PJM's tariff, but that if IARRs are not eliminated, IARRs should be subject to the same proration rules that apply to all other ARR rights. (Priority: Low. First reported 2018. Status: Not adopted.)

FTR

- The MMU recommends that FTR funding be based on total congestion, including day-ahead and balancing congestion. (Priority: High. First reported 2017. Status: Not adopted.)

- The MMU recommends that PJM enforce the FTR auction bid limits at the parent company level starting immediately. (Priority: High. First reported 2020. Status: Adopted 2021.)
- The MMU recommends a requirement that the details of all bilateral FTR transactions be reported to PJM. (Priority: High. First reported 2020. Status: Not adopted.)
- The MMU recommends that PJM continue to evaluate the bilateral indemnification rules and any asymmetries they may create. (Priority: Low. First reported 2018. Status: Not adopted.)
- The MMU recommends that PJM reduce FTR sales on paths with persistent overallocation of FTRs, including a clear definition of persistent overallocation and how the reduction will be applied. (Priority: High. First reported 2013. Status: Partially adopted, 2014/2015 planning period.)
- The MMU recommends that PJM eliminate generation to generation paths and all other paths that do not represent the delivery of power to load. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that the Long Term FTR product be eliminated. If the Long Term FTR product is not eliminated, the Long Term FTR Market should be modified so that the supply of prevailing flow FTRs in the Long Term FTR Market is based solely on counter flow offers in the Long Term FTR Market. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that PJM improve transmission outage modeling in the FTR auction models, including the use of probabilistic outage modeling. (Priority: Low. First reported 2013. Status: Not adopted.)
- The MMU recommends that the forfeiture amount from the FTR forfeiture rule be based on the correct hourly cost of an FTR, rather than a simple daily price divided by 24. (Priority: High. First reported 2018. Status: Adopted 2019.)

Surplus

- The MMU recommends that all FTR auction revenue be distributed to ARR holders monthly, regardless of FTR funding levels. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that, under the current FTR design, all congestion revenue in excess of FTR target allocations be distributed to ARR holders on a monthly basis. (Priority: High. First reported 2018. Status: Not adopted.)
- The MMU recommends that FTR auction revenues not be used by PJM to buy counter flow FTRs for the purpose of improving FTR payout ratios.⁵ (Priority: High. First reported 2015. Status: Not adopted.)

FTR Subsidies

- The MMU recommends that PJM eliminate portfolio netting to eliminate cross subsidies among FTR market participants. (Priority: High. First reported 2012. Status: Not adopted. Rejected by FERC.)
- The MMU recommends that PJM eliminate subsidies to counter flow FTRs by applying the payout ratio to counter flow FTRs in the same way the payout ratio is applied to prevailing flow FTRs. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that PJM eliminate geographic cross subsidies. (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that PJM examine the mechanism by which self scheduled FTRs are allocated when load switching among LSEs occurs throughout the planning period. (Priority: Low. First reported 2011. Status: Not adopted.)

FTR Liquidation

- The MMU recommends that the FTR portfolio of a defaulted member be canceled rather than liquidated or allowed to settle as a default cost on the membership. (Priority: High. First reported 2018. Status: Not adopted.)

⁵ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

Conclusion

Solutions

The annual ARR allocation should be designed to ensure that the rights to all congestion revenues are assigned to load, without requiring contract path physical transmission rights that are inconsistent with the network based delivery of power and the actual way congestion is generated in security constrained LMP markets. When there are binding transmission constraints and locational price differences, load pays more for energy than generation is paid to produce that energy. The difference is congestion. As a result, congestion belongs to load and should be returned to load.

The current contract path based design should be replaced with a network design in which the rights to actual congestion are assigned directly to load by node. The assigned right is to the actual difference between load payments, both day-ahead and balancing, and revenues paid to the generation used to serve that load. The load can retain the right to the network congestion or sell the right through auctions. The correct assignment of congestion revenues to load is fully consistent with retaining FTR auctions for the sale by ARR holders of their congestion revenue rights.

Issues

If the original PJM FTR approach had been designed to return congestion revenues to load without use of the generation to load contract paths, and if the distortions subsequently introduced into the FTR design not been added, many of the subsequent issues with the FTR design and complex redesigns would have been avoided. PJM would not have had to repeatedly intervene in the functioning of the FTR system in an effort to meet the artificial and incorrectly defined goal of revenue adequacy.

PJM has persistently and subjectively intervened in the FTR market in order to affect the payments to FTR holders. These interventions are not appropriate. For example, in the 2014/2015, 2015/2016 and 2016/2017 planning periods, PJM significantly reduced the allocation of ARR capacity, and FTRs, in order

to guarantee full FTR funding. PJM reduced system capability in the FTR auction model by including more outages, reducing line limits and including additional constraints. PJM's modeling changes resulted in significant reductions in Stage 1B and Stage 2 ARR allocations, a corresponding reduction in the available quantity of FTRs, a reduction in congestion revenues assigned to ARRs, and an associated surplus of congestion revenue relative to FTR target allocations. This also resulted in a significant redistribution of ARRs among ARR holders based on differences in allocations between Stage 1A and Stage 1B ARRs. Starting in the 2017/2018 planning period, with the allocation of balancing congestion and M2M payments to load rather than FTRs, PJM increased system capability allocated to Stage 1B and Stage 2 ARRs, but continued to conservatively select outages to manage FTR funding levels.

PJM has intervened aggressively in the FTR market since its inception in order to meet various subjective objectives including so called revenue adequacy. PJM should not intervene in the FTR market to subjectively manage FTR funding. PJM should fix the FTR/ARR design and then should let the market work to return congestion to load and to let FTR values reflect actual congestion.

Load should never be required to subsidize payments to FTR holders, regardless of the reason.⁶ The FERC order of September 15, 2016, introduced a subsidy to FTR holders at the expense of ARR holders.⁷ The order requires PJM to ignore balancing congestion when calculating total congestion dollars available to fund FTRs. As a result, balancing congestion and M2M payments are assigned to load, rather than to FTR holders, as of the 2017/2018 planning period. When combined with the direct assignment of both surplus day-ahead congestion and surplus FTR auction revenues to FTR holders, the Commission's order shifted substantial revenue from load to the holders of FTRs and further reduced the offset to congestion payments by load. This approach ignores the fact that load pays both day-ahead and balancing congestion, and that congestion is defined, in an accounting sense, to equal the sum of day-ahead and balancing congestion. Eliminating balancing congestion from the FTR revenue calculation requires load to pay twice for congestion. Load pays total

⁶ Such subsidies have been suggested repeatedly. See FERC Dockets Nos. EL13-47-000 and EL12-19-000.

⁷ See 156 FERC ¶ 61,180 (2016), *reh'g denied*, 156 FERC ¶ 61,093 (2017).

congestion and pays negative balancing congestion again. The fundamental reasons that there has been a significant and persistent difference between day-ahead and balancing congestion include inadequate transmission modeling in the FTR auction and the role of UTCs in taking advantage of these modeling differences and creating negative balancing congestion. There is no reason to impose these costs on load.

These changes were made in order to increase the payout to holders of FTRs who are not loads. Increasing the payout to FTR holders at the expense of the load is not a supportable market objective. PJM should implement an FTR design that calculates and assigns congestion rights to load rather than continuing to modify the current, fundamentally flawed, design.

Load was made significantly worse off as a result of the changes made to the FTR/ARR process by PJM based on the FERC order of September 15, 2016. ARR revenues were significantly reduced for the 2017/2018 FTR Auction, the first auction under the new rules. ARRs and self scheduled FTRs offset only 49.5 percent of total congestion costs for the 2017/2018 planning period rather than the 58.0 percent offset that would have occurred under the prior rules, a difference of \$101.4 million.

A subsequent rule change was implemented that modified the allocation of surplus auction revenue to load. Beginning with the 2018/2019 planning period, surplus day-ahead congestion and surplus FTR auction revenue are assigned to FTR holders only up total target allocations, and then distributed to ARR holders.⁸ ARR holders will only be allocated this surplus after full funding of FTRs is accomplished. While this rule change increased the level of congestion revenues returned to load, the rules do not fully recognize ARR holders' rights to congestion revenue. With this rule in effect for the first 10 months of the 2020/2021 planning period, ARRs and FTRs offset 45.8 percent of total congestion.

The complex process related to what is termed the overallocation of Stage 1A ARRs are entirely an artificial result of reliance on the contract path model in the assignment of FTRs. For example, there is a reason that transmission is not

⁸ 163 FERC ¶61,165 (2018).

built to address the Stage 1A overallocation issue. The Stage 1A overallocation issue is a fiction based on the use of outdated and irrelevant generation to load contract paths to assign Stage 1A rights that have nothing to do with actual power flows.

Proposed Design

To address the issues with the current contract path based ARR/FTR market design, the MMU recommends that the current design be replaced with a network design in which the rights to actual congestion are assigned directly to load by node. The assigned right would be the actual difference between load payments, both day-ahead and balancing, and revenues paid to the generation used to serve that load. The load could retain the right to the network congestion or sell the right through auctions. The correct assignment of congestion revenues to load is fully consistent with retaining FTR auctions for the sale by ARR holders of their congestion revenue rights.

With a network assignment of actual congestion, there would be no cross subsidies among rights holders and no over or under allocation of rights relative to actual network market solutions. There would be no revenue shortfalls as congestion payments equal congestion collected. The risk of default would be isolated to the buyer and seller of the right, and any default would not be socialized to other right holders. In the case of a defaulting buyer, the rights to the congestion revenues would revert to the load. There would be no risk of a network right flipping in value from positive to negative, because congestion is always the positive difference between what load pays for energy, and generation is paid for energy as a result of transmission constraints.

The MMU proposal requires the calculation of constraint specific congestion and the calculation of that specific constraint's congestion related charges to each physical load bus downstream of that constraint. Under the MMU proposal, the constraint specific congestion calculated by hour, from both the day-ahead and balancing market would be paid directly to the physical load as a credit against the associated load serving entity's (LSE) energy bill. This right to the congestion is defined as the network based financial transmission right (NFTR) to the physical load at a defined bus, zone or aggregate. The LSE

could choose to sell all or a portion of the NFTR and its associated congestion revenue stream through auctions.

An NFTR is the right to actual, realized network related congestion that is collected from a specific bus, zone or aggregate. Under the MMU proposal a bus, zone or aggregate specific NFTR could be sold as a defined share of the actual congestion. For example, an LSE could sell 50 percent of its congestion credit for the planning period to a third party. The third party buyer would then be entitled to 50 percent of the congestion that will be credited to that specific bus, zone or aggregate for the planning period. The remaining 50 percent of the congestion credit for the specified bus, zone or aggregate would be paid to the LSE along with auction clearing price for the 50 percent of NFTR that was sold to the third party. Depending on actual congestion, an LSE selling its congestion revenue rights could be better or worse off than if it retained its rights.

Under the MMU proposal, the LSE would be able to set reservation prices in the auction for the sale of portions or all of its NFTR. Third parties would have an opportunity to bid for the offered portions of the NFTR, and the market for the congestion revenue associated with the specified bus, zone or aggregate would clear at a price. If the reservation price of an identified portion of the offered NFTR was not met at the clearing price, that portion of the offered NFTR would remain with the load. Auctions could be annual and/or monthly.

Auction Revenue Rights

Auction Revenue Rights (ARRs) are the mechanism used to assign congestion rights to load, using an archaic contract path based approach, and sell those rights to FTR buyers in various auctions. ARR values are based on nodal price differences established by cleared FTR bids in the Annual FTR Auction. ARR sellers have no opportunity to define a price at which they are willing to sell and must accept the prices as defined by FTR buyers. ARR revenues are a function of FTR auction participants' expectations of congestion, risk, competition and available supply. But some auction revenues may be returned to FTR buyers, despite the fact that FTR buyers willingly paid a defined

price for FTRs. PJM has significant discretion over the level of supply made available to FTR buyers. The appropriate goals of that discretion should be significantly limited and defined clearly in the tariff.

ARRs are available only as obligations (not options) and only as a 24 hour product. ARRs are available to the nearest 0.1 MW. The ARR target allocation is equal to the product of the ARR MW and the price difference between the ARR sink and source from the Annual FTR Auction.⁹ ARR target allocations are a set value at the time of the Annual FTR Auction. It is logically possible for ARRs to be revenue inadequate if the money collected from the FTR auction is not enough to pay the entirety of ARR target allocations for the planning period. This is extremely unlikely and can only happen if there is a modeling difference between the system model used for ARRs and the system model used for FTRs and the FTR MW are reduced. An ARR's target allocation, or value, which is established from the Annual FTR Auction, can be a benefit or liability depending on the price difference between sink and source.

The goal of the ARR/FTR design should be to provide an efficient mechanism to ensure that load receives the rights to all congestion revenues. In the current design, all auction revenues should be paid to ARR holders.

The quantity of the product made available as ARRs or for sale in the FTR auctions is defined as system capability, meaning the capacity of the transmission system to deliver power. But system capability is not congestion and system capability is not the difference in congestion prices across transmission contract paths nor the potential for such difference. The concept of system capability is not relevant to assigning the rights to congestion revenues to load. The use, or misuse, of the concept of system capability in assigning ARRs is derived entirely from the contract path approach used in the PJM design. The definition of ARRs based on contract paths led to the mistaken idea that some transmission system capacity was used by ARRs but some was not and that both the ARR capability and the excess capacity was available for sale as FTRs. In the current approach, system capability available to ARR holders is limited by the system capability made available in PJM's annual FTR transmission system market model. PJM's annual FTR

⁹ These nodal prices are a function of the market participants' annual FTR bids and binding transmission constraints.

transmission market model represents annual, expected system capability, modified by PJM to achieve PJM's goal of guaranteeing revenue equal to target allocations for FTRs, and subject to the requirement that all Stage 1A ARR requests must be allocated. Stage 1A ARR right requests are guaranteed and system capability necessary to accommodate the rights must be included in PJM's annual FTR transmission system market model.

Market Design

ARRs have been available to network service and firm, point to point transmission service customers since June 1, 2003, when the annual ARR allocation was first implemented for the 2003/2004 planning period. The initial allocation covered the Mid-Atlantic Region and the APS Control Zone. For the 2006/2007 planning period, the choice of ARRs or direct allocation FTRs was available to eligible market participants in the AEP, DAY, DUQ and DOM Control Zones. For the 2007/2008 and subsequent planning periods through the present, all eligible market participants were allocated ARRs.

Each March, PJM allocates annual ARRs to eligible customers in a three stage process: Stage 1A, Stage 1B and Stage 2B. Stage 1A ARRs are assigned based on historic contract paths and Stage 1A ARRs must be preserved for at least ten planning periods regardless of system or regulatory changes.¹⁰

In Stage 1A, LSEs can obtain ARRs, based on their lowest daily peak load in the prior twelve month period, and based on generation to load contract paths that reflect generation resources that had historically served load, or their qualified replacements if the resource has retired and PJM has replaced it. The historical reference year is the year in which PJM markets were implemented, which is 1999 for the original zones, or the year in which a zone joined PJM. Firm, point to point transmission service customers can obtain Stage 1A ARRs, up to 50 percent of the MW of firm, point to point transmission service provided between the receipt and delivery points for the historical reference year, subject to a cap of lowest daily peak load in the prior year. Network service customers can obtain Stage 1A ARRs based on the MW of firm service provided during the reference year, subject to a cap of lowest daily peak load

¹⁰ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan 27, 2021) at 23.

in the prior year. Stage 1A ARR allocations cannot be prorated. If Stage 1A ARR allocations are found to be infeasible, transmission system upgrades must be undertaken to maintain feasibility.¹¹

In Stage 1B, network transmission service customers can obtain ARR allocations based on their share of zonal peak load, based on generation to load contract paths, up to the difference between their share of zonal peak load and Stage 1A allocations. Firm, point to point transmission service customers can obtain ARR allocations based on the MW of long-term, firm, point to point service provided between the receipt and delivery points for the historical reference year.

In Stage 2, network transmission service customers can obtain ARR allocations from any hub, control zone, generator bus or interface pricing point to any part of their aggregate load in the control zone or load aggregation zone up to their total peak network load in that zone. Firm, point to point transmission service customers can obtain ARR allocations consistent with their transmission service as in Stage 1A and Stage 1B.

When ARR holders self schedule FTRs, the ARR holders choose to be paid based on variable target allocations rather than the fixed ARR value determined in the annual FTR auction. ARR holders can self schedule ARR allocations as FTRs during the Annual FTR Auction.¹² ARR allocations can be traded between LSEs prior to the first round of the Annual FTR Auction.

Effective for the 2015/2016 planning period, when residual zonal pricing was introduced, ARR allocations default to sinking at the load settlement point if different than the zone, but the ARR holder may elect to sink their ARR at the zone instead.¹³

In 2016, FERC ordered PJM to remove retired resources from the generation to load contract paths used to allocate Stage 1A ARR allocations.¹⁴ PJM replaced retired units with operating generators, termed qualified replacement resources (QRRs).¹⁵ Existing Stage 1A resources retain their current allocations, while

¹¹ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

¹² OATT Attachment K 7.1.1.(b).

¹³ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021) at 35.

¹⁴ 156 FERC ¶ 61,180 (2016).

¹⁵ See FERC Docket No. EL16-6-003.

ARR allocations to QRRs that replace retired Stage 1A resources are prorated based on the feasibility of these ARR allocations after existing resources are allocated. As a result of this proration, ARR allocations for QRRs have lower priority than ARR allocations from generators that existed in 1998.

Generation to load paths, even from active generators, are based on a contract path model rather than a network model. Generation to load contract paths should not be used as a basis for assigning the rights to congestion revenue. Contract paths are not an accurate representation of the reasons that congestion revenues are paid or of how load is served in a network and will, by definition, not accurately measure the exposure of load to congestion.

Market Structure

ARR allocations are allocated on an annual basis. For the 2020/2021 planning period there were 1,392 individual participants, held by 131 parent companies.

The ownership of ARR allocations was unconcentrated, with an HHI of 851, for the 2020/2021 planning period.

Market Performance

Stage 1A Infeasibility

Stage 1A ARR allocations are allocated for a year, but guaranteed for 10 years, with the ability for a participant to opt out of any planning period within the 10 years. PJM conducts a simultaneous feasibility analysis to determine the transmission upgrades required to ensure that the long term ARR allocations can remain feasible. The rules provide that if a simultaneous feasibility test violation occurs in any year, PJM will identify or accelerate any transmission upgrades to resolve the violation and these upgrades will be recommended for inclusion in the PJM RTEP process. But such transmission upgrades must pass PJM's RTEP process.

PJM's transmission planning process (RTEP) does not identify a need for new transmission associated with Stage 1A overallocations because there is, in fact, no need for new transmission associated with Stage 1A ARR allocations. The

Stage 1A overallocation issue is a fiction based on the use of outdated and irrelevant generation to load contract paths to assign Stage 1A rights that have nothing to do with actual power flows. This continues to be true even with the replacement of retired generating units.

For the 2019/2020 planning period, Stage 1A of the Annual ARR Allocation was infeasible, resulting in an over allocation of ARRs on the affected facilities. As a result, modeled system capability, in excess of actual system capability, was provided to the Stage 1A ARRs and added to the FTR auction. According to Section 7.4.2 (i) of the OATT, the capability limits of the binding constraints rendering these ARRs infeasible must be increased in the model and these increased limits must be used in subsequent ARR and FTR allocations and auctions for the entire planning period, except in the case of extraordinary circumstances.

ARR Reassignment for Retail Load Switching

PJM rules provide that when load switches between LSEs during the planning period, an LSE gaining load in the same control zone is allocated a proportional share of positively valued ARRs and residual ARRs within the control zone based on the shifted load.¹⁶ ARRs are reassigned to the nearest 0.001 MW and may be reassigned multiple times over a planning period. The reassignment of positively valued ARRs supports competition by ensuring that the offset to congestion follows load, thereby removing a barrier to competition among LSEs and, by ensuring that only ARRs with a positive value are reassigned, preventing an LSE from assigning poor ARR choices to other LSEs. However, when ARRs are self scheduled as FTRs, the self scheduled FTRs do not follow load that shifts while the ARRs do follow load that shifts, and this may result in lower value of the ARRs for the receiving LSE compared to the total value held by the original ARR holder.

There were 31,683 MW of ARRs associated with \$657,300 of revenue that were reassigned for the 2019/2020 planning period. There were 27,383 MW of ARRs associated with \$373,700 of revenue that were reassigned in the first 10 months of the 2020/2021 planning period.

¹⁶ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

Table 13-3 summarizes ARR MW and associated revenue reassigned for network load in each control zone where changes occurred between June 2019 and March 2021.

Table 13-3 ARRs and ARR revenue automatically reassigned for network load changes by control zone: June 2019 through March 2021

Control Zone	ARRs Reassigned (MW-day)		ARR Revenue Reassigned [Dollars (Thousands) per MW-day]	
	2019/2020 (12 months)	2020/2021 (10 months)	2019/2020 (12 months)	2020/2021 (10 months)
ACEC	373	382	\$4.8	\$2.5
AEP	5,435	2,382	\$151.0	\$19.5
APS	1,383	1,307	\$39.4	\$18.0
ATSI	2,865	2,539	\$42.6	\$19.0
BGE	2,252	2,281	\$103.9	\$140.3
COMED	2,583	2,305	\$27.1	\$14.1
DAY	765	565	\$9.3	\$3.8
DUKE	839	720	\$58.3	\$20.9
DUQ	1,622	1,450	\$5.8	\$5.8
DOM	632	431	\$6.2	\$4.4
DPL	702	683	\$52.2	\$19.2
EKPC	0	0	\$0.0	\$0.0
JCPLC	1,032	847	\$4.8	\$3.8
MEC	540	545	\$5.6	\$2.4
OVEC	0	0	\$0.0	\$0.0
PECO	3,196	3,473	\$24.8	\$22.3
PE	570	545	\$15.7	\$6.3
PEPCO	1,947	2,096	\$35.4	\$24.5
PPL	3,538	3,220	\$38.3	\$36.2
PSEG	1,340	1,266	\$31.8	\$10.5
REC	69	350	\$0.2	\$0.1
Total	31,683	27,387	\$657.3	\$373.7

Residual ARRs

Introduced August 1, 2012, Residual ARRs are available for eligible ARR holders when a transmission outage was modeled in the Annual ARR Allocation, but the transmission facility returns to service during the planning period. Residual ARRs can only be allocated to participants whose ARRs were prorated in Stage 1B and only to a maximum of the prorated reduction, so not all available Residual ARRs are allocated. Residual ARRs are automatically assigned to eligible participants the month before the effective date, are

effective for a single month and cannot be self scheduled. Residual ARR target allocations are based on the clearing prices from FTR obligations in the relevant monthly auction, may not exceed zonal network services peak load or firm transmission reservation levels and are only available up to the prorated ARR MW capacity as allocated in the Annual ARR Allocation. For the following planning period, these Residual ARRs are available as ARRs in the annual ARR allocation. Residual ARRs are a separate product from incremental ARRs. Beginning with the June 2017 monthly auction, Residual ARRs that would have cleared with a negative target allocation are not assigned to participants.¹⁷ In prior planning periods, PJM's modeling of excess outages in order to manage FTR market outcomes resulted in the allocation of some ARRs that would have been allocated in Stage 1B being allocated as Residual ARRs on a month to month basis without the option to self schedule.

Table 13-4 shows the Residual ARRs allocated to participants and the associated target allocations. The available volume is the total additional capacity available to be allocated as Residual ARRs. The cleared volume is the residual ARR capacity actually allocated to participants with prorated ARRs based on the level of prorated ARRs in Stage 1B and the affected paths. In the first 10 months of the 2020/2021 planning period, PJM allocated a total of 20,616.0 MW of Residual ARRs with a target allocation of \$9.4 million. In the same time period for the 2019/2020 planning period, PJM allocated a total of 22,090.7 MW of residual ARRs with a target allocation of \$11.1 million.

Table 13-4 Residual ARR allocation volume and target allocation: 2014/2015 planning period through 2020/2021 planning period

Planning Period	Available Volume (MW)	Cleared Volume (MW)	Cleared Volume	Target Allocation
2014/2015	65,095.3	22,532.9	34.6%	\$8,160,918.27
2015/2016	61,807.0	37,042.4	59.9%	\$8,620,353.27
2016/2017	71,000.7	35,034.9	49.3%	\$6,986,723.44
2017/2018	81,040.8	39,597.4	48.9%	\$17,497,625.78
2018/2019	49,646.9	27,335.6	55.1%	\$11,817,002.00
2019/2020	48,286.5	27,233.2	56.4%	\$12,369,580.58
2020/2021*	37,783.1	20,616.0	54.6%	\$9,360,516.78

* First ten months of 2020/2021 planning period

¹⁷ See FERC Letter Order, Docket No. ER17-1057 (April 5, 2017).

IARRs

In theory, Incremental Auction Revenue Rights (IARRs) are ARRs made available by physical transmission system upgrades from customer funded transmission projects or from merchant transmission or generation interconnection requests. In order for a transmission project to result in IARRs, the project must create simultaneously feasible incremental market flow capability in PJM's ARR market model, over and above all system capability being used by existing allocated ARRs and/or would be used by granting any prorated outstanding ARR requests, in the ARR market model.¹⁸

There are three sources of IARRs: IARRs based on a specific transmission investment; IARRs based on merchant transmission or generation interconnection projects; and IARRs based on RTEP upgrades. In the case of a specific transmission investment, the participant elects desired IARR MW between a specified source and sink and PJM and the affected transmission owners determine the upgrades necessary to create incremental capability.¹⁹ In the other two cases, the participants paying for the upgrades are assigned IARRs if any are created. There have been 13 successful IARR requests totaling 2,990.1 MW. One IARR path of 64.5 MW was terminated (June 1, 2012), leaving 12 unique source and sink combinations of 2,925.6 MW of IARRs. Of these 12 unique paths, three paths consisting of 1,200.0 MW were based on specific transmission investments requests, six paths consisting of 1,047.4 MW were based on merchant transmission requests and three paths consisting of 678.6 MW were based on customer funded (RTEP) transmission projects. The three paths based on specific transmission investments involved a generation company working with its affiliated transmission company. The other nine paths were based on projects that would have been built regardless of the addition of IARRs.

The MMU supports increased competition to provide transmission using market mechanisms. The IARR process is not a viable mechanism for facilitating competitive transmission investments. Maintaining the IARR process impedes the search for real solutions. PJM's process for creating and assigning IARRs

¹⁸ See PJM Incremental Auction Revenue Rights Model Development and Analysis, PJM June 12, 2017. <<https://www.pjm.com/~media/markets-ops/ft/pjm-iarr-model-development-and-analysis.ashx>>.

¹⁹ See Attachment EE of the PJM Open Access Transmission Tariff <<https://www.pjm.com/directory/merged-tariffs/oatt.pdf>>.

is fundamentally flawed and cannot be made consistent with the requirements of Order No. 681 which established IARRs.²⁰

Order No. 681 requires that long-term firm transmission rights made feasible by transmission upgrades or expansions be available upon request to the party that pays for such upgrades or expansions.²¹ Order No. 681 also requires that the rights granted by upgrades/expansions cannot come at the expense of transmission rights held by others. IARRs are treated as Stage 1A rights, which are given first and absolute priority in PJM's annual allocation process. Granting Stage 1A status to IARRs is preferential treatment of IARR rights relative to the ARR rights belonging to load. If the annual market model used to assign existing ARR rights in a given year cannot simultaneously support all Stage 1A ARR requests, the system model is modified so as to make the Stage 1A ARR requests feasible. The result is an over allocation of congestion rights relative to expected congestion. To avoid having FTR target allocations exceed expected congestion, PJM reduces the annual supply (market model system capability) available to non-Stage 1A rights through selective line outages and line rating reductions. The resulting market model artificially supports all the Stage 1A ARR requests and artificially reduces the amount of remaining later tier ARRs from other rights holders. Stage 1A ARRs, including IARRs, are approved at the expense of other preexisting congestion rights. In the case of IARRs, this is in violation of Order No. 681.

The MMU recommends that IARRs be eliminated from the PJM tariff. If IARRs are not eliminated, the MMU recommends that IARRs be subject to prorating like all other ARR rights rather than being exempt from prorating.

Financial Transmission Rights

FTRs are financial instruments that entitle their holders to receive revenue or require them to pay charges based on locational congestion price differences in the day-ahead energy market across specific FTR transmission paths. These day-ahead congestion price differences, multiplied by the FTR position in MW, are termed the FTR target allocations. The FTR target allocations define

²⁰ See November 7, 2019 Comments on TranSource, LLC v. PJM, 168 FERC ¶ 61,119 (2019) ("Opinion No. 566").

²¹ *Long-Term Firm Transmission Rights in Organized Electricity Markets*, Order No. 681, 116 FERC ¶61,077 (2006) ("Order No. 681"), *order on reh'g*, Order No. 618-A, 117 FERC ¶ 61,201 (2006), *order on reh'g*, Order No. 681-A, 126 FERC ¶ 61,254 (2009).

the maximum, but not guaranteed, payout for FTRs. The target allocation of an FTR reflects the difference in day-ahead congestion prices (CLMPs) rather than the difference in LMPs, which includes both congestion and marginal losses. Negative target allocations require the FTR holder to make payments rather than receive revenues in the FTR market. One of the fundamental flaws in the FTR design is the mismatch between congestion and the differences in day-ahead prices between nodes. The difference in day-ahead congestion prices is not congestion. Target allocations are not congestion.

Under the current rules, the revenue available to pay FTR holders' target allocations in a given month includes day-ahead congestion, payments by holders of negatively valued FTRs, auction revenues greater than ARR target allocations, and any charges made to day-ahead operating reserves which occur where there are hours with net negative congestion. Any such revenue above FTR target allocations from prior months in a planning period are used to pay any current month shortfalls. Target allocations are a cap on payments to FTR holders for each planning period. At the end of each planning period, any surplus revenue above the target allocations is distributed to ARR holders.

FTR funding is not on a path specific basis or on an hour to hour basis and treats all FTRs the same. For example, if the payout ratio is less than 1.0 at the end of the planning period, the payments to all FTRs are reduced. Payments are made pro rata based on target allocations. The result is widespread cross subsidies because assignment of path specific FTRs may exceed system capability and affect the payments to FTRs on other paths. FTR auction revenues and excess revenues are carried forward from prior months and distributed back from later months within a planning period. At the end of a planning period, if some months remain not fully funded, an uplift charge is collected from any FTR market participants that hold FTRs for the planning period based on their pro rata share of total net positive FTR target allocations, excluding any charge to FTR holders with a net negative FTR position for the planning period.

Auction market participants may offer to buy FTRs between any eligible pricing nodes on the system, as defined by PJM for each auction. For the

Annual FTR Auction and FTRs bought in the monthly auctions, the available FTR source and sink points include hubs, control zones, aggregates, generator buses, load buses and interface pricing points. For the Long Term FTR Auction there is a more restricted set of available hubs, control zones, aggregates, generator buses and interface pricing points available. PJM does not allow FTR buy bids to clear with a price of zero unless there is at least one constraint in the auction which affects the FTR path. FTRs are available to the nearest 0.1 MW.

FTRs are bought from supply defined by PJM. The fact that load is selling congestion revenue rights is not fully recognized in the FTR design, although FTR buyers can resell FTRs at a price they agree to accept. Load has no role in defining the price at which PJM sells FTRs on their behalf. PJM's objective in the auctions is to maximize auction revenue, given the total set of bid prices and bid MW, but absent reservation prices from load. The failure to allow sellers the ability to decide at what price to sell FTRs is a fundamental flaw in the FTR market. The result is that PJM cannot actually maximize auction revenue and that the FTR market is not really a market.

Once bought from PJM, FTRs can be bought and sold. Buy bids are bids to buy FTRs in the auctions. Sell offers are offers to sell existing FTRs in the auctions.

Market participants can buy and sell existing FTRs, outside of the auction process, through a voluntary bulletin board, termed the PJM bilateral market. FTRs can also be exchanged bilaterally without using the bulletin board. There is no requirement to report bilateral transactions, or any information about them, to PJM.

Supply and Demand

Total FTR supply in each auction is limited by the definition of the transmission system capacity included in the PJM FTR market model as modified, for example, by PJM assumptions about transmission outages, for which there are no clear rules. PJM may also limit available transmission capacity through subjective judgment exercised without any clear guidelines.

The MMU recommends that the full transmission capacity of the system be allocated as ARRAs prior to sale as FTRs.

The FTR auction process does not account for the fact that significant transmission outages, which have not been provided to PJM by transmission owners prior to the auction date, will occur during the periods covered by the auctions. Such transmission outages may or may not be planned in advance or may be emergency outages.²² In addition, it is difficult to model in an annual auction two outages of similar significance and similar duration in different areas which do not overlap in time. The choice of which to model will generally have significant distributional consequences; they will affect different areas very differently. The fact that outages are modeled at significantly lower than historical levels results in selling too much FTR capacity, which creates downward pressure on ARR prices. To address this issue, the MMU recommends that PJM use probabilistic outage modeling to better align the supply of ARRAs and FTRs with actual expected transmission capacity.

Long Term FTR Auctions

In July 2006, FERC approved Order No. 681 mandating the creation of long term firm transmission rights in transmission organizations with organized electricity markets. FERC's goal was that "load serving entities be able to request and obtain transmission rights up to a reasonable amount on a long-term firm basis, instead of being limited to obtaining exclusively annual rights."²³ Despite that order and inconsistent with the directive in that order, LSEs are not able to request ARRAs nor are LSEs guaranteed rights to the revenue from Long Term FTR Auctions in PJM's long term FTR auction market design. Excess system capability in years two and three of the long term FTR auction is never made available to load in the form of ARRAs and is only made available to FTR buyers.

PJM conducts the Long Term FTR Auction for the next three consecutive planning periods. The Long Term FTR Auction consists of five rounds beginning

²² See the *2019 State of the Market Report for PJM*, Volume II, Section 12: Transmission Facility Outages: Transmission Facility Outages Analysis for the FTR Market.

²³ Order No. 681 at P 17.

in June of the preceding planning period and continuing through March. FTRs purchased in prior rounds or Long Term Auctions may be offered for sale in subsequent rounds of the long term, annual or monthly FTR auctions. FTRs obtained in the Long Term FTR Auctions have terms of one year. FTR products available in the Long Term Auction include 24 hour, on peak and off peak FTR obligations, with FTR options unavailable in the Long Term FTR Auctions.

Beginning with Round 2 of the 2019/2022 Long Term FTR Auction, PJM implemented revisions to the determination of residual system capability made available in the Long Term FTR Auctions, and eliminated the YRALL product, consistent with the MMU's recommendation. The revisions affect the determination of ARR rights reserved for ARR holders. Rather than simply preserving the ARR cleared capacity from the previous annual allocation, PJM reruns the simultaneous feasibility test for the ARR/FTR market model, without outages, using the previous year's ARR requests, prorated when necessary, and uses the resulting ARRs as the basis for reserving capacity for ARR holders in the Long Term FTR Auction. The ARR requests are greater than the previously cleared ARRs. The difference between the requested ARRs and the ARR/FTR market model's transmission system capacity, both without outages, determines the residual capacity offered in the Long Term FTR Auction. The revisions provide ARR holders with more congestion rights in the Long Term FTR Auction that will carry into the Annual FTR Auction.

But the revisions do not address the congestion revenue rights sold in years two and three of the Long Term FTR Auction, which remain unavailable to ARRs. Capacity awarded in the Long Term FTR Auction is unavailable as ARRs in years two and three. As a result, the rights to significant congestion revenues are still assigned to the Long Term FTR Auction without ever having been made available to ARR holders. That outcome is inconsistent with the basic logic of ARRs and inconsistent with the stated intent of the market design which is to return all congestion revenues to load.

Long Term FTR Auction transmission capacity is determined by removing all outages and running an offline model of the previous Annual FTR Auction model with all ARR bids from the prior annual ARR allocation. Any ARR

MW that clear in this offline model are reserved for ARR holders in the relevant planning periods, and are removed from the Long Term FTR Auction capability. Even this approach does not, and cannot, preserve all possible capacity for ARR holders in the first year of the Long Term Auction due to changes in system topology and outage selection between planning periods. PJM outage assumptions are a key factor in determining the supply of ARRs and the related supply of FTRs in the Annual FTR Auction.

Annual FTR Auctions

Annual FTRs are effective for an entire planning period, June 1 through May 31. Outages expected to last two or more months, as well as any outages of a shorter duration that PJM decides would cause FTR revenue inadequacy if not modeled, are included in the determination of the simultaneous feasibility for the Annual FTR Auction.²⁴ While the full list of outages selected is publicly posted, PJM exercises significant subjective judgment in selecting outages to accomplish FTR revenue adequacy goals and the process by which these outages are selected is not clear, is not defined and is not documented. ARR holders who wish to self schedule must inform PJM prior to round one of the annual auction. Any self scheduled ARR requests clear 25 percent of the requested volume in each round of the Annual FTR Auction as price takers. The Annual FTR Auction consists of four rounds that allow any PJM member to bid for any FTR or to offer for sale any FTR that they currently hold. FTRs in this auction can be obligations or options for peak, off peak or 24 hour periods. FTRs purchased in one round of the Annual FTR Auction can be sold in later rounds or in the Monthly Balance of Planning Period FTR Auctions.

Monthly Balance of Planning Period FTR Auctions

Total Monthly FTR Auction capacity is based on the residual capacity available after the Long Term and Annual FTR auctions are conducted and adjustments are made to outages to reflect anticipated system conditions for the time periods auctioned. Outages expected to last five or more days are included in the determination of the simultaneous feasibility test for the Monthly Balance of Planning Period FTR Auction. These are single-round monthly auctions that allow any transmission service customer or PJM member to bid

²⁴ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

for any FTR or to offer for sale any FTR that they currently hold. Before the 2020/2021 planning period, the first three individual months, and quarterly periods that had not yet begun, were available for bid or offer. Beginning with the 2020/2021 planning period, market participants can bid for or offer monthly FTRs for any of the remaining individual calendar months in the planning period. FTRs in the auctions include obligations and options and 24 hour, on peak and off peak products.²⁵

Bilateral Market

Market participants can buy and sell existing FTRs, outside of the auction process, through a voluntary bulletin board, termed the PJM bilateral market. FTRs can also be exchanged bilaterally without using the bulletin board. There is currently no requirement to report bilateral transactions, or any information about them, to PJM. Bilateral transactions that are not done through PJM can involve parties that are not PJM members. PJM has no knowledge of bilateral transactions, or the terms and risks of bilateral transactions, that are done outside of PJM's bilateral market system. Bilateral transactions not reported to PJM are dependent on the contract established between the parties.

For bilateral trades reported to PJM, the FTR transmission path must remain the same, FTR obligations must remain obligations, and FTR options must remain options. However, an individual FTR may be split up into multiple, smaller FTRs, down to increments of 0.1 MW. Bilateral FTRs reported to PJM can also include more restrictive start and end times, meaning that the start time cannot be earlier than the original FTR start time and the end time cannot be later than the original FTR end time.

FTR Bid Limits

PJM has the authority to limit participant's bids to 5,000 to avoid or mitigate significant system performance problems related to bid/offer volume.²⁶ PJM has had a cap of 10,000 bids and offers per auction round and per period at the corporate family level for more than a year, although the rule has not been enforced. On December 11, 2019, PJM made an informational announcement

²⁵ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

²⁶ Operating Agreement Schedule 1 § 7.3.5(d) allows PJM to limit participant's bids to 5,000 to avoid or mitigate significant system performance problems related to bid/offer volume.

to urge participants to respect the rule.²⁷ Some participants continued to exceed the limit in 2020 through the use of multiple affiliates, although the number of such participants was significantly reduced. On October 26, 2020, the MMU informed stakeholders that it had notified companies that violated the limits persistently that the companies should comply, and recommended that PJM enforce the limit.²⁸ On November 5, 2020, PJM proposed to add a language in PJM Manual 6 regarding the bid limit.²⁹ The MMU recommends that PJM enforce the FTR auction bid limits at the corporate family level starting immediately.

Market Structure

In order to evaluate the ownership of FTRs, the MMU categorizes all participants owning FTRs in PJM as either physical or financial. Physical entities include utilities and customers which primarily take physical positions in PJM markets. Financial entities include banks, trading firms and hedge funds which primarily take financial positions in PJM markets. International market participants that primarily take financial positions in PJM markets are generally considered to be financial entities even if they are utilities in their own countries.

Table 13-5 presents the monthly balance of planning period FTR auction cleared FTRs for 2021 by trade type, organization type and FTR direction. Financial entities purchased 88.6 percent of prevailing flow FTRs, up 9.4 percentage points, and 92.2 percent of counter flow FTRs, up 6.9 percentage points, from 2020, with the result that financial entities purchased 90.4 percent, up 8.1 percentage points, of all prevailing and counter flow FTR buy bids in the monthly balance of planning period FTR auction for 2021.

²⁷ See "Informational Update: FTR Auction Bid Limits," PJM Presentation to the Market Implementation Committee (December 11, 2019) <<https://www.pjm.com/-/media/committees-groups/committees/mic/20191211/20191211-item-06-ftr-auction-bid-limits.ashx>>.

²⁸ See "Market Monitor Report," IMM Presentation to the Members Committee (October 26, 2020) <<https://www.pjm.com/-/media/committees-groups/committees/mc/2020/20201026-webinar/20201026-item-07-imm-report.ashx>>.

²⁹ See "Manual 6, Rev. 26: FTR Auction Bid Limits," PJM Presentation to the Market Implementation Committee (November 5, 2020) <<https://www.pjm.com/-/media/committees-groups/committees/mic/2020/20201105/20201105-item-05a-m6-updates-ftr-bid-limits.ashx>>.

Table 13-5 Monthly Balance of Planning Period FTR Auction patterns of ownership by FTR direction: January through March, 2021

Trade Type	Organization Type	FTR Direction		
		Prevailing Flow	Counter Flow	All
Buy Bids	Physical	11.4%	7.8%	9.6%
	Financial	88.6%	92.2%	90.4%
	Total	100.0%	100.0%	100.0%
Sell Offers	Physical	4.3%	4.5%	4.4%
	Financial	95.7%	95.5%	95.6%
	Total	100.0%	100.0%	100.0%

Table 13-6 shows the monthly cumulative HHI values for cleared obligation MW for the first ten months of the 2020/2021 planning period monthly auctions for prevailing flow FTRs. Cleared prevailing flow bids were unconcentrated in all of the months.³⁰

Table 13-6 Monthly Balance of Planning Period FTR Auction HHIs by period for prevailing flow FTRs

Auction	Auction Period											
	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Jun-20	359	415	446	591	720	625	855	686	763	752	686	768
Jul-20		296	369	446	551	518	701	553	546	646	594	607
Aug-20			304	398	458	469	623	506	506	590	555	555
Sep-20				314	413	435	577	491	467	531	519	506
Oct-20					341	404	503	443	432	545	536	536
Nov-20						340	456	422	440	549	552	565
Dec-20							386	398	413	530	543	562
Jan-21								337	379	502	513	538
Feb-21									337	450	479	511
Mar-21										410	467	498

Table 13-7 shows the monthly cumulative HHI values for cleared obligation MW for the first 10 months of the 2020/2021 planning period monthly auctions by month for counter flow FTRs. Cleared counter flow bids were unconcentrated in all but two of the months, which were moderately concentrated, in the first 10 months of the 2020/2021 planning period.

³⁰ See 2020 Quarterly State of the Market Report for PJM: January through June, Section 3: Energy Market, Competitive Assessment for HHI definitions.

Table 13-7 Monthly Balance of Planning Period FTR Auction HHIs by period for counter flow FTRs

Auction	Auction Period											
	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Jun-20	655	636	806	771	914	905	1012	772	831	939	1007	974
Jul-20		514	571	658	745	753	811	642	673	773	866	855
Aug-20			508	560	625	660	708	603	632	728	776	768
Sep-20				537	596	604	673	599	627	697	763	764
Oct-20					546	567	638	616	646	736	773	786
Nov-20						585	608	604	631	746	812	797
Dec-20							653	615	650	722	808	807
Jan-21								622	617	705	799	798
Feb-21									522	640	747	759
Mar-21										600	722	725

Table 13-8 shows the average daily FTR ownership for all FTRs for the first three months of 2021, by FTR direction and self scheduled FTRs.

Table 13-8 Daily FTR held position ownership by FTR direction: 2021

Organization Type	FTR Direction		
	Prevailing Flow	Counter Flow	All
Physical	24.8%	14.0%	19.7%
Physical Self Scheduled	3.6%	0.1%	1.9%
Financial	71.5%	85.9%	78.4%
Total	100.0%	100.0%	100.0%

Market Performance

Volume

PJM regularly intervenes in the FTR market based on subjective judgment which is not based on clear or documented guidelines. Such intervention in the FTR, or any market, is not appropriate and not consistent with the operation of competitive markets. In an apparent effort to manage FTR revenues, PJM may adjust normal transmission limits in the FTR auction model. If, in PJM's judgment, the normal transmission limit is not consistent with revenue adequacy goals and simultaneous feasibility, then transmission limits are reduced pro rata based on the MW of Stage 1A infeasibility and the availability of auction bids for counter flow FTRs.³¹ PJM may also remove or

³¹ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

reduce infeasibilities caused by transmission outages by clearing counter flow bids without being required to clear the corresponding prevailing flow bids.³² The use of both of these procedures is contingent on the conditions that: PJM actions not affect the revenue adequacy of allocated ARRs; all requested self scheduled FTRs clear; and net FTR auction revenue is positive.

Monthly Balance of Planning Period Auctions

Table 13-9 provides the monthly balance of planning period FTR auction market volume for the entire 2019/2020 and the first 10 months of the 2020/2021 planning periods. There were 27,587,143 MW of FTR obligation buy bids and 12,138,048 MW of FTR obligation sell offers for all bidding periods in the first 10 months of the 2020/2021 planning period. The monthly balance of planning period FTR auction cleared 4,966,621 (18.0 percent) of FTR obligation buy bids and 2,079,720 MW (17.1 percent) of FTR obligation sell offers.

There were 5,570,264 MW of FTR option buy bids and 3,369,613 MW of FTR option sell offers for all bidding periods in the Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning period. The ownership of options was highly concentrated in all periods. The monthly auctions cleared 304,575 MW (5.5 percent) of FTR option buy bids and 499,308 MW (14.8 percent) of FTR option sell offers.

Table 13-9 Monthly Balance of Planning Period FTR Auction market volume: 2021

Monthly Auction	Type	Trade Type	Bid and Requested Count	Bid and Requested Volume (MW)	Cleared Volume (MW)	Cleared Volume (%)	Uncleared Volume (MW)	Uncleared Volume (%)
Jan-21	Obligations	Buy bids	381,342	1,836,655	322,062	17.5%	1,514,593	82.5%
		Sell offers	217,469	811,662	130,359	16.1%	681,304	83.9%
	Options	Buy bids	6,018	442,023	14,751	3.3%	427,272	96.7%
		Sell offers	28,121	237,886	32,306	13.6%	205,581	86.4%
Feb-21	Obligations	Buy bids	376,380	1,790,943	392,484	21.9%	1,398,459	78.1%
		Sell offers	202,939	761,827	137,133	18.0%	624,694	82.0%
	Options	Buy bids	2,117	200,050	8,830	4.4%	191,221	95.6%
		Sell offers	20,855	207,239	30,062	14.5%	177,176	85.5%
Mar-21	Obligations	Buy bids	294,408	1,424,569	327,035	23.0%	1,097,534	77.0%
		Sell offers	150,359	603,193	126,499	21.0%	476,694	79.0%
	Options	Buy bids	1,593	102,266	5,694	5.6%	96,572	94.4%
		Sell offers	14,659	155,357	37,104	23.9%	118,253	76.1%
2019/2020*	Obligations	Buy bids	5,926,122	20,396,353	3,975,985	19.5%	16,420,368	80.5%
		Sell offers	3,436,131	7,709,887	1,586,486	20.6%	6,123,402	79.4%
	Options	Buy bids	86,428	2,779,104	148,918	5.4%	2,630,186	94.6%
		Sell offers	179,301	1,656,059	409,029	24.7%	1,247,031	75.3%
2020/2021**	Obligations	Buy bids	6,002,707	27,587,143	4,966,621	18.0%	22,620,522	82.0%
		Sell offers	3,678,703	12,138,048	2,079,720	17.1%	10,058,327	82.9%
	Options	Buy bids	87,739	5,570,264	304,575	5.5%	5,265,690	94.5%
		Sell offers	505,343	3,369,613	499,308	14.8%	2,870,305	85.2%

* Shows 12 months for 2019/2020 ** Shows 10 months for 2020/2021

³² See *id.*

Figure 13-1 shows the bid volume from each monthly auction for each period of the Monthly Balance of Planning Period FTR Auction. The prompt month is the first month for which FTRs are sold. The bid volume for the non-prompt months is significantly lower than for the prompt months. On average, the non-prompt month bid volume is 42.1 percent of the prompt month bid volume.

Figure 13-1 Monthly Balance of Planning Period FTR Auction bid volume (MW per period): June through March, 2021 Auction

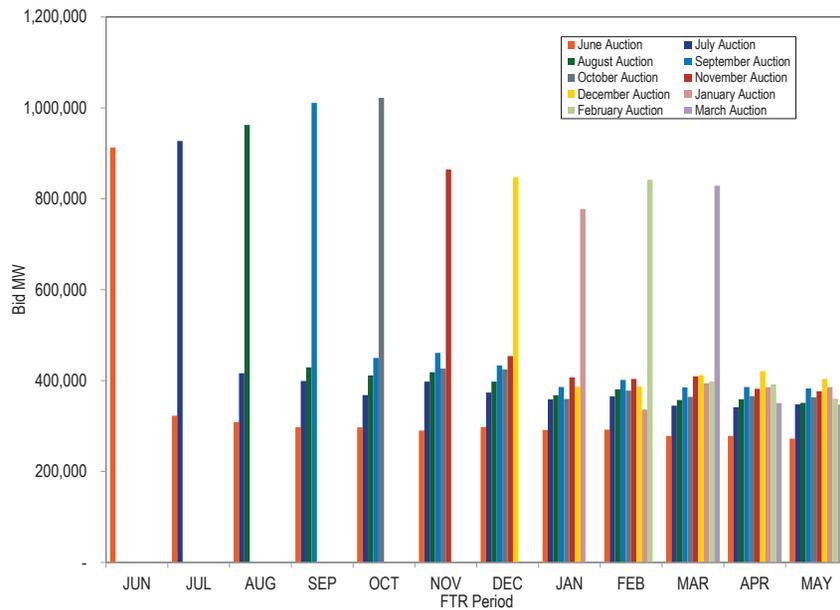
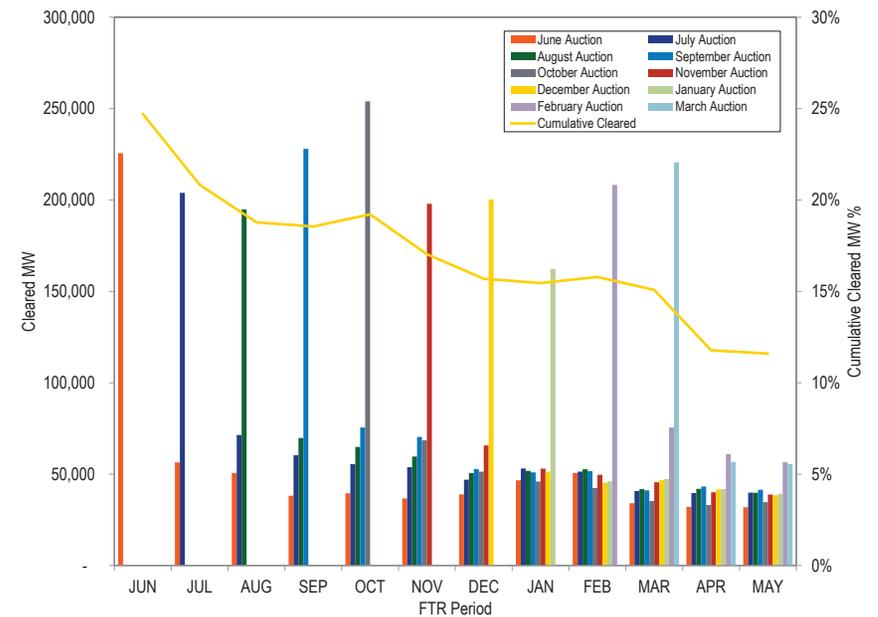


Figure 13-2 shows the cleared volume from each monthly auction for each period of the Monthly Balance of Planning Period FTR Auction. The cleared volume for non-prompt months is also significantly lower than in prompt months. On average, the non-prompt month cleared volume is 24.2 percent of the prompt month cleared volume.

Figure 13-2 Monthly Balance of Planning Period FTR Auction cleared volume (MW per period): June through March, 2021 Auction



Bilateral Market

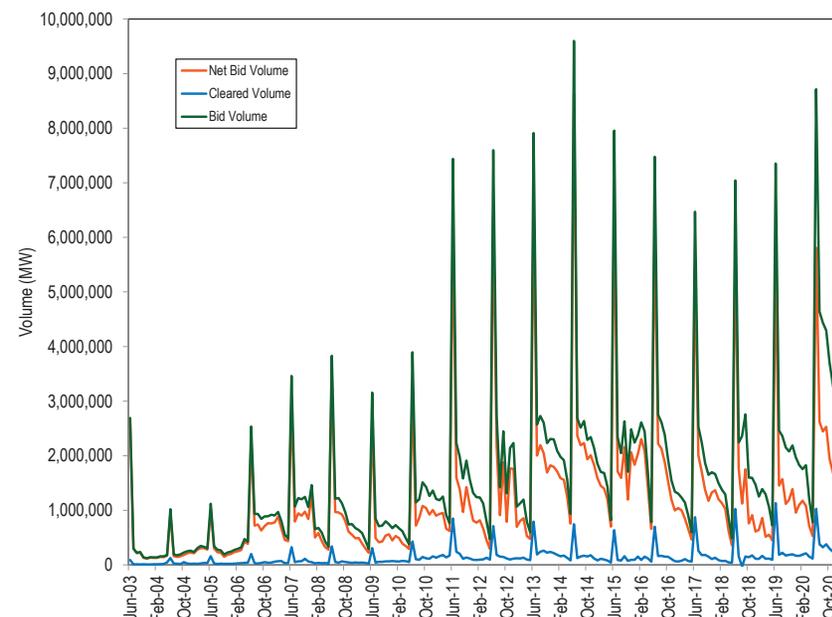
Table 13-10 provides the PJM registered secondary bilateral FTR market volume for the 2019/2020 and the 2020/2021 planning periods. Bilateral FTR transactions registered through PJM do not need to include an accurate price or the entire volume of the transaction. Bilateral FTR transactions are not required to be registered through PJM. As a result, the bilateral data are not a reliable basis for evaluating actual bilateral activity in PJM FTRs.

Table 13-10 Secondary bilateral FTR market volume: 2019/2020 and 2020/2021³³

Planning Period	Type	Class Type	Volume (MW)
2019/2020	Obligation	24-Hour	5,032.9
		On Peak	1,996.1
		Off Peak	1,661.8
		Total	8,690.8
		Option	24-Hour
		On Peak	0.0
		Off Peak	0.0
		Total	0.0
2020/2021	Obligation	24-Hour	6,164.0
		On Peak	392.0
		Off Peak	96.0
		Total	6,652.0
		Option	24-Hour
		On Peak	0.0
		Off Peak	0.0
		Total	0.0

Figure 13-3 shows the FTR bid, net bid and cleared volume from June 2003 through March 2021 for Long Term, Annual and Monthly Balance of Planning Period Auctions. Cleared volume includes FTR buy and sell offers that were accepted. The net bid volume includes the total buy, sell and self scheduled offers, counting sell offers as a negative volume. The bid volume is the total of all bid and self scheduled offers, excluding sell offers. The cleared volume in August 2018 was negative due to the liquidation of the GreenHat FTR portfolio, which resulted in a large quantity of FTRs selling in the monthly auction.

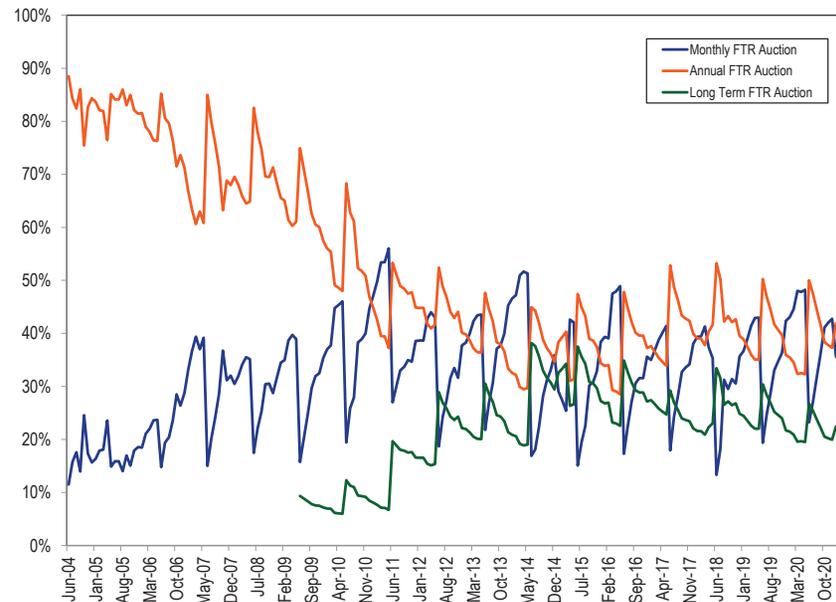
Figure 13-3 Long Term, Annual and Monthly FTR Auction bid and cleared volume: June 2003 through March 2021



³³ The 2019/2020 planning period covers bilateral FTRs that are effective for any time between June 1, 2019 through May 31, 2020, which originally had been purchased in a Long Term FTR Auction, Annual FTR Auction or Monthly Balance of Planning Period FTR Auction.

Figure 13-4 shows cleared auction volumes by auction type as a percent of the total FTR cleared volume by calendar months for June 2004 through March 2021. FTR volumes are included in the calendar month they are effective, with long term and annual FTR auction volumes spread equally to each month in the relevant planning period. Over the course of each planning period an increasing number of Monthly Balance of Planning Period FTRs are purchased, resulting in a greater share of total FTRs. When the Annual FTR Auction occurs, FTRs purchased in previous Monthly Balance of Planning Period Auctions, other than the current June auction, are no longer effective, resulting in a smaller share for monthly and a greater share for annual FTRs.

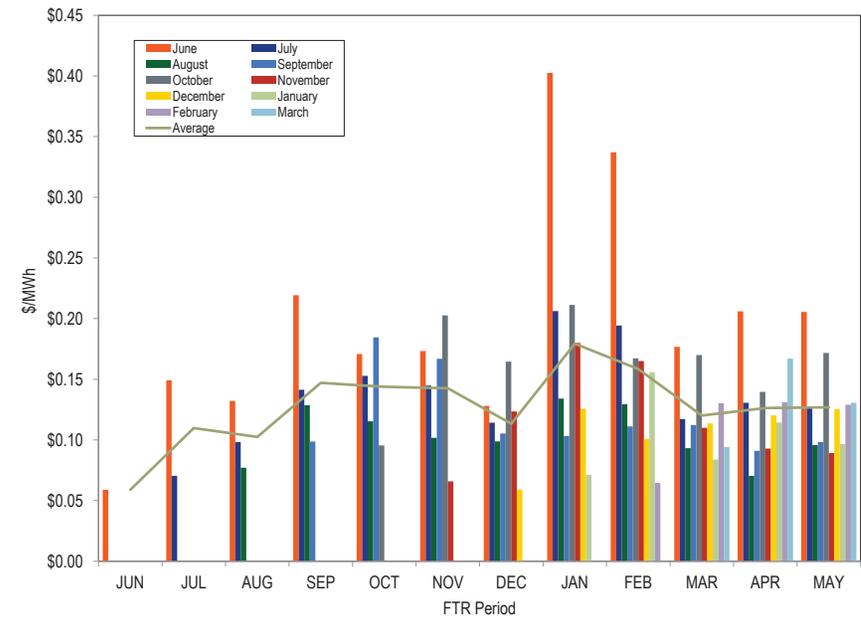
Figure 13-4 Cleared auction volume (MW) as a percent of total FTR cleared volume by calendar month: June 2004 through March 2021



Price

Figure 13-5 shows the weighted average cleared buy bid price of obligations in the Monthly Balance of Planning Period FTR Auctions by bidding period for the first 10 months of the 2020/2021 planning period and the average price per MWh for each of the FTR periods.

Figure 13-5 Monthly Balance of Planning Period FTR Auction cleared, weighted-average, buy bid price per period (Dollars per MWh): 2020/2021 planning period



Profitability

FTR profitability is the difference between the revenue received directly from holding an FTR plus any revenue from the sale of an FTR, and the cost of the FTR. FTR profitability is relevant only to participants purchasing FTRs and is not relevant to self scheduled FTRs. For a prevailing flow FTR, the FTR revenue is the actual revenue that an FTR holder is paid as the target allocation plus the auction price from the sale of the FTR, if relevant, and the FTR cost is the auction price. For a counter flow FTR, the FTR revenue is the auction price that an FTR holder is paid to take the FTR plus the positive auction price from the sale of the FTR, if relevant, and the FTR cost is the target allocation that the FTR holder must pay plus the negative auction price from the sale of the FTR, if relevant. Profits include the payment of surplus to FTRs. Bilateral transactions are excluded from the profit calculations because there are inconsistent reporting requirements and no assurance that reported prices reflect the actual prices under the PJM rules. ARR holders that self schedule FTRs receive congestion revenues but do not receive profits from those FTRs because ARR holders are assigned the rights to congestion revenues which they choose to take directly as the congestion payments associated with the corresponding FTRs.

Hourly FTR profits are the sum of the hourly revenues minus the hourly costs for each FTR. The hourly revenues equal hourly FTR target allocations, adjusted by the payout ratio. The hourly auction costs are the product of the FTR MW and the auction price divided by the time period of the FTR in hours. The FTR revenues do not include after the fact adjustments which are very small and do not occur in every month.

The surplus includes surplus day-ahead congestion revenue and FTR auction surplus. Revenues from the surplus are included in FTR profits because the surplus is first allocated to FTR holders to cover any shortfall in paying FTR target allocations. Beginning with the 2018/2019 planning period, after covering any shortfall in FTR target allocations within the planning period, the net surplus at the end of the planning period is distributed to ARR holders.

The fact that FTR profits in each planning period have been positive for financial entities as a group, regardless of the payout ratio, raises questions about the competitiveness of the market. FTR profits for financial entities were not positive in the 2019/2020 planning period when accounting for GreenHat losses but were positive otherwise. FTR profits for financial entities without GreenHat losses were positive in every completed planning period from 2012/2013 through 2020/2021 except the 2016/2017 planning period, and were positive if summed over the entire period (Table 13-13). It is not clear, in a competitive market, why FTR profits for financial entities remain persistently profitable. In a competitive market, it would be expected that profits would be competed to zero.

Table 13-11 lists FTR profits, and the congestion returned through self scheduled FTRs, by organization type and FTR direction for the first 10 months of the 2020/2021 planning period. This table includes the auction cost and revenue from both buying and selling FTRs that were effective between June 2020 and March 2021. This includes FTRs from the 2018/2021, 2019/2022 and 2020/2023 Long Term auctions, the 2020/2021 Annual auction, and the Monthly auctions from June 2020 through March 2021. The costs and revenues of the yearly FTR products are prorated based on the time period of the FTRs. Any revenues or costs related to bilateral transactions are not included in profits. All participants who were assigned ARRs are classified as physical ARR. Some participants that are not eligible for ARRs are classified as physical because they are physical participants, for example companies that own only generation.

Self scheduled FTRs have zero cost. ARR holders who self scheduled FTRs received \$116.8 million in congestion revenues. Revenues from self scheduled FTRs are a return of congestion to the load that paid the congestion and are not profits.

Table 13-11 FTR profits and revenues by organization type and FTR direction: 2020/2021: June 2020 through March 2021

Organization Type	Purchased FTRs Profit			Self Scheduled FTRs Revenue Returned		
	Prevailing Flow	Counter Flow	Total	Prevailing Flow	Counter Flow	Total
Financial	\$97,918,824	\$113,073,995	\$210,992,819			
Financial without GreenHat	\$98,626,758	\$113,632,693	\$212,259,451			
Physical	\$37,617,473	\$9,215,906	\$46,833,379			
Physical ARR	\$29,058,196	(\$5,123,074)	\$23,935,122	\$116,764,628	\$44,704	\$116,809,332
Total	\$164,594,493	\$117,166,828	\$281,761,320	\$116,764,628	\$44,704	\$116,809,332

Table 13-12 lists the monthly FTR profits for the 2019/2020 planning period and the first 10 months of the 2020/2021 planning period by organization type. FTR profits include revenue from FTR sales, but do not include any net end of planning period surplus distribution and do not include any revenue or cost from bilateral transactions. FTR revenues for self scheduled FTRs are not included. FTR profits for FTRs purchased in auctions by ARR holders are included. In the first 10 months of the 2020/2021 planning period, profits for all participants were \$281.8 million, up from \$66.3 million in losses for the same time period in the 2019/2020 planning period. The largest month to month increase in profits was in February, \$80.6 million and the second largest month to month increase in profits was in March, \$79.0 million. Among organization types, financial organizations had the largest increase in profits in the first 10 months of the 2020/2021 planning period, \$220.5 million. The increase in profits was a result of higher target allocations and lower auction costs.

Table 13-12 Monthly FTR profits by organization type: 2019/2020 and 2020/2021³⁴

Month	Organization Type				
	Financial	Financial without GreenHat	Physical	Physical ARR	Total
Jun-19	(\$7,530,412)	(\$5,175,703)	(\$4,406,629)	(\$5,300,686)	(\$17,237,726)
Jul-19	\$11,073,631	\$13,727,088	\$1,715,298	\$2,195,625	\$14,984,553
Aug-19	(\$11,192,103)	(\$7,445,637)	(\$4,515,760)	(\$2,965,124)	(\$18,672,988)
Sep-19	\$13,219,100	\$20,305,030	\$6,308,310	\$4,870,000	\$24,397,410
Oct-19	\$6,628,121	\$12,845,824	\$2,404,277	\$3,916,338	\$12,948,736
Nov-19	\$6,579,914	\$10,996,869	\$2,167,865	\$2,038,284	\$10,786,063
Dec-19	\$6,176,313	\$11,021,397	(\$212,596)	(\$3,696,208)	\$2,267,509
Jan-20	(\$5,308,687)	(\$132,954)	(\$10,539,357)	(\$10,405,137)	(\$26,253,180)
Feb-20	(\$14,980,199)	(\$11,873,252)	(\$11,213,649)	(\$10,337,622)	(\$36,531,470)
Mar-20	(\$14,165,737)	(\$12,669,353)	(\$8,006,489)	(\$10,777,549)	(\$32,949,775)
Apr-20	(\$14,526,206)	(\$11,926,918)	(\$11,145,117)	(\$11,779,700)	(\$37,451,023)
May-20	\$2,886,620	\$5,478,459	(\$5,416,808)	(\$7,372,412)	(\$9,902,600)
Summary for Planning Period 2019/2020					
Total	(\$21,139,644)	\$25,150,852	(\$42,860,656)	(\$49,614,191)	(\$113,614,490)
Jun-20	\$13,554,491	\$14,170,298	\$2,967,605	(\$105,462)	\$16,416,634
Jul-20	\$35,653,206	\$35,594,893	\$9,241,525	\$3,750,023	\$48,644,754
Aug-20	\$26,092,413	\$25,931,889	\$6,939,322	\$3,240,451	\$36,272,185
Sep-20	\$23,104,806	\$22,840,765	\$7,494,858	\$4,494,466	\$35,094,131
Oct-20	\$9,277,479	\$8,820,041	\$5,351,521	(\$843,912)	\$13,785,088
Nov-20	\$7,421,871	\$7,749,580	(\$3,695,203)	(\$2,396,979)	\$1,329,689
Dec-20	\$26,218,336	\$26,428,773	\$146,925	\$2,536,264	\$28,901,524
Jan-21	\$11,761,694	\$11,835,814	(\$1,479,704)	\$893,921	\$11,175,912
Feb-21	\$26,370,355	\$27,294,233	\$14,503,650	\$3,170,577	\$44,044,582
Mar-21	\$31,538,169	\$31,593,164	\$5,362,880	\$9,195,771	\$46,096,821
Summary for Planning Period 2020/2021					
Total	\$210,992,819	\$212,259,451	\$46,833,379	\$23,935,122	\$281,761,320

³⁴ The GreenHat Default Allocation Assessment by PJM was \$46.3 million for the 2019/2020 planning period and \$1.4 million for the first 10 months of the 2020/2021 planning period, excluding the FTR Waiver Settlement of \$17.5 million. The calculated GreenHat losses do not exactly match the assessment. The loss calculation is based on GreenHat's actual portfolio instead of the assessment formula and does not consider bilateral transaction or GreenHat's collateral.

Table 13-13 lists the historical profits by calendar year by organization type beginning in the 2012/2013 planning period for purchased FTRs. (Profits do not include congestion revenue to self scheduled FTRs.) Profits include revenue from the sale of FTRs and exclude bilateral transactions. Profits include any surplus distribution or uplift payments. The end of planning period surplus or uplift was distributed to FTR holders prorata based on FTR positive target allocations through the 2017/2018 planning period. Beginning with the 2018/2019 planning period, any net end of planning period surplus, after paying out any shortfall in FTR target allocations within the planning period, was distributed to ARR holders. Surplus allocated to ARR holders in the 2018/2019 planning period was \$112.3 million and in the 2019/2020 planning period, it was \$140.7 million.

Table 13-13 FTR profits by organization type: 2012/2013 through 2020/2021³⁵

		2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021
Financial	Profit	\$201,825,234	\$913,502,323	\$250,551,943	\$68,895,867	(\$12,525,947)	\$239,981,474	\$113,086,231	(\$21,139,644)	\$210,992,819
	Surplus	(\$50,304,408)	(\$145,080,521)	\$19,453,837	\$4,921,078	\$8,810,267	\$90,361,918			
	Total	\$151,520,826	\$768,421,802	\$270,005,781	\$73,816,945	(\$3,715,680)	\$330,343,392	\$113,086,231	(\$21,139,644)	\$210,992,819
Financial without GreenHat	Profit	\$201,825,234	\$913,502,323	\$250,551,785	\$70,094,918	(\$11,821,248)	\$240,111,850	\$223,376,757	\$25,150,852	\$212,259,451
	Surplus	(\$50,304,408)	(\$145,080,521)	\$19,453,837	\$4,921,078	\$8,810,267	\$90,361,918			
	Total	\$151,520,826	\$768,421,802	\$270,005,623	\$75,015,995	(\$3,010,981)	\$330,473,768	\$223,376,757	\$25,150,852	\$212,259,451
Physical	Profit	\$68,537,800	\$297,456,284	\$82,853,390	\$10,007,327	(\$4,010,669)	\$57,532,872	(\$5,945,233)	(\$42,860,656)	\$46,833,379
	Surplus	(\$41,626,011)	(\$53,642,077)	\$5,395,706	\$1,865,146	\$4,181,855	\$34,296,618			
	Total	\$26,911,789	\$243,814,207	\$88,249,096	\$11,872,473	\$171,186	\$91,829,490	(\$5,945,233)	(\$42,860,656)	\$46,833,379
Physical ARR	Profit	\$26,572,818	\$366,128,947	\$112,609,140	\$82,181,795	(\$2,468,152)	\$66,458,939	(\$6,248,557)	(\$49,614,191)	\$23,935,122
	Surplus	(\$25,873,836)	(\$81,279,067)	\$18,515,990	\$7,110,576	\$12,040,688	\$47,753,635			
	Surplus from Self scheduled FTRs	(\$45,978,766)	(\$81,765,964)	\$15,530,158	\$3,073,711	\$6,469,297	\$42,513,186			
	Total	\$698,982	\$284,849,881	\$131,125,130	\$89,292,371	\$9,572,536	\$114,212,574	(\$6,248,557)	(\$49,614,191)	\$23,935,122
	Total	\$179,131,597	\$1,297,085,890	\$489,380,007	\$174,981,788	\$6,028,043	\$536,385,456	\$100,892,442	(\$113,614,490)	\$281,761,320

* Bilateral transactions are included in surplus allocation calculation but are not included in profits calculation

* The first 10 months of the 2020/2021 planning period

Table 13-14 shows the profits and losses of the five most and the five least profitable participants by patterns of ownership. Total MWh is the sum of all MWh by ownership type regardless of profitability. The Top 5 Profit is the sum of the profits of the five most profitable participants by ownership type. The Top 5 Profit/MWh is the Top 5 Profit divided by the sum of the MWh of the top 5 participants by ownership type. The Top 5 Market Share of MWh is the sum of the MWh of the top 5 participants by ownership type divided by Total MWh. The Top 5 Profit Share Among Profitable Participants is the Top 5 Profit divided by the sum of the profits of all profitable participants by ownership type. The same logic applies for the statistics related to the Bottom 5 participants. The All row includes all participants including all ownership types when calculating the share of the profits and losses of the Top 5 and Bottom 5 participants. When all participants across ownership types are considered, all of the Top 5 participants are financial participants and three of the Bottom 5 participants are financial participants. Of all the ownership types, the Top 5 physical ARR participants' share of profits is the highest, 86.8 percent, as is their share of MWh, 54.5 percent. There are only a small number of physical ARR participants who directly purchase FTRs. The Bottom 5 financial participants' share of losses is the highest, 91.6 percent (excluding GreenHat's losses) while bottom 5 of physical participants' share is 66.9 percent. The losses from financial participants are concentrated in a small number of participants. The profit/MWh of the Top 5 physical participants was the highest, by ownership type. The loss/MWh of the Bottom 5 physical participants was the lowest, by ownership type.

³⁵ Bilateral profits and losses net to zero in market total profits and losses.

Table 13-14 Top 5 and bottom 5 FTR profits by ownership type: 2020/2021, June 2020 through March 2021

Organization Type	Total MWh	Top 5				Bottom 5			
		Profit	Profit/MWh	Market Share in MWh	Profit Share Among Profitable Participants	Loss	Loss/MWh	Market Share in MWh	Loss Share Among Unprofitable Participants
Financial	3,037,801,722	\$105,295,712	\$0.17	20.7%	33.3%	(\$95,560,081)	(\$0.23)	13.7%	90.5%
Financial without GreenHat	3,017,197,636	\$105,295,712	\$0.17	20.9%	33.3%	(\$95,560,081)	(\$0.23)	13.8%	91.6%
Physical	392,376,552	\$35,008,825	\$0.30	29.6%	48.4%	(\$17,004,432)	(\$0.57)	7.6%	66.8%
Physical ARR	372,936,582	\$33,206,833	\$0.16	54.5%	86.8%	(\$9,298,739)	(\$0.45)	5.6%	64.9%
All	3,803,114,856	\$105,295,712	\$0.17	16.6%	24.7%	(\$100,070,248)	(\$0.29)	8.9%	68.9%

Table 13-15 shows the shares of profitable and unprofitable FTR MWh by ownership type in the first 10 months of the 2020/2021 planning period. All ownership types had more profitable MWh than unprofitable MWh.

Table 13-15 MWh share by profitability by ownership type: 2020/2021, June 2020 through March 2021

Organization Type	Unprofitable	Profitable
Financial	17.6%	82.4%
Financial without GreenHat	17.0%	83.0%
Physical	18.6%	81.4%
Physical ARR	13.6%	86.4%
Total	20.2%	79.8%

Revenue

Monthly Balance of Planning Period FTR Auction Revenue

Table 13-16 shows monthly balance of planning period FTR auction revenue by trade type, type and class type for 2021. The Monthly Balance of Planning Period FTR Auctions for the first 10 months of the 2020/2021 planning period netted \$39.0 million in revenue, the difference between buyers paying \$229.8 million and sellers receiving \$190.9 million. For the entire 2019/2020 planning period, the Monthly Balance of Planning Period FTR Auctions netted \$52.9 million in revenue with buyers paying \$331.1 million and sellers receiving \$278.2 million.

Table 13-16 Monthly Balance of Planning Period FTR Auction revenue: 2021

Monthly Auction	Type	Trade Type	Class Type			
			24-Hour	On Peak	Off Peak	All
Jan-21	Obligations	Buy bids	\$1,941,358	\$3,115,732	\$6,036,272	\$11,093,362
		Sell offers	\$118,732	\$1,962,676	\$4,515,876	\$6,597,284
	Options	Buy bids	\$7,201	\$295,920	\$368,044	\$671,165
		Sell offers	\$52,076	\$1,307,888	\$1,874,030	\$3,233,994
Feb-21	Obligations	Buy bids	\$1,488,611	\$4,102,215	\$8,421,228	\$14,012,054
		Sell offers	\$151,204	\$3,430,637	\$6,788,020	\$10,369,861
	Options	Buy bids	\$6,780	\$178,510	\$273,701	\$458,991
		Sell offers	\$66,074	\$845,917	\$1,324,871	\$2,236,862
Mar-21	Obligations	Buy bids	\$875,232	\$4,248,129	\$8,919,313	\$14,042,674
		Sell offers	(\$370,674)	\$2,359,553	\$6,212,710	\$8,201,589
	Options	Buy bids	\$19,057	\$213,699	\$311,568	\$544,324
		Sell offers	\$52,023	\$1,084,212	\$1,726,196	\$2,862,432
2019/2020*	Obligations	Buy bids	\$133,437,559	\$129,554,826	\$45,741,569	\$308,733,954
		Sell offers	\$7,250,257	\$132,773,410	\$66,392,916	\$206,416,583
	Options	Buy bids	\$567,551	\$13,430,803	\$8,397,321	\$22,395,675
		Sell offers	\$1,210,460	\$44,320,769	\$26,237,313	\$71,768,541
	Net Total		\$125,544,393	(\$34,108,549)	(\$38,491,339)	\$52,944,505
2020/2021**	Obligations	Buy bids	\$75,696,027	\$49,987,312	\$92,071,410	\$217,754,749
		Sell offers	\$4,812,139.62	\$50,060,850	\$87,884,146	\$142,757,136
	Options	Buy bids	\$200,794	\$5,176,072	\$6,689,404	\$12,066,271
		Sell offers	\$1,021,582	\$19,949,359	\$27,126,810	\$48,097,752
	Net Total		\$70,063,099	(\$14,846,824)	(\$16,250,142)	\$38,966,132

* Shows twelve months for 2019/2020 **Shows ten months for 2020/2021

FTR Target Allocations

FTR target allocations were examined separately by source and sink contribution. Hourly FTR target allocations were divided into those that were benefits and liabilities and summed by sink and by source. Figure 13-6 shows the 10 largest positive and negative FTR target allocations, summed by sink, for the first 10 months of the 2020/2021 planning period. The top 10 sinks that produced financial benefit accounted for 35.1 percent of total positive target allocations with the Western Hub accounting for 10.9 percent of all positive target allocations. The top 10 sinks that created liability accounted for 16.4 percent of total negative target allocations with PSEG accounting for 3.8 percent of all negative target allocations.

Figure 13-6 Ten largest positive and negative FTR target allocations summed by sink: 2020/2021

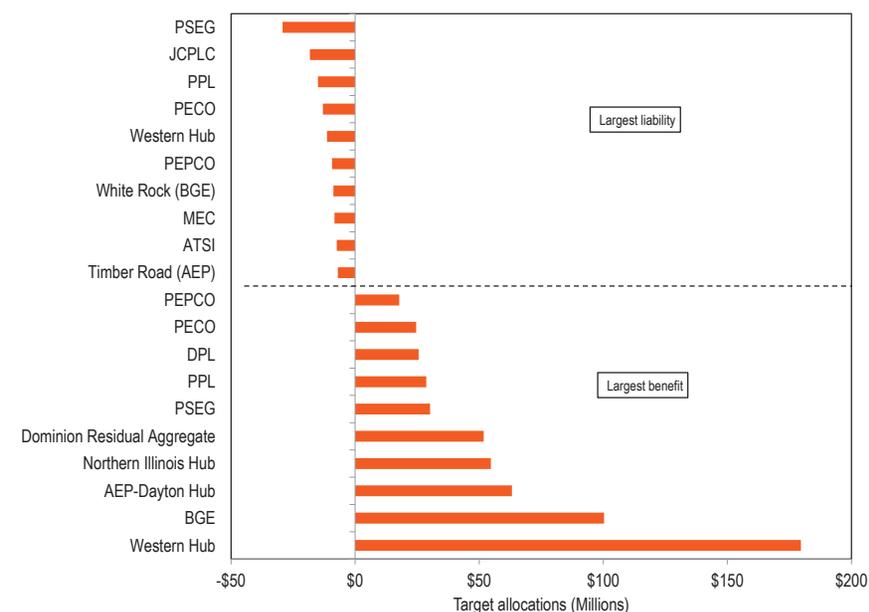
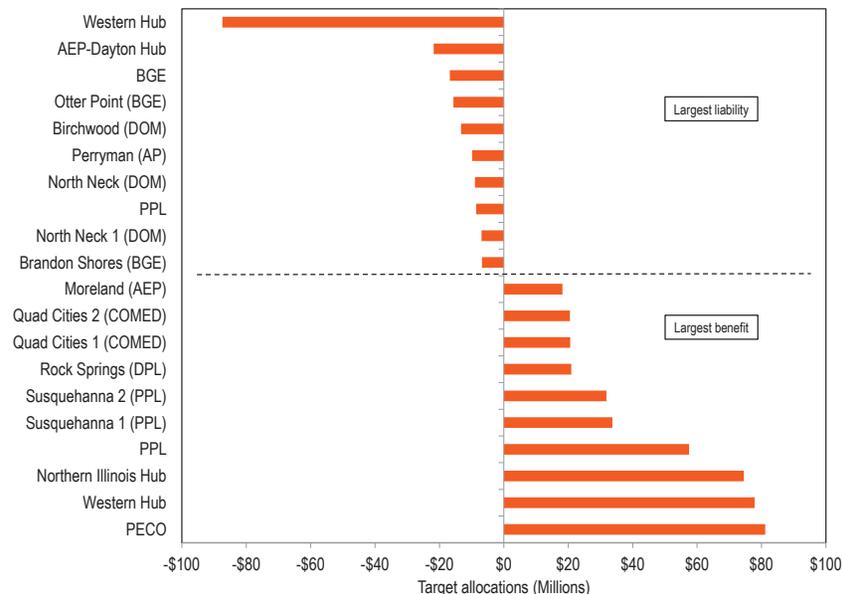


Figure 13-7 shows the 10 largest positive and negative FTR target allocations, summed by source, for the first 10 months of the 2020/2021 planning period. The top 10 sources with a positive target allocation accounted for 26.6 percent of total positive target allocations with the PECO accounting for 4.9 percent of total positive target allocations. The top 10 sources with a negative target allocation accounted for 25.2 percent of all negative target allocations, with the Western Hub accounting for 11.2 percent of total negative target allocations.

Figure 13-7 Ten largest positive and negative FTR target allocations summed by source: 2020/2021



Surplus Congestion Revenue

Surplus congestion revenue is a misnomer. In fact, there is no such thing as surplus congestion revenue. The rights to all congestion revenue belong to load. Surplus congestion revenue, as defined in PJM rules, is an artifact of the flawed design of the current approach to FTR/ARRs.

In the current design, surplus congestion revenue should be allocated to ARR holders because such revenue is part of total congestion revenues. In addition, FTR Auction revenue results from the prices paid by willing FTR buyers and should not be returned to FTR buyers for any reason and should be settled monthly.

Surplus day-ahead congestion is defined as the difference between the day-ahead congestion collected and FTR target allocations. Surplus FTR auction revenue is defined as the difference between the sum of monthly FTR auction revenue from the Long Term, Annual and monthly auctions, and ARR target allocations. Surplus FTR auction revenue can result from high prices in the FTR auctions, and from FTR capacity sold in excess of assigned ARR capacity on specific paths, and FTR capacity sold on paths not available to ARR holders.

Surplus congestion revenue is defined as the sum of the surplus day-ahead congestion revenue and the surplus FTR auction revenue at the end of each month.³⁶ Beginning with the 2014/2015 planning period, PJM may use surplus FTR auction revenue to pay for the clearing of counter flow FTRs as part of the auction clearing process.³⁷ The remaining surplus is first used to ensure that ARR target allocations in the month are fully funded. Any remaining surplus is used to pay any shortfall in FTR target allocations for the current month or prior months in the planning period. Any remaining surplus is used to pay any shortfall in FTR target allocations for the entire planning period at the end of the planning period. Any remaining surplus is distributed to ARR holders.³⁸

³⁶ Prior to the 2017/2018 planning period, the surplus congestion revenue was not the simple sum of the surplus FTR auction revenue and surplus day-ahead congestion because there were various cross market charges subtracted from FTR revenue, including M2M and competing use charges, which reduced available surplus congestion revenue.

³⁷ See "PJM Manual 6: Financial Transmission Rights," Rev. 26 (Jan. 27, 2021).

³⁸ On May 31, 2018, a rule change was implemented. Effective for the 2018/2019 planning period, surplus day-ahead congestion charges and surplus FTR auction revenue that remain at the end of the Planning Period allocated to ARR holders, rather than to FTR holders. 163 FERC ¶ 61,165 (2018).

If, at the end of the planning period, all the surplus congestion revenue has been provided to FTR holders and target allocations for the year are not covered, an uplift charge is assigned to FTR holders to cover the net planning period deficiency. An individual participant’s uplift charge allocation is the ratio of their share of net positive target allocations to the total net positive target allocations.

Figure 13-8 shows the distribution of the monthly surplus congestion revenue distributed to FTR holders as if it were settled monthly. The figure shows the portions of total monthly surplus, represented by the total height of the bar, that are from day-ahead congestion surplus, represented by the blue portion of the bar, and from auction surplus, represented by the orange portion of the bar. The horizontal green lines represent the amount of revenue that FTRs were paid from the surplus to be made whole for that month. The height of the bar below the green line is the portion of auction surplus that went to FTR holders, and the height of the bar above the green line is the portion that would have gone to ARR holders at the end of the planning period, if nothing changed and this surplus was not provided to FTRs. If a green line is above the bar that means there was not enough surplus congestion in that month to make FTRs whole. For example, September 2020 did not have enough surplus congestion to make FTRs whole. Those FTRs were made whole using surplus revenue from previous months.

The market rules should recognize that ARR holders have the right to all surplus congestion revenue, not just the remainder after funding FTRs. The MMU recommends that all FTR auction revenue be distributed to ARR holders monthly, regardless of FTR funding levels. The MMU recommends that, under the current FTR design, all congestion revenue in excess of FTR target allocations be distributed to ARR holders on a monthly basis. In Figure 13-8 the amount represented by each bar would be assigned to ARR holders in every month. In the first 10 months of the 2020/2021 planning period, \$117.4 million of surplus congestion revenue was paid to FTR holders that would have been paid to ARR holders under the MMU recommendation.

Figure 13-8 Monthly surplus congestion and auction revenue distributed to FTR holders: June 2017 through March 2021³⁹

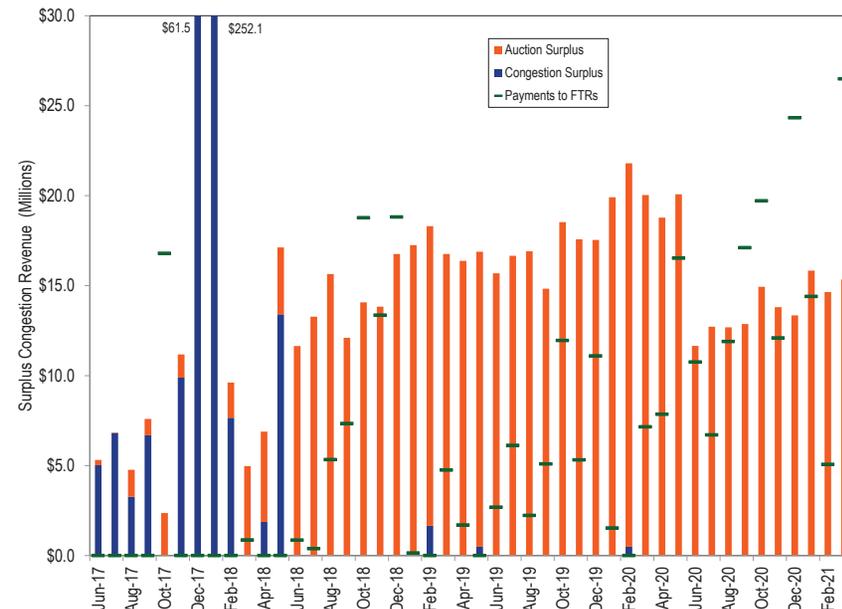


Figure 13-9 shows the surplus FTR auction revenue from the 2011/2012 planning period through the 2020/2021 planning period. Each new planning period introduces a new FTR model, including outages and PJM’s discretionary adjustments for revenue adequacy. The differences in the assumptions in the market model can result in large differences in FTR auction surplus and ARR revenue from one planning period to another.

FTR auction revenue is the value that FTR buyers assign to congestion rights that belong to ARR holders. There is no logical or market based reason to assign any part of that auction revenue back to the FTR buyers. It is inconsistent with the operation of a market that sellers are required to return some of the purchase price to buyers if the purchase is less profitable for buyers than expected. Auction revenue from the sale of FTRs should be distributed directly

³⁹ The bars for December 2018 and January 2019 are truncated.

and completely to ARR holders. The MMU recommends that all FTR auction revenue be distributed to ARR holders on a monthly basis.

Figure 13-9 Monthly FTR auction surplus: 2011/2012 through 2020/2021

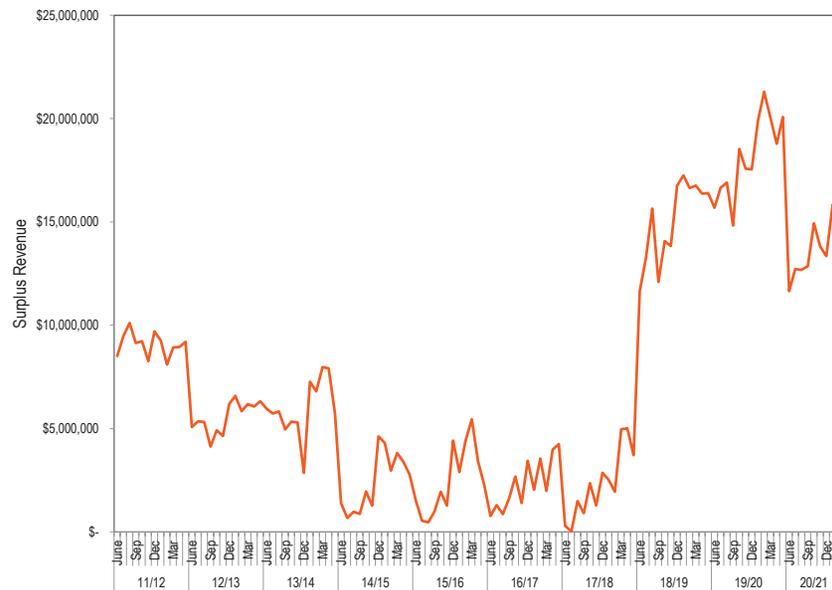


Table 13-17 shows the surplus FTR auction revenue, surplus day-ahead congestion revenue and surplus congestion revenue for planning periods 2010/2011 through the first 10 months of the 2020/2021 planning period.

Table 13-17 Surplus FTR Auction Revenue: 2010/2011 through 2020/2021⁴⁰

Planning Period	Surplus FTR Auction Revenue (Millions)	Surplus Day-Ahead Congestion (Millions)	Surplus Congestion Revenue (Millions)
2010/2011	\$29.7	(\$1,218.7)	(\$449.3)
2011/2012	\$108.9	(\$460.3)	(\$192.5)
2012/2013	\$66.7	(\$328.5)	(\$292.3)
2013/2014	\$71.7	(\$715.3)	(\$678.7)
2014/2015*	\$29.0	\$139.8	\$139.6
2015/2016	\$29.6	\$56.4	\$42.5
2016/2017	\$27.9	\$97.1	\$72.6
2017/2018	\$27.4	\$344.0	\$371.2
2018/2019	\$180.8	(\$68.5)	\$112.3
2019/2020	\$217.8	(\$87.9)	\$140.7
2020/2021**	\$137.8	(\$151.6)	(\$10.6)
Total	\$927.3	(\$2,393.4)	(\$744.5)

*Start of counter flow "buy back"

**First ten months

Revenue Adequacy

FTR revenue adequacy, like surplus congestion revenue, is a misnomer. FTR revenue adequacy, as defined in PJM rules, is an artifact of the flawed design of the current approach to FTR/ARRs.

As defined, FTR revenue adequacy simply compares congestion revenues to FTR target allocations. (Target allocations are the CLMP differences between the source and sink of the FTR times the MW of the FTR.) There is no reason to expect congestion revenues to equal FTR target allocations under the path based approach. Revenue adequacy is not a benchmark for how well the FTR process is working. Target allocations define the maximum payments to FTRs but target allocations are not congestion. FTR revenue adequacy is not equivalent to the adequacy of ARRs as an offset for load against total congestion. A path specific target allocation is not a guarantee of payment.

⁴⁰ Total congestion surplus not equal to the sum of the columns in years prior to the 2017/2018 planning period because other charges were subtracted from the congestion surplus.

Actual congestion revenues are unrelated to PJM's decisions about the FTR auction model. As a result, the fewer FTRs sold, the higher the probability that congestion will exceed the sum of the FTR target allocations. For example, PJM's subjective decision to reduce available system capability in FTR auctions for the 2014/2015 through 2016/2017 planning periods resulted in a high level of revenue adequacy. PJM's decisions have included the arbitrary use of higher outage levels and the decision to include additional constraints (closed loop interfaces) both of which reduced the FTRs made available for sale in FTR auctions. PJM's actions have led to a significant reduction in the allocation of Stage 1B and Stage 2 ARR and therefore a reduction in available FTRs.

While PJM's arbitrary decision to increase outages in the ARR allocation and in the Annual FTR Auction reduced FTR revenue inadequacy, it did not address the Stage 1A ARR over allocation issue directly because Stage 1A ARR allocations cannot be prorated. Instead, PJM's actions for the 2014/2015 through 2016/2017 planning periods resulted in decreased Stage 1B ARR allocations, decreased Stage 2 ARR allocations and decreased FTR capability. The direct assignment of balancing congestion and M2M payments to load beginning in the 2017/2018 planning period increased the congestion revenue available to pay FTR holders. In response, PJM reduced the number of outages taken in the ARR allocation and in the Annual FTR Auction, increasing ARR allocations and FTR availability.

The current ARR/FTR design does not serve as an efficient way to ensure that load receives all the congestion revenues or has the ability to receive the auction revenues associated with all the potential congestion revenues. There are several reasons for the disconnect between congestion revenues and ARR/FTR revenues in the current design. The reasons include: the use of generation to load paths rather than a measure of total congestion to assign congestion revenue rights; the failure to provide to ARR holders the full system capability that is provided to FTR purchasers in the Long Term FTR Auction; unavoidable modeling differences such as emergency outages; avoidable modeling differences such as outage modeling decisions; and cross subsidies among and between FTR participants and ARR holders.

Revenue adequacy for ARRs is, for practical purposes, a meaningless concept. Revenue adequacy for ARRs means that FTR buyers collectively pay more than zero for FTRs in FTR auctions, and that those payments were received by ARR holders. Unsurprisingly, ARRs have been revenue adequate for every auction to date. ARR revenue adequacy has nothing to do with the adequacy of ARRs as an offset to total congestion. ARRs can be revenue adequate at the same time that ARRs return only half of congestion to load, or even much less.

Total net FTR auction revenue for the 2019/2020 planning period, before accounting for self scheduling, load shifts or residual ARRs, was \$982.0 million. The FTR auction revenue pays ARR holders' credits. For the first 10 months of the 2020/2021 planning period, total net FTR auction revenue was \$688.7 million.

Table 13-18 presents the PJM FTR revenue detail for the 2019/2020 planning period and the first 10 months of the 2020/2021 planning period. This includes ARR target allocations from the Annual ARR Allocation and net revenue sources from the Long Term, Annual and Monthly Balance of Planning Period FTR Auctions.⁴¹ In this table, under the new balancing congestion and M2M payment rules, any negative congestion is from day-ahead congestion and does not include balancing congestion. A negative deficiency is a surplus, which will be distributed to ARR holders at the end of the planning period, while a positive deficiency is a shortfall, which will be charged as FTR uplift at the end of the planning period.

⁴¹ The final ARR values may change if load shifts.

Table 13-18 Total annual ARR and FTR revenue detail (Dollars (Millions)): 2019/2020 and 2020/2021

Accounting Element	2019/2020	2020/2021*
ARR information		
ARR target allocations	\$752.2	\$514.8
ARR credits	\$752.2	\$514.8
FTR auction revenue	\$982.0	\$688.7
Annual FTR Auction net revenue	\$844.6	\$577.0
Long Term FTR Auction net revenue	\$84.5	\$72.7
Monthly Balance of Planning Period FTR Auction net revenue	\$52.9	\$39.0
Surplus auction revenue		
ARR Surplus	\$217.8	\$137.9
ARR payout ratio	100%	100%
FTR targets		
Positive target allocations	\$904.3	\$1,124.0
Negative target allocations	(\$224.3)	(\$259.0)
FTR target allocations	\$680.1	\$865.0
Adjustments:		
Adjustments to FTR target allocations	(\$7.9)	(\$3.2)
Total FTR targets	\$673.5	\$861.8
FTR payout ratio	100%	99%
FTR revenues		
ARR excess	\$217.8	\$137.8
Congestion		
Net Negative Congestion (enter as negative)	\$0.0	\$0.0
Hourly congestion revenue	\$596.4	\$713.4
M2M Payments(credit to PJM minus credit to M2M entity)	\$0.0	\$0.0
Adjustments:		
Surplus revenues carried forward into future months	\$0.0	\$8.4
Surplus revenues distributed back to previous months	\$0.0	\$11.6
Other adjustments to FTR revenues	\$0.0	\$0.0
Total FTR revenues		
Surplus revenues distributed to other months	\$0.0	\$20.6
Net Negative Congestion charged to DA Operating Reserves	\$0.0	\$0.0
Total FTR congestion credits	\$814.2	\$871.8
Total congestion credits(includes end of year distribution)	\$814.2	\$871.8
Remaining deficiency	(\$140.7)	\$10.6

* First ten months of 2020/2021 planning period

FTR target allocations are defined based on hourly CLMP differences in the day-ahead energy market for FTR paths. FTR credits are paid to FTR holders and, depending on market conditions, can be less than the target allocations but are capped at target allocations. Table 13-19 lists the FTR revenues, target allocations, credits, payout ratios, congestion credit deficiencies and excess congestion charges by month.

The total row in Table 13-19 is not the sum of each of the monthly rows because the monthly rows may include excess revenues carried forward from prior months and excess revenues distributed back from later months. September 2020 had revenue shortfalls totaling \$4.2 million, but September FTR target allocations were fully funded using surplus revenue from previous months. March 2021 had revenue shortfalls that could not be made whole using surplus revenues from previous months, resulting in a revenue shortfall for the planning period through March.

Table 13-19 Monthly FTR accounting summary (Dollars (Millions)): 2019/2020 and 2020/2021

Period	FTR Revenues (with adjustments)	FTR Target Allocations	FTR Payout Ratio (original)	FTR Credits (with adjustments)	FTR Payout Ratio (with adjustments)	Monthly Credits Surplus/Deficiency (with adjustments)
Jun-19	\$52.1	\$39.4	100.0%	\$52.1	100.0%	(\$13.0)
Jul-19	\$91.7	\$82.0	100.0%	\$91.7	100.0%	(\$10.5)
Aug-19	\$57.1	\$42.8	100.0%	\$57.1	100.0%	(\$14.7)
Sep-19	\$83.4	\$73.6	100.0%	\$83.4	100.0%	(\$9.7)
Oct-19	\$91.1	\$84.5	100.0%	\$91.1	100.0%	(\$6.6)
Nov-19	\$84.6	\$72.3	100.0%	\$84.6	100.0%	(\$12.3)
Dec-19	\$80.6	\$74.1	100.0%	\$80.6	100.0%	(\$6.4)
Jan-20	\$63.2	\$44.8	100.0%	\$63.2	100.0%	(\$18.4)
Feb-20	\$50.0	\$28.2	100.0%	\$50.0	100.0%	(\$21.8)
Mar-20	\$51.4	\$38.5	100.0%	\$51.4	100.0%	(\$12.9)
Apr-20	\$42.9	\$32.0	100.0%	\$42.9	100.0%	(\$10.9)
May-20	\$66.2	\$62.7	100.0%	\$66.2	100.0%	(\$3.5)
Summary for Planning Period 2019/2020						
Total	\$814.2	\$674.9		\$814.2		(\$140.7)
Jun-20	\$74.4	\$73.3	100.0%	\$74.7	100.0%	(\$1.1)
Jul-20	\$118.3	\$112.3	100.0%	\$118.3	100.0%	(\$6.0)
Aug-20	\$95.2	\$94.4	100.0%	\$95.2	100.0%	(\$0.8)
Sep-20	\$90.9	\$95.2	94.9%	\$95.2	100.0%	\$0.0
Oct-20	\$67.5	\$72.2	93.1%	\$72.2	100.0%	\$0.0
Nov-20	\$55.1	\$53.4	100.0%	\$55.1	100.0%	(\$1.7)
Dec-20	\$79.6	\$90.5	87.5%	\$90.5	100.0%	\$0.0
Jan-20	\$69.0	\$67.6	100.0%	\$69.0	100.0%	(\$1.4)
Feb-20	\$104.9	\$95.4	100.0%	\$104.9	100.0%	(\$9.6)
Mar-20	\$96.9	\$107.5	89.6%	\$96.9	90.2%	\$10.6
Summary for Planning Period 2020/2021						
Total	\$851.8	\$861.8		\$872.2		\$10.6

Figure 13-10 shows the original PJM reported FTR payout ratio by month, excluding excess revenue distribution, for January 2004 through December 2020. The months with payout ratios above 100 percent have congestion revenue greater than the target allocations and the months with payout ratios under 100 percent have congestion revenue that is less than the target allocations. Figure 13-10 also shows the payout ratio after distributing surplus congestion revenue across months within the planning period. The payout ratio for revenue inadequate months in the current planning period may change if surplus congestion revenue is collected in the remainder of the planning period.

Figure 13-10 FTR payout ratio by month, excluding and including excess revenue distribution: January 2004 through March 2021

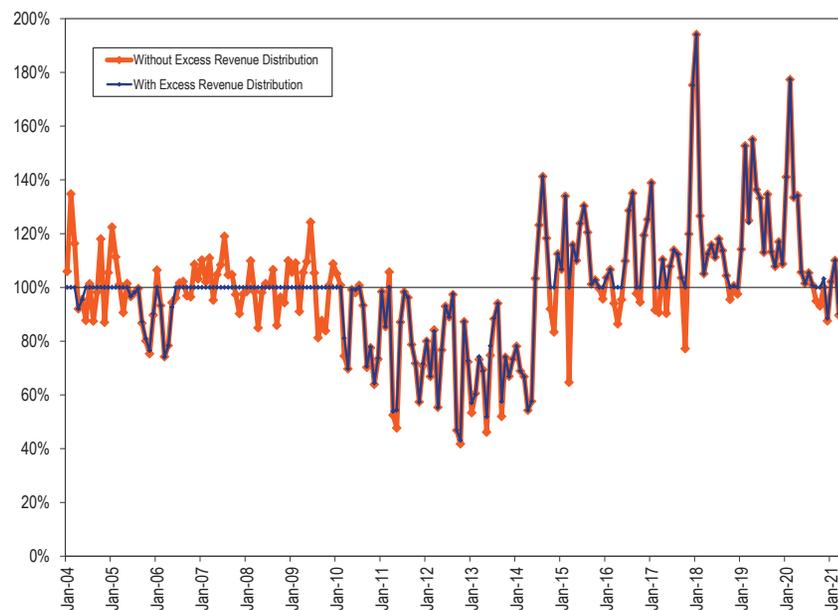


Table 13-20 shows the FTR payout ratio by planning period from the 2003/2004 planning period forward. Planning period 2013/2014 includes the additional revenue from unallocated congestion charges from Balancing Operating Reserves. Beginning with the 2018/2019 planning period payments to FTRs are limited to 100 percent of the target allocations.

Table 13-20 Reported FTR payout ratio by planning period⁴²

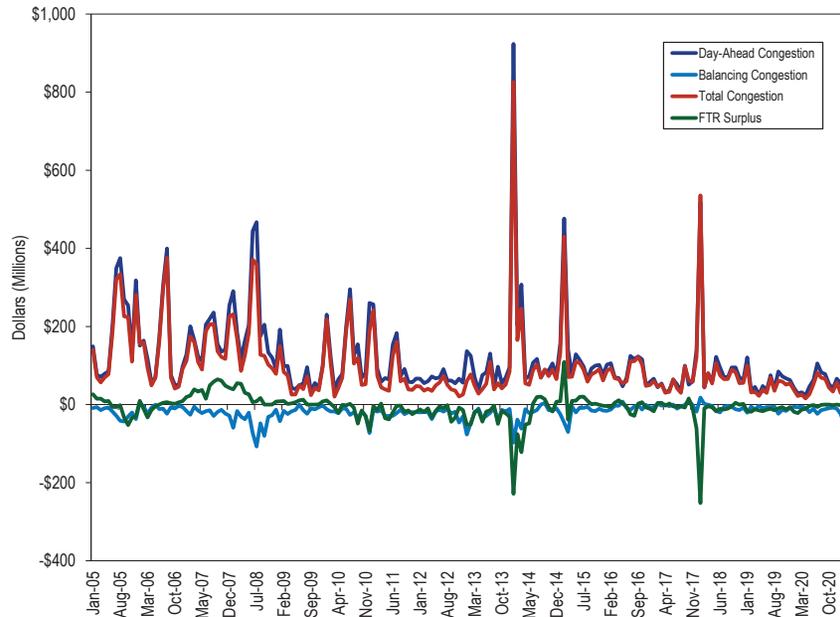
Planning Period	FTR Payout Ratio
2003/2004	97.7%
2004/2005	100.0%
2005/2006	90.7%
2006/2007	100.0%
2007/2008	100.0%
2008/2009	100.0%
2009/2010	96.9%
2010/2011	85.0%
2011/2012	80.6%
2012/2013	67.8%
2013/2014	72.8%
2014/2015	116.2%
2015/2016	106.8%
2016/2017	112.6%
2017/2018	138.5%
2018/2019	100.0%
2019/2020	100.0%
2020/2021*	98.8%

* First 10 months of 2020/2021

42. The actual payout ratios for planning periods 2006/2007, 2007/2008, and 2008/2009 may have exceeded 100 percent.

Figure 13-11 shows the FTR surplus, day-ahead, balancing and total congestion payments from January 2005 through March 2021.

Figure 13-11 FTR surplus and day-ahead, balancing and total congestion: 2005 through March 2021



ARRs as an Offset to Congestion for Load

Load pays for the transmission system and pays congestion revenues. FTRs, and later ARRs, were intended to return congestion revenues to load to offset an unintended consequence of locational marginal pricing. With the implementation of the current, path based FTR/ARR design, the purpose of FTRs has been subverted. The inconsistencies between actual network solutions used to serve load and path based rights available to load cause a misalignment of congestion paid by load and the congestion paid to load, in aggregate and on a specific load basis. These inconsistencies between actual network use and path based rights cause cross subsidies between ARR holders

and FTR holders and among ARR holders. One result of this misalignment is that individual zones have very different offsets due to the location of their path based ARRs compared to their actual congestion costs from actual network use.

Table 13-21 shows the ARR and FTR revenue paid to load, the congestion offset available to load with and without allocating balancing congestion to load and the congestion offset when surplus congestion revenue is allocated to load. The highlighted offsets are the actual offsets based on the rules that were effective in that planning period. The pre 2017/2018 offset is calculated as the ARR credits and the FTR credits excluding balancing congestion and M2M payments, divided by the total day-ahead congestion and the load share of balancing and M2M payments.

The allocation of balancing congestion and M2M payments to load went into effect for the 2017/2018 planning period. If these rules had been in place beginning with the 2011/2012 planning period, ARR holders would have received a total of \$1,351.4 million less in congestion offsets from the 2011/2012 through the 2019/2020 planning period. The total overpayment to FTR holders for the 2011/2012 through 2019/2020 planning period would have been \$1,534.3 million.

Total ARR and self scheduled FTR revenue offset 45.8 percent of total congestion costs for the first 10 months of the 2020/2021 planning period. For the 2019/2020 planning period, FTR bidders paid more in the auctions than the actual day-ahead target allocations for the same paths. The unexpected reduction in energy prices in 2020 led to a corresponding unexpected reduction in target allocations and in actual congestion. This resulted in an offset over 100 percent because the resulting total ARR value was greater than actual congestion costs. FTR prices were lower in the Annual FTR Auction for 2020/2021, reducing the offset for the first 10 months of the 2020/2021 planning period.

Table 13-21 ARR and FTR total congestion offset (in millions) for ARR holders: 2011/2012 through 2020/2021

Planning Period	Revenue					Pre 2017/2018 (Without Balancing)		2017/2018 (With Balancing)		Post 2017/2018 (With Balancing and Surplus)				
	ARR Credits	Unadjusted FTR Credits	Day Ahead Congestion	Balancing + M2M Congestion	Total Congestion	Surplus Revenue Pre 2017/2018 Rules	Surplus Revenue 2017/2018 Rules	Post 2017/2018 Rules	Total ARR/ FTR Offset	Percent Offset	Current Revenue Received	Percent Offset	New Revenue Received	New Offset
2011/2012	\$512.2	\$310.0	\$1,025.4	(\$275.7)	\$749.7	(\$50.6)	\$35.6	\$113.9	\$771.6	102.9%	\$582.1	77.6%	\$660.4	88.1%
2012/2013	\$349.5	\$268.4	\$904.7	(\$379.9)	\$524.8	(\$94.0)	\$18.4	\$62.1	\$523.9	99.8%	\$256.4	48.9%	\$300.1	57.2%
2013/2014	\$337.7	\$626.6	\$2,231.3	(\$360.6)	\$1,870.6	(\$139.4)	(\$49.0)	(\$49.0)	\$824.8	44.1%	\$554.6	29.7%	\$554.6	29.7%
2014/2015	\$482.4	\$348.1	\$1,625.9	(\$268.3)	\$1,357.6	\$36.7	\$111.2	\$400.6	\$867.2	63.9%	\$673.4	49.6%	\$962.8	70.9%
2015/2016	\$635.3	\$209.2	\$1,098.7	(\$147.6)	\$951.1	\$9.2	\$42.1	\$188.9	\$853.7	89.8%	\$739.0	77.7%	\$885.9	93.1%
2016/2017	\$640.0	\$149.9	\$885.7	(\$104.8)	\$780.8	\$15.1	\$36.5	\$179.0	\$805.0	103.1%	\$721.6	92.4%	\$864.0	110.7%
2017/2018	\$427.3	\$212.3	\$1,322.1	(\$129.5)	\$1,192.6	\$52.3	\$80.4	\$370.7	\$692.0	58.0%	\$590.6	49.5%	\$880.9	73.9%
2018/2019	\$529.1	\$130.1	\$832.7	(\$152.6)	\$680.0	(\$5.8)	\$16.2	\$112.2	\$653.34	96.1%	\$522.7	76.9%	\$618.8	91.0%
2019/2020	\$542.0	\$91.9	\$612.1	(\$169.4)	\$442.7	(\$1.6)	\$21.6	\$157.8	\$632.3	142.8%	\$486.1	109.8%	\$622.2	140.6%
2020/2021*	\$311.0	\$133.1	\$713.4	(\$213.5)	\$499.9	(\$34.6)	(\$1.6)	(\$1.6)	\$409.48	81.9%	\$229.0	45.8%	\$229.0	45.8%
Total	\$4,766.5	\$2,479.6	\$11,251.8	(\$2,201.9)	\$9,049.9	(\$212.7)	\$311.3	\$1,534.5	\$7,033.4	77.7%	\$5,355.5	59.2%	\$6,578.7	72.7%

* 10 months of 2020/2021 planning period

Table 13-21 illustrates the inadequacies of the ARR/FTR design. The goal of the design should be to give the rights to 100 percent of the congestion revenues to the load.

The cumulative offset, beginning in the 2011/2012 planning period, is the sum of the revenue received for that planning period and all previous planning periods divided by the total congestion for that planning period and all previous planning periods. The cumulative shortfall is the cumulative difference between the ARR holders' revenue and the congestion they paid, for the planning period and prior planning periods.

Table 13-22 also shows the cumulative offset and shortfall, assuming the rules implemented in the 2017/2018 planning period. The cumulative offset percentage has increased since the 2014/2015 planning period except for the 2019/2020 planning period. The cumulative offset would have been 72.7 percent if the 2017/2018 surplus allocation rules had been in place for the entire period.

Table 13-22 ARR and FTR cumulative offset for ARR holders using 2017/2018 surplus allocation: 2011/2012 through 2020/2021

Planning Period	Cumulative Offset	Cumulative Shortfall (Millions)
2011/2012	88.1%	(\$89.3)
2012/2013	75.4%	(\$314.0)
2013/2014	48.2%	(\$1,630.0)
2014/2015	55.0%	(\$2,024.8)
2015/2016	61.7%	(\$2,090.0)
2016/2017	67.8%	(\$2,006.8)
2017/2018	68.8%	(\$2,318.5)
2018/2019	70.6%	(\$2,379.8)
2019/2020	74.3%	(\$2,200.2)
2020/2021*	72.7%	(\$2,471.1)

* 10 months of 2020/2021 Planning Period

Table 13-23 shows the cumulative offset and shortfall using the rules that were effective in the given planning period to calculate the ARR/FTR revenue. The cumulative offset was 74.1 percent based on the rules that were in place for each planning period. Load has been underpaid by \$2.3 billion from the 2011/2012 planning period through the first 10 months of the 2020/2021 planning period. The amount of underpayment would have been even greater, \$3.7 billion, if the 2017/2018 surplus allocation rules had been in place for the entire period.

Table 13-23 ARR and FTR cumulative offset for ARR holders using effective surplus allocation rules: 2011/2012 through 2020/2021

Planning Period	Cumulative Offset	Cumulative Shortfall (Millions)
2011/2012	102.9%	\$21.9
2012/2013	101.6%	\$21.0
2013/2014	67.4%	(\$1,024.8)
2014/2015	66.3%	(\$1,515.2)
2015/2016	70.4%	(\$1,612.6)
2016/2017	74.5%	(\$1,588.4)
2017/2018	70.5%	(\$2,190.4)
2018/2019	72.2%	(\$2,251.7)
2019/2020	75.8%	(\$2,072.1)
2020/2021*	74.1%	(\$2,343.0)

* 10 months of 2020/2021 Planning Period

Zonal ARR Congestion Offset

Zonal ARR congestion offsets vary significantly across zones. There is no reason that this should be the result. This outcome is a direct result of the flawed definition of congestion and of the method for assigning rights to congestion to ARR holders. The results show that path based ARR assignments in the current path based ARR/FTR design are not aligned with actual network use by load, and are therefore not aligned with how congestion is actually paid by load on actual network usage. Due to this misalignment of ARR rights relative to actual network usage, individual loads cannot claim the congestion they paid through assigned ARRs. The misalignment of path based ARR rights produces cross subsidies among ARR holders.

ARRs are allocated to zonal load based on historical generation to load transmission contract paths, in many cases based on 1999 contract paths. ARRs are allocated within zones based on zonal base load (Stage 1A) and zonal peak loads (other stages). ARR revenue is the result of the prices that result from the sale of FTRs through the FTR auctions. ARR revenue for each zone is the revenue for the ARRs that sink in each zone.

Congestion paid by load in a zone is the total difference between what the zonal load pays in congestion charges net of payments to the generation that serves the zonal load, including generation in the zone and outside the zone.⁴³

Table 13-24 shows the day-ahead congestion and balancing congestion and M2M charges paid by load in each zone along with the congestion offsets paid to load: FTR auction revenue; self scheduled FTR revenue adjusted by the payout ratio for FTRs if below 100 percent; and the allocation of end of planning period surplus.⁴⁴ The offset for the 2020/2021 planning period assigns the current surplus revenue at the end of the quarter to ARR holders. Table 13-24 also shows payments by load for balancing congestion and M2M payments. The total congestion offset paid to load is the sum of all of those credits and charges.

The zonal offset percentage shown in Table 13-24 is the sum of the congestion related revenues (offset) paid to load in each zone divided by the total congestion payment made by load in each zone.

⁴³ See "Constraint Based Congestion Calculations," PJM ARR FTR Market Task Force (July 17, 2020) <<https://www.pjm.com/-/media/committees-groups/task-forces/afmtf/2020/20200722/20200722-item-03a-constraint-based-congestion-calculations.ashx>>.

⁴⁴ See 2019 State of the Market Report for PJM, Volume II, Section 11: Congestion and Marginal Losses

Table 13-24 Zonal ARR and FTR total congestion offset (in millions) for ARR holders: 2020/2021 planning period

Zone	ARR Credits	Balancing+			Total Offset	Day Ahead Congestion	Balancing Congestion	M2M Payments	Total Congestion	Offset
		Adjusted FTR Credits	M2M Charge	Surplus Allocation						
ACEC	\$3.7	\$0.0	(\$2.3)	(\$0.1)	\$1.5	\$6.6	(\$2.0)	(\$0.3)	\$4.4	33.3%
AEP	\$33.6	\$25.7	(\$31.4)	(\$1.7)	\$28.0	\$115.5	(\$27.8)	(\$3.6)	\$84.1	33.3%
APS	\$27.3	\$12.8	(\$12.3)	(\$1.0)	\$27.8	\$48.1	(\$10.9)	(\$1.4)	\$35.8	77.8%
ATSI	\$17.0	\$0.2	(\$16.1)	(\$0.4)	\$1.0	\$55.1	(\$14.3)	(\$1.8)	\$39.1	2.6%
BGE	\$48.6	\$2.8	(\$7.6)	(\$1.2)	\$43.9	\$26.4	(\$6.7)	(\$0.9)	\$18.9	232.5%
COMED	\$30.3	\$10.7	(\$23.6)	(\$0.9)	\$17.5	\$84.3	(\$20.9)	(\$2.7)	\$60.7	28.8%
DAY	\$5.0	\$0.5	(\$4.3)	(\$0.1)	\$1.2	\$12.8	(\$3.8)	(\$0.5)	\$8.5	13.9%
DUKE	\$20.2	\$3.5	(\$6.6)	(\$0.6)	\$17.1	\$19.8	(\$5.9)	(\$0.8)	\$13.2	129.6%
DUQ	\$4.7	\$0.2	(\$3.3)	(\$0.1)	\$1.5	\$8.0	(\$2.9)	(\$0.5)	\$4.6	33.9%
DOM	\$6.3	\$56.6	(\$31.6)	(\$1.4)	\$31.3	\$93.4	(\$28.7)	(\$0.4)	\$64.3	48.7%
DPL	\$24.0	\$7.8	(\$5.8)	(\$0.7)	\$26.0	\$41.0	(\$5.2)	(\$3.0)	\$32.8	79.2%
EKPC	\$2.5	\$0.0	(\$3.5)	(\$0.1)	(\$0.9)	\$10.1	(\$3.1)	(\$0.4)	\$6.6	(13.7%)
EXT	\$0.4	\$0.0	(\$12.8)	(\$0.0)	(\$12.4)	\$21.0	(\$12.8)	\$0.0	\$8.2	(151.9%)
JCPLC	\$5.0	\$0.0	(\$5.0)	(\$0.1)	\$0.0	\$15.4	(\$4.3)	(\$0.6)	\$10.4	0.3%
MEC	\$2.9	\$0.5	(\$4.4)	(\$0.1)	(\$1.0)	\$17.6	(\$4.0)	(\$0.4)	\$13.2	(7.8%)
OVEC	\$0.0	\$0.0	(\$0.2)	\$0.0	(\$0.2)	\$1.0	(\$0.2)	\$0.0	\$0.8	(30.8%)
PECO	\$12.4	\$0.2	(\$9.0)	(\$0.3)	\$3.7	\$28.3	(\$7.9)	(\$1.1)	\$19.3	18.9%
PE	\$5.0	\$4.2	(\$5.0)	(\$0.2)	\$4.2	\$19.0	(\$4.6)	(\$0.5)	\$14.0	30.4%
PEPCO	\$21.5	\$3.0	(\$6.8)	(\$0.6)	\$17.7	\$21.8	(\$6.0)	(\$0.8)	\$15.0	118.4%
PPL	\$19.6	\$2.7	(\$9.5)	(\$0.5)	\$12.8	\$33.8	(\$8.4)	(\$1.2)	\$24.3	52.9%
PSEG	\$20.6	\$0.0	(\$11.8)	(\$0.5)	\$8.8	\$31.9	(\$10.6)	(\$1.2)	\$20.1	43.8%
REC	\$0.2	\$0.0	(\$0.5)	(\$0.0)	(\$0.3)	\$2.3	(\$0.4)	(\$0.0)	\$1.9	(16.7%)
Total	\$311.0	\$131.6	(\$213.4)	(\$10.6)	\$229.2	\$713.4	(\$191.4)	(\$22.0)	\$499.9	45.8%

The total congestion offset paid to loads in the first 10 months of the 2020/2021 planning period was 45.8 percent of congestion costs. The results vary significantly by zone. Loads in some zones, like BGE, receive substantially more in offsets than their total congestion payments. Loads in other zones, like ATSI, receive substantially less in offsets than their total congestion payments. The offsets are a function of the assignment of ARRs and the valuation of ARRs in the FTR auctions.

Offset Available from Self Scheduling

It is not possible for load to recover all of the congestion that they pay under the current design in which the rights to congestion revenues are assigned based on fictitious contract paths. Table 13-25 shows the total congestion offset that would be available to ARR holders via allocated ARRs, by zone, if the ARR holders self scheduled all their allocated ARRs as FTRs in the 2016/2017 through 2019/2020 planning periods. The results show that the recovery of congestion varies significantly by zone and that some zones recover more than the congestion they pay and some zones recover less. This is not consistent with a rational FTR/ARR design based on the fundamentals of the way that congestion costs are actually paid. The total offset available to ARR holders if they were to self schedule all of their ARRs in aggregate is less than total congestion paid by load in aggregate.

Table 13-25 Offset available to load if all ARRs self scheduled: 2016/2017 through 2019/2020 planning periods

	17/18 Planning Period				18/19 Planning Period				19/20 Planning Period			
	SS FTR	Bal+M2M	Congestion+M2M	Offset	SS FTR	Bal+M2M	Congestion+M2M	Offset	SS FTR	Bal+M2M	Congestion+M2M	Offset
ACEC	\$1.8	(\$1.6)	\$13.2	1.4%	\$11.5	(\$1.9)	\$9.7	99.3%	\$2.6	(\$2.0)	\$3.7	16.3%
AEP	\$203.3	(\$20.4)	\$189.3	96.6%	\$84.9	(\$23.7)	\$102.0	60.0%	\$62.7	(\$26.2)	\$79.9	45.7%
APS	\$78.7	(\$7.8)	\$57.2	123.9%	\$37.4	(\$9.2)	\$43.0	65.5%	\$31.2	(\$10.1)	\$30.9	68.2%
ATSI	\$54.1	(\$10.6)	\$71.2	61.0%	\$45.3	(\$12.4)	\$50.7	65.0%	\$27.9	(\$13.5)	\$35.8	40.3%
BGE	\$83.1	(\$5.0)	\$42.6	183.3%	\$49.0	(\$5.8)	\$19.2	224.9%	\$53.7	(\$6.4)	\$14.9	316.6%
COMED	\$110.9	(\$15.4)	\$181.0	52.8%	\$51.4	(\$17.8)	\$95.9	35.1%	\$40.6	(\$19.6)	\$66.9	31.4%
DAY	\$10.5	(\$2.8)	\$21.2	36.7%	\$11.2	(\$3.2)	\$12.2	65.0%	\$5.6	(\$3.5)	\$9.5	21.3%
DUKE	\$72.2	(\$4.3)	\$37.6	180.5%	\$50.4	(\$5.0)	\$22.7	199.9%	\$30.5	(\$5.6)	\$14.5	171.6%
DUQ	\$10.6	(\$2.2)	\$12.2	68.9%	\$7.2	(\$2.5)	\$7.4	63.5%	\$8.1	(\$3.8)	\$5.0	86.2%
DOM	\$42.4	(\$15.8)	\$133.8	19.9%	\$55.8	(\$18.7)	\$63.5	58.5%	\$32.8	(\$2.8)	\$57.7	52.1%
DPL	\$38.0	(\$2.9)	\$68.6	51.1%	\$57.7	(\$3.4)	\$58.5	92.8%	\$27.3	(\$21.0)	\$17.6	35.9%
EKPC	(\$3.5)	(\$2.1)	\$20.5	(27.2%)	\$0.9	(\$2.4)	\$9.0	(16.8%)	\$4.1	(\$2.7)	\$7.2	20.3%
EXT	\$3.4	(\$5.2)	\$28.7	(6.3%)	\$1.7	(\$7.5)	\$13.6	(42.7%)	\$0.9	(\$9.0)	\$7.0	(115.0%)
JCPLC	\$2.7	(\$3.6)	\$32.1	(2.7%)	\$2.6	(\$4.2)	\$19.7	(7.9%)	\$2.3	(\$4.6)	\$9.0	(25.3%)
MEC	\$7.6	(\$2.5)	\$26.5	19.3%	\$5.0	(\$2.9)	\$14.0	14.9%	\$0.8	(\$3.2)	\$8.6	(27.8%)
OVEC	\$0.0	\$0.0	\$0.0	0.0%	\$0.0	\$0.0	\$0.0	0.0%	\$0.0	\$0.0	\$0.3	0.0%
PECO	\$15.7	(\$6.4)	\$57.7	16.2%	\$15.7	(\$7.5)	\$28.7	28.5%	\$16.8	(\$8.1)	\$12.5	68.9%
PE	\$15.4	(\$2.7)	\$30.5	41.7%	\$17.5	(\$3.2)	\$18.3	78.2%	\$11.2	(\$3.5)	\$10.6	72.2%
PEPCO	\$38.1	(\$4.8)	\$39.2	84.9%	\$19.5	(\$5.5)	\$17.4	80.3%	\$23.2	(\$6.0)	\$13.3	128.9%
PPL	\$14.7	(\$6.4)	\$65.3	12.7%	\$4.3	(\$7.6)	\$35.3	(9.2%)	\$39.2	(\$8.4)	\$19.8	155.7%
PSEG	\$58.6	(\$6.9)	\$62.4	82.9%	\$35.6	(\$8.1)	\$37.5	73.5%	\$21.3	(\$8.9)	\$17.8	69.6%
REC	(\$0.1)	(\$0)	\$1.9	(17.1%)	\$0.2	(\$0.3)	\$1.7	(6.2%)	\$0.2	(\$0.3)	\$0.7	(18.0%)
Total	\$858.0	(\$129.5)	\$1,192.6	61.1%	\$565.0	(\$152.7)	\$680.2	60.6%	\$443.0	(\$169.4)	\$443.1	61.8%

Credit

There were five collateral defaults in 2021. There were five payment defaults in 2021 not involving GreenHat Energy, LLC for a total of \$1.8 million. GreenHat Energy accrued payment defaults of \$1.1 million in 2021 for a total of \$163.0 million in defaults to date, which will continue to accrue through May 2021, including the auction liquidation costs.⁴⁵ In addition, PJM added the settlement fee and claimant payee funds to the default allocation, resulting in a total of \$180.5 million to date.

⁴⁵ See the 2019 Quarterly State of the Market Report for PJM: January through June for a more complete explanation of credit issues that occurred in 2019.

GreenHat Settlement Proceedings

On June 5, 2019, FERC issued an order that established a paper hearing and settlement judge procedures regarding the GreenHat liquidation waiver request.⁴⁶ FERC recognized “...there are multiple complexities associated with implementing the Waiver Order Directive that should be addressed in a paper hearing...”⁴⁷ Before the paper hearing began, FERC established a settlement procedure to “...encourage the parties to make every effort to settle their disputes before the paper hearing commences.”⁴⁸

- By delegated order issued December 30, 2019, the Commission approved a settlement agreement between PJM and the interested parties.⁴⁹ The result of the settlement was a release of all claims of harm resulting from the July auction liquidation of GreenHat’s portfolio, the payment of \$12.5 million directly to two participants, and payment of up to \$5 million total to participants that can show economic harm from PJM’s actions during the July auction.

This settlement, requiring up to \$17.5 million in additional payments, will be recovered via the default allocation assessment fund, which is allocated to all PJM members in proportion to their total net bill.

Default Portfolio Considerations

Under the method applied to the GreenHat default, when an FTR participant defaults on their positions, their portfolio remains in the FTR market and will continue to accrue revenues and/or charges and must be reconciled. Under this method, PJM leaves the participant’s positions unchanged, lets the positions settle at day-ahead prices, and charges any net losses to the default allocation assessment. This method exposes all members in PJM to an uncertain charge for the default allocation assessment that will not be known until those FTRs settle.

⁴⁶ On June 21, 2018, GreenHat Energy, LLC was declared in payment default for non-payment of a \$1.2 million weekly invoice on June 5, 2018. GreenHat had been declared in default twice earlier in June 2018 for two collateral calls totaling \$2.8 million. Daugherty, Suzanne, email sent to the MC, MRC, CS, and MSS email distribution list, “Notification of GreenHat Energy, LLC Payment Default,” (June 22, 2018).

⁴⁷ See 167 FERC ¶ 61, 2019 at P 27 (2019).

⁴⁸ See *Id.* at P 28.

⁴⁹ See 169 FERC ¶ 61,260 (2019).

The MMU recommends a method under which defaulted FTRs would be canceled rather than holding or liquidating them. Canceling the FTRs would release the FTRs to the FTR market. The market would then decide the value of the capacity released and the timing of its release. There would be no discretion necessary to settle the defaulted position and the losses would be contained within the ARR/FTR market.

Cancellation of a defaulting portfolio does not change congestion. But cancellation of a defaulting portfolio can affect ARR/FTR funding as a result of changes in auction revenue, changes in the net target allocations, and potential simultaneous feasibility violations, while any collateral collected from the defaulted participant is available to offset losses from the cancelled FTRs. However, PJM can and does address similar issues routinely. PJM has tools available, such as the counter flow buyback and Stage 1A over allocation rules, and uses them regularly in the Annual FTR Auction, to improve funding as well as address feasibility concerns. Cancellation of FTRs would isolate the costs of the default to those participating in and benefitting from the FTR market.

FTR Forfeitures

In the Forfeiture Rule Directive, the Commission determined that the Forfeiture Rule is just and reasonable and “...serves to deter such manipulation” related to virtual transaction cross product manipulation.⁵⁰ The Commission identified four main tenets with which the Forfeiture Rule must comply, including that it: (i) deter manipulation, (ii) provide transparency allowing participants to modify their behavior, (iii) base forfeitures on an individual participant’s actions and (iv) is not punitive.⁵¹

The point of the Forfeiture Rule is to avoid an inefficient and costly process and to establish an objective rule that prevents profiting from virtual trading on one’s own FTR positions. The Forfeiture Rule operates to remove the incentive to engage in manipulation; the rule does not involve findings of manipulation.⁵²

⁵⁰ Forfeiture Rule Directive at P 33.

⁵¹ Forfeiture Rule Directive at P 62.

⁵² See “Protest and Motion for Rejection of the Independent Market Monitor for PJM,” Docket No. EL20-41 (June 1, 2020).

The FTR forfeiture rule considers the impact of a participant's net virtual transaction portfolio on all constraints.⁵³ If a participant's net virtual portfolio impacts a constraint by the greater of 0.1 MW or 10 percent or more of the line limit, and that constraint affects an individual FTR's target allocation by \$0.01, metric that the participant's net virtual portfolio increased the value of the FTR, then the FTR is subject to FTR forfeiture.

The FTR Forfeiture Rule does not penalize FTR holders. The FTR forfeiture rule does not affect the profits or losses of virtual activity. The FTR Forfeiture Rule, if triggered by a participant's virtual portfolio, results in forfeiting only FTR profits and only in the specific hours for which the rule is violated. The profit is calculated as the hourly FTR target allocation minus the FTR's hourly cost. Even when FTR profits are forfeited, the value that the buyer assigned to congestion in the FTR auction (the price paid) is not affected. For example, if a buyer paid \$5.00/MWh for congestion and congestion was \$5.00/MWh, the forfeiture would be zero. If congestion were \$7.00/MWh, the forfeiture would be \$2.00/MWh. Market participants understand the relationship between FTR and virtual positions in detail and can avoid violating the FTR forfeiture rule if they choose to do so.

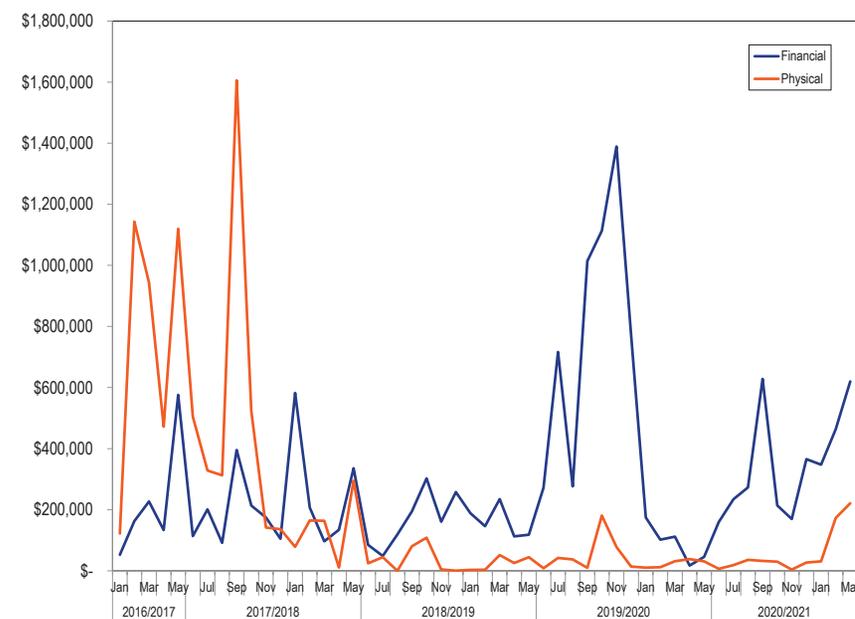
The FTR forfeiture rule has not reduced participation in the PJM FTR market or participation in virtual activity. There has been an increase in the number of participants in the FTR market since the implementation of the new FTR forfeiture rule, and a decrease in the number of participants with forfeitures.

Figure 13-12 shows the monthly FTR forfeitures under the modified FTR forfeiture rule from January 19, 2017, through March 31, 2021. As required by the FERC order, PJM began retroactively billing FTR forfeitures with the September 2017 bill. In the period from January 2017 through September 2017, participants did not have good information about the level of their FTR forfeitures, so they could not accurately modify their bidding behavior to avoid FTR forfeitures. After September 2017, FTR forfeitures decreased significantly, and stabilized, as participants received information on their FTR forfeitures.

⁵³ A modified FTR forfeiture rule was implemented effective January 19, 2017. See *2019 State of the Market Report for PJM*, Volume II, Section 13: Financial Transmission Rights for the full history.

On June 24, 2019, PJM implemented a new method to properly calculate the hourly cost of an FTR only for hours in which it is effective.⁵⁴ Beginning with the September 2019 bill, PJM began billing using the correct hourly cost calculation. For the first 10 months of the 2020/2021 planning period, total FTR forfeitures were \$4.0 million.

Figure 13-12 Monthly FTR forfeitures for physical and financial participants



⁵⁴ See "Minor modification to Tariff Language for FTR Forfeiture Rule," Docket No. ER19-2240 (June 24, 2019).

