

State of the Market Report for PJM

Volume 1:
Introduction

Monitoring Analytics, LLC

Independent
Market Monitor
for PJM

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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 *2020 Annual State of the Market Report for PJM*.³

¹ PJM Open Access Transmission Tariff (OATT) Attachment M (PJM Market Monitoring Plan) § V.I.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: *2020 Annual State of the Market Report for PJM*.

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Introduction

2020 in Review

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 the energy market were competitive in 2020. The results of the last base capacity auction, run in 2018 for 2021/2022, were not competitive and the underlying issues need to be addressed, including the overstated offer cap in the capacity market. The PJM markets bring customers the benefits of competition. The results of PJM markets were reliable in 2020. 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.

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. The FRR explorations by multiple states illustrated a possible path forward. Under that path, while the FERC market would be unaffected by subsidies, many states would just 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 for the markets 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 the application of the Effective Load Carrying Capability (ELCC) approach to defining a dynamic and market based method for determining the capacity contribution of intermittent resources. 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. Implementing ELCC incorrectly, as PJM has proposed to do, based on average rather than 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.

Renewable energy was a relatively small share of PJM total energy and capacity in 2020 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 23,095 MW of combined cycle projects in the queue, 15,849.4 MW (68.6 percent) are expected to go in service based on historical completion rates as of December 31, 2020, providing both energy and capacity at that level. Of the 129,844.9 MW of renewable projects in the queue, only 16,541 MW (12.7 percent) are expected to go in service based on historical completion rates and be available to supply energy. Of those 16,541 MW, only 6,487.5 MW (5.0 percent of the total) will be capacity, based on the average derate factors for wind and solar.

If the 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, and Pennsylvania is preparing to join. 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 including those that currently do

not belong to RGGI: for RECs markets; for potential agreement on carbon pricing including 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 were lower in 2020 than in any year since PJM markets were established in 1999. Energy prices in PJM were already among the lowest in PJM's history in 2019. The load-weighted average real-time LMP was 20.3 percent lower in 2020 than in 2019, \$21.77 per MWh versus \$27.32 per MWh. Of the \$5.55 per MWh decrease, 50.3 percent was a direct result of lower fuel costs. The other major contributor to the decline in energy prices was the significant drop in demand as a result of both the mild winter weather and COVID-19. On a cumulative basis, PJM load was down 4.0 percent compared to 2019, and load was down 3.4 percent after accounting 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. In 2020, the short run marginal cost of combined cycle generation was substantially lower than the short run marginal cost of even a new efficient coal plant as the result of lower gas prices and the high efficiency of gas-fired combined cycle plants. The capacity factor of coal units fell from 30.1 percent to 25.6 percent, and the share of total PJM energy produced from coal fell from 23.8 percent in 2019 to 19.3 percent in 2020, while the share of gas increased from 36.4 to 39.8 percent. The increased 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.

The recent events in ERCOT have refocused attention on reliability and on the role of very high energy prices under extreme weather conditions. The PJM system is reliable and PJM continues to focus on reliability. But it

is essential to not be complacent. PJM's capacity market rules, including the resultant capacity reserve margin, contribute to but do not guarantee reliability under extreme weather conditions. The capacity market rules do not require that all resources have firm fuel supplies. Gas pipeline tariffs do not require that pipelines have the ability to serve all firm fuel customers simultaneously in an extreme weather event. Market power in the gas commodity market during extreme weather events has not been adequately addressed. The price impacts of extreme events in PJM can be significant. Under the current rules, PJM energy market prices can exceed \$5,700 per MWh in emergency conditions. Under the rules for the extended ORDC, which will go into effect on June 1, 2022, PJM energy market prices can exceed \$14,000 per MWh in emergency conditions. While appropriate scarcity 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.

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. Net revenues are significantly affected by fuel prices, energy prices and capacity prices. Net revenues decreased for all unit types in 2020 compared to 2019 as a result of lower energy prices. Theoretical net revenues decreased by 19 percent for a new combustion turbine, 23 percent for a new combined cycle, and 22 percent for a new nuclear plant. Theoretical net revenues decreased by 56 percent for a new coal unit, meaning that the theoretical capacity factor of a new entrant coal plant was 17 percent.

The competitiveness of energy market prices cannot be taken for granted. Despite low average marginal unit markups in 2020, 5.2 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. During the cold and hot weather alerts in 2020, PJM scheduled and paid \$821,403 in uplift to units that did not use flexible operating parameter limits. 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. 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 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 shows selected summary statistics describing PJM markets.

Table 1 PJM market summary statistics: 2019 and 2020¹

	2019	2020	Percent Change
Average Hourly Load Plus Exports (MW)	92,920	90,059	(3.1%)
Average Hourly Generation Plus Imports (MW)	94,618	91,681	(3.1%)
Peak Load (MW)	148,228	141,449	(4.6%)
Installed Capacity at December 31 (MW)	184,744	184,237	(0.3%)
Load Weighted Average Real Time LMP (\$/MWh)	\$27.32	\$21.77	(20.3%)
Total Congestion Costs (\$ Million)	\$583.3	\$528.6	(9.4%)
Total Uplift Credits (\$ Million)	\$88.5	\$90.9	2.7%
Total PJM Billing (\$ Billion)	\$39.20	\$33.64	(14.2%)

PJM Market Background

The PJM Interconnection, L.L.C. (PJM) operates a centrally dispatched, competitive wholesale electric power market that, as of December 31, 2020, had installed generating capacity of 184,237 megawatts (MW) and 1,034 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).^{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.

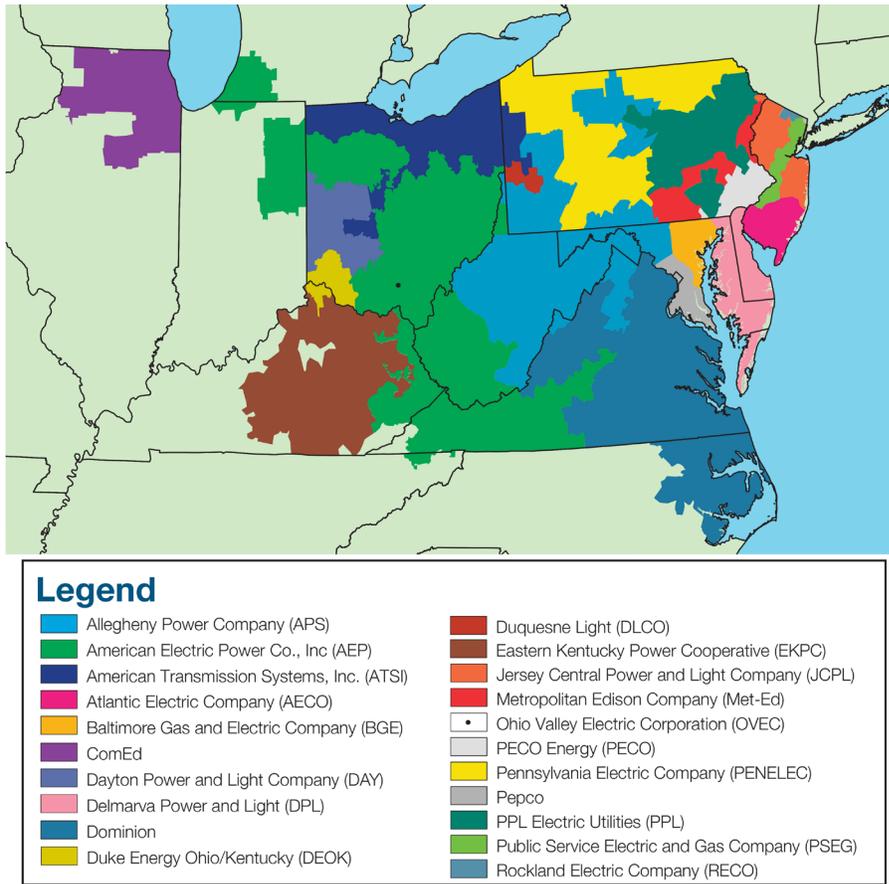
¹ In Table 1-1, Average Hourly Load includes load and exports, and Average Hourly Generation includes generation and imports. Versions of this table prior to the *2020 Quarterly State of the Market Report for PJM: January through June* did not include exports or imports in these calculations.

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>>.

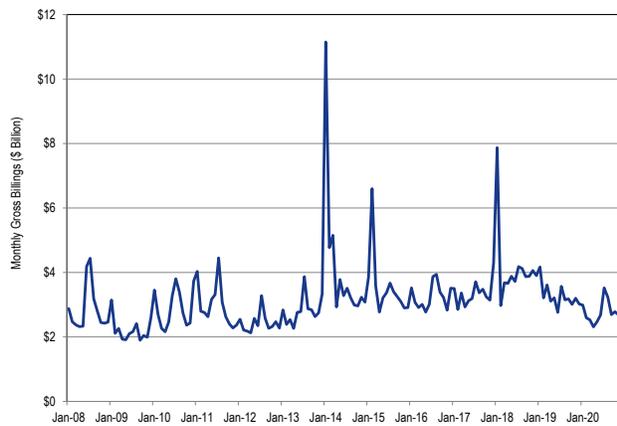
⁴ See the *2019 State of the Market Report for PJM*, Volume II, Appendix A: "PJM Overview" for maps showing the PJM footprint and its evolution prior to 2020.

Figure 1 PJM's footprint and its 21 control zones



In 2020, PJM had total billings of \$33.64 billion, a decrease of 14.2 percent from \$39.20 billion in 2019 (Figure 2).⁵ The total of \$33.64 billion in 2020 was the lowest annual total since 2012. The decline in weather normalized load, generation, prices and billings were all in significant part a result of the economic impact of COVID-19.

Figure 2 PJM reported monthly billings (\$ Billion): 2008 through 2020



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

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. 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 2020, 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.

⁶ See also the *2019 State of the Market Report for PJM*, Volume 2, Appendix A: "PJM Overview."

⁷ Analysis of 2020 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 (DLCO) 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 (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.) 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."

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 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 2020.

Table 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 2020 was unconcentrated by FERC HHI standards. Average HHI was 726 with a minimum of 526 and a maximum of 1080 in 2020. The peaking segment of supply was highly concentrated. 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. 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. 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.⁹ 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 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.¹⁰ The conclusions are a result of the MMU's evaluation of the last Base Residual Auction, for the 2021/2022 Delivery Year.

Table 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.¹¹ 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.¹²
- 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

⁸ OATT Attachment M (PJM Market Monitoring Plan).

⁹ 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.

¹⁰ 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.

¹¹ 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.

¹² 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.

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 2020.

Table 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 2020.

Table 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 zero hours in 2020. The day-ahead scheduling reserve market structure remains evaluated as not competitive based on persistent structural issues.
- 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 1,235 hours in 2020. In 95.0 percent of hours when the clearing price was above \$0, the clearing price was the offer price of the marginal unit. In the remaining 5.0 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 2020.

Table 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 93.5 percent of the hours in 2020.
- Participant behavior in the PJM Regulation Market was evaluated as competitive in 2020 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 2020.

Table 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 ARRs is unconcentrated.
- Participant behavior was evaluated as partially competitive as a result of the behavior of GreenHat Energy, LLC. Supply side participants 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 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 unsupported 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.¹³ 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.¹⁴

¹³ 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).

¹⁴ OATT Attachment M § IV; 18 CFR § 1c.2.

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.

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.¹⁵ The MMU has direct, confidential access to FERC.¹⁶ The MMU may also refer matters to the attention of state commissions.¹⁷

The MMU monitors market behavior for violations of FERC Market Rules and PJM Market Rules, including the actual or potential exercise of market power.¹⁸ 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

¹⁵ OATT Attachment M § IV.

¹⁶ OATT Attachment M § IV.K.3.

¹⁷ OATT Attachment M § IV.H.

¹⁸ 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.")

inefficiencies...”^{19 20 21} The MMU also monitors PJM for compliance with the rules, in addition to market participants.²²

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 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 the cost-based offer does 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.²³

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.^{24 25 26 27}

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.

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.^{28 29}

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.³⁰

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.³¹ The MMU initiates and proposes changes to the design of such markets or the PJM Market Rules in stakeholder or regulatory proceedings.³² 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

19 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.

20 OATT § I.1.

21 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 participate as a party or provide information or testimony in regulatory or other proceedings.

22 OATT Attachment M § IV.C.

23 OATT Attachment M–Appendix § II.E.

24 OATT Attachment M–Appendix § II.B.

25 OATT Attachment M–Appendix § II.C.

26 OATT Attachment M–Appendix § IV.

27 OATT Attachment M–Appendix § VII.

28 OATT Attachment M–Appendix § II(p).

29 OATT Attachment M–Appendix § III.

30 OA Schedule 6 § 1.5.

31 OATT Attachment M § IV.D.

32 *Id.*

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.³³ 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.³⁴ The MMU may provide in its annual, quarterly and other reports "recommendations regarding any matter within its purview."³⁵

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.³⁶

In this *2020 State of the Market Report for PJM*, the MMU includes 26 new recommendations made for 2020, eight of which are new in this 2020 annual report.^{37 38}

New Recommendations from Section 3, Energy Market

- 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. New recommendation. 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. New recommendation. Status: Not adopted.)
- 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 Q3, 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 Q3, 2020. 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 Q3, 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 Q3, 2020. 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 Q3, 2020. Status: Not adopted.)
- 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 Q3, 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 Q3, 2020. Status: Not adopted.)

³³ *Id.*; see also, e.g., 171 FERC ¶ 61,039; 167 FERC ¶ 61,084 at PP 70–76, *reh'g denied*, 168 FERC ¶ 61,141.

³⁴ *Id.*

³⁵ OATT Attachment M § VI.A.

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

³⁷ New recommendations include all MMU recommendations that were reported for the first time in the *2020 State of the Market Report for PJM* or in any of the three quarterly state of the market reports that were published in 2020.

³⁸ For a complete list of MMU recommendations, see the *2020 State of the Market Report for PJM*, Vol II, Section 2, Recommendations.

- 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 Q1, 2020. Status: Not adopted.)

New Recommendation from Section 4, Energy Uplift

- 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 Q3, 2020. Status: Not adopted.)

New Recommendation from Section 5, Capacity Market

- The MMU recommends that PJM update the values in the CRF table in the tariff when the components change. (Priority: High. New recommendation. Status: Not adopted.)

New Recommendation from Section 6, Demand Response

- 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.)

New Recommendations from Section 9, Interchange Transactions

- 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.)

- 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 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.)

New Recommendations from Section 10, Ancillary Services

- 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. New recommendation. 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. New recommendation. Status: Not 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.³⁹ (Priority: Medium. New recommendation. 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 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. (Priority: High. First reported Q2, 2020. Status: Not adopted.)

New Recommendations from Section 12, Generation and Transmission Planning

- 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. New recommendation. Status: Not adopted.)
- 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.

³⁹ 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>).

(Priority: Medium. New recommendation. Status: Not adopted.)

- The MMU recommends that storage resources not be includable as transmission assets for any reason. (Priority: High. First reported Q3, 2020. Status: Not adopted.)

New Recommendations from Section 13, Financial Transmission Rights and Auction Revenue Rights

- The MMU recommends that PJM enforce the FTR auction bid limits at the parent company level starting immediately. (Priority: High. First reported Q3, 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 Q2, 2020. Status: Not adopted.)

Total Price of Wholesale Power

The total price of wholesale power is the total price per MWh of wholesale electricity in PJM markets.⁴⁰ 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 8 shows the average price, by component, for 2019 and 2020.

The total billing values shown in Table 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 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

⁴⁰ 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 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 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.
- The Transmission Service Charges component is the average price per MWh of network integration charges, and firm and nonfirm point to point transmission service.⁴¹
- The Energy Uplift (Operating Reserves) component is the average price per MWh of day-ahead and balancing operating reserves and synchronous condensing charges.⁴²
- The Reactive component is the average cost per MWh of reactive supply and voltage control from generation and other sources.⁴³
- The Regulation component is the average cost per MWh of regulation procured through the PJM Regulation Market.⁴⁴
- 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.⁴⁵
- 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.⁴⁶

- The Emergency Load Response component is the average cost per MWh of the PJM Emergency Load Response Program.⁴⁷
- 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.⁴⁸
- 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.⁴⁹
- The Synchronized Reserve component is the average cost per MWh of synchronized reserve procured through the synchronized reserve market.⁵⁰
- The Black Start component is the average cost per MWh of black start service.⁵¹
- The RTO Startup and Expansion component is the average cost per MWh of charges to recover AEP, ComEd and DAY's integration expenses.⁵²
- The NERC/RFC component is the average cost per MWh of NERC and RFC charges, plus any reconciliation charges.⁵³
- The Economic Load Response component is the average cost per MWh of day-ahead and real-time economic load response program charges to LSEs.⁵⁴
- The Transmission Facility Charges component is the average cost per MWh of Ramapo Phase Angle Regulators charges allocated to PJM Mid-Atlantic transmission owners.⁵⁵
- The nonsynchronized reserve component is the average cost per MWh of non-synchronized reserve procured through the nonsynchronized reserve market.⁵⁶
- The Emergency Energy component is the average cost per MWh of emergency energy.⁵⁷

41 OATT §§ 13.7, 14.5, 27A & 34.

42 OA Schedules 1 §§ 3.2.3 & 3.3.3.

43 OATT Schedule 2 and OA Schedule 1 § 3.2.3B. The line item in Table 18 includes all reactive services charges.

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

45 OATT Schedule 12.

46 RAA Schedule 8.1.

47 OATT PJM Emergency Load Response Program.

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

49 OATT Schedule 1A.

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

51 OATT Schedule 6A. The line item in Table 18 includes all Energy Uplift (Operating Reserves) charges for Black Start.

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

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

54 OA Schedule 1 § 3.6.

55 OA Schedule 1 § 5.3b.

56 OA Schedule 1 § 3.2.3A.001.

57 OA Schedule 1 § 3.2.6.

Table 8 shows that energy, capacity and transmission charges are the three largest components of the total price per MWh of wholesale power, comprising 96.9 percent of the total price per MWh in 2020. 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, the cost of transmission service was greater than the cost of capacity. In 2020, 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 was greater than the cost of capacity.

Table 8 Total price per MWh by category: 2019 and 2020^{58 59 60 61}

Category	2019 \$/MWh	2019 (\$ Millions)	2019 Percent of Total	2020 \$/MWh	2020 (\$ Millions)	2020 Percent of Total	Percent Change
Load Weighted Energy	\$27.32	\$21,088	54.3%	\$21.77	\$16,171	48.8%	(20.3%)
Capacity	\$11.27	\$8,700	22.4%	\$9.45	\$7,023	21.2%	(16.1%)
Capacity	\$11.25	\$8,686	22.4%	\$9.45	\$7,023	21.2%	(16.0%)
Capacity (FRR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Capacity (RMR)	\$0.02	\$14	0.0%	\$0.00	\$0	0.0%	(100.0%)
Transmission	\$10.39	\$8,019	20.6%	\$11.98	\$8,898	26.9%	15.3%
Transmission Service Charges	\$9.75	\$7,524	19.4%	\$11.29	\$8,388	25.3%	15.8%
Transmission Enhancement Cost Recovery	\$0.55	\$427	1.1%	\$0.59	\$441	1.3%	7.5%
Transmission Owner (Schedule 1A)	\$0.09	\$69	0.2%	\$0.09	\$69	0.2%	4.6%
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	\$0.72	\$555	1.4%	\$0.73	\$544	1.6%	1.7%
Reactive	\$0.44	\$336	0.9%	\$0.48	\$355	1.1%	9.8%
Regulation	\$0.12	\$91	0.2%	\$0.10	\$77	0.2%	(11.8%)
Black Start	\$0.08	\$65	0.2%	\$0.09	\$65	0.2%	4.5%
Synchronized Reserves	\$0.04	\$34	0.1%	\$0.03	\$25	0.1%	(24.4%)
Non-Synchronized Reserves	\$0.02	\$12	0.0%	\$0.01	\$8	0.0%	(28.1%)
Day Ahead Scheduling Reserve (DASR)	\$0.02	\$18	0.0%	\$0.02	\$13	0.0%	(22.0%)
Administration	\$0.51	\$394	1.0%	\$0.52	\$383	1.2%	1.2%
PJM Administrative Fees	\$0.47	\$365	0.9%	\$0.48	\$355	1.1%	1.0%
NERC/RFC	\$0.03	\$27	0.1%	\$0.04	\$28	0.1%	8.4%
RTO Startup and Expansion	\$0.00	\$2	0.0%	\$0.00	\$1	0.0%	(58.1%)
Energy Uplift (Operating Reserves)	\$0.11	\$88	0.2%	\$0.12	\$90	0.3%	6.9%
Demand Response	\$0.00	\$4	0.0%	\$0.00	\$1	0.0%	(70.2%)
Load Response	\$0.00	\$3	0.0%	\$0.00	\$1	0.0%	(57.6%)
Emergency Load Response	\$0.00	\$1	0.0%	\$0.00	\$0	0.0%	(100.0%)
Emergency Energy	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Total Price	\$50.33	\$38,848	100.0%	\$44.57	\$33,111	100.0%	(11.4%)
Total Load (GWh)	771,929			742,987			(3.7%)
Total Billing (\$ Billions)	\$38.85			\$33.11			(14.8%)

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

59 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.

60 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.

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

Table 9 shows the inflation adjusted average price, by component, for 2019 and 2020. 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).⁶²

Table 9 Inflation adjusted total price per MWh by category: 2019 and 2020⁶³

Category	2019 \$/MWh	2019 (\$ Millions)	2019 Percent of Total	2020 \$/MWh	2020 (\$ Millions)	2020 Percent of Total	Percent Change
Load Weighted Energy	\$17.28	\$13,337	54.3%	\$13.58	\$10,091	48.8%	(21.4%)
Capacity	\$7.13	\$5,506	22.4%	\$5.90	\$4,385	21.2%	(17.2%)
Capacity	\$7.12	\$5,497	22.4%	\$5.90	\$4,385	21.2%	(17.1%)
Capacity (FRR)	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Capacity (RMR)	\$0.01	\$9	0.0%	\$0.00	\$0	0.0%	(100.0%)
Transmission	\$6.57	\$5,069	20.6%	\$7.48	\$5,556	26.9%	13.9%
Transmission Service Charges	\$6.16	\$4,756	19.4%	\$7.05	\$5,238	25.3%	14.4%
Transmission Enhancement Cost Recovery	\$0.35	\$270	1.1%	\$0.37	\$276	1.3%	6.2%
Transmission Owner (Schedule 1A)	\$0.06	\$43	0.2%	\$0.06	\$43	0.2%	3.4%
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	\$0.45	\$351	1.4%	\$0.46	\$339	1.6%	0.5%
Reactive	\$0.28	\$213	0.9%	\$0.30	\$222	1.1%	8.5%
Regulation	\$0.07	\$57	0.2%	\$0.06	\$48	0.2%	(12.8%)
Black Start	\$0.05	\$41	0.2%	\$0.05	\$41	0.2%	3.2%
Synchronized Reserves	\$0.03	\$22	0.1%	\$0.02	\$16	0.1%	(25.5%)
Non-Synchronized Reserves	\$0.01	\$7	0.0%	\$0.01	\$5	0.0%	(28.9%)
Day Ahead Scheduling Reserve (DASR)	\$0.01	\$11	0.0%	\$0.01	\$8	0.0%	(23.1%)
Administration	\$0.32	\$249	1.0%	\$0.32	\$239	1.2%	(0.1%)
PJM Administrative Fees	\$0.30	\$231	0.9%	\$0.30	\$221	1.1%	(0.2%)
NERC/RFC	\$0.02	\$17	0.1%	\$0.02	\$17	0.1%	6.8%
RTO Startup and Expansion	\$0.00	\$1	0.0%	\$0.00	\$1	0.0%	(57.9%)
Energy Uplift (Operating Reserves)	\$0.07	\$55	0.2%	\$0.08	\$56	0.3%	5.3%
Demand Response	\$0.00	\$2	0.0%	\$0.00	\$1	0.0%	(70.0%)
Load Response	\$0.00	\$2	0.0%	\$0.00	\$1	0.0%	(57.1%)
Emergency Load Response	\$0.00	\$1	0.0%	\$0.00	\$0	0.0%	(100.0%)
Emergency Energy	\$0.00	\$0	0.0%	\$0.00	\$0	0.0%	0.0%
Total Price	\$31.83	\$24,570	100.0%	\$27.82	\$20,668	100.0%	(12.6%)
Total Load (GWh)	771,929			742,987			(3.7%)
Total Billing (\$ Billions)	\$24.57			\$20.67			(15.9%)

62 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>> (January 13, 2021).

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

Figure 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 3 Top three components of quarterly total price (\$/MWh): 1999 through 2020⁶⁴

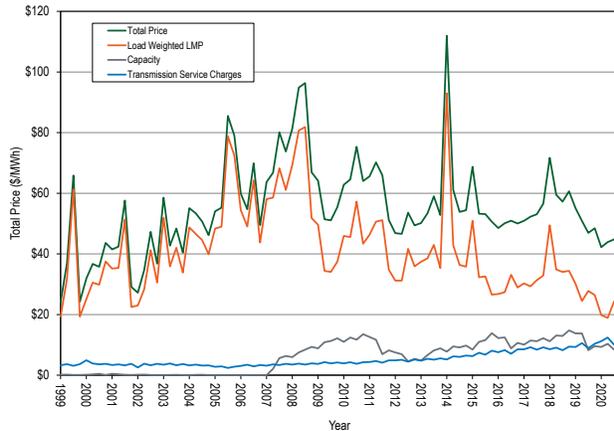
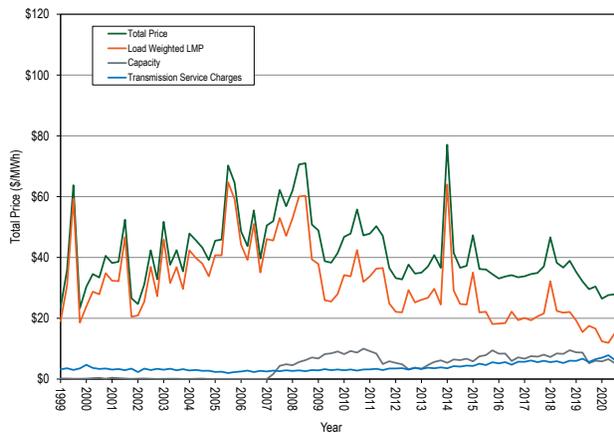


Figure 4 shows the inflation adjusted contributions of load-weighted energy, capacity and transmission service charges to the total price of wholesale power for each quarter since 1999.⁶⁵

Figure 4 Inflation adjusted top three components of quarterly total price (\$/MWh): 1999 through 2020⁶⁶



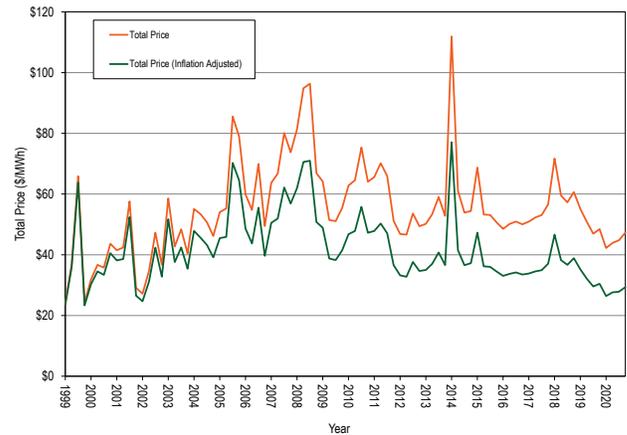
64 Note: The totals presented in this figure include after the fact billing adjustments and may not match totals presented in past reports.

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>> (January 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.

Figure 5 shows the total price of wholesale power and the inflation adjusted total price of wholesale power for each quarter since 1999.⁶⁷

Figure 5 Quarterly total price and quarterly inflation adjusted total price (\$/MWh): 1999 through 2020⁶⁸



Section Overviews

Overview: Section 3, Energy Market

Supply and Demand

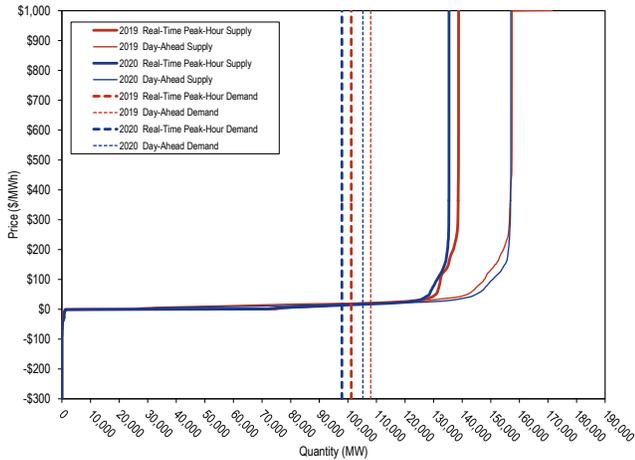
Market Structure

- Supply.** The average hourly day-ahead supply was 157,005 for 2020, and 171,443 MW for 2019. The average on-peak hourly offered real-time supply was 135,383 MW for 2020, and 138,779 MW for 2019. In 2020, 2,556.7 MW of new resources were added in the energy market, and 3,255.0 MW of resources and 457.0 MW of pseudo tied resources were retired.

67 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>> (January 13, 2021).

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

Figure 6 Hourly real-time and aggregate day-ahead supply curve comparison: 2019 and 2020



- PJM average hourly real-time cleared generation in 2020 decreased by 2.7 percent from 2019, from 93,434 MWh to 90,946 MWh.

PJM average hourly day-ahead cleared supply in 2020, including INCs and up to congestion transactions, decreased by 4.9 percent from 2019, from 117,250 MWh to 111,470 MWh.

- **Demand.** The PJM system real-time hourly peak load in 2020 was 141,449 MWh in the HE 1700 on July 20, 2020, which was 6,778 MWh, 4.6 percent, lower than the PJM peak load in 2019, which was 148,228 MWh in the HE 1800 on July 19, 2019.
- PJM average hourly real-time load in 2020 decreased by 4.0 percent from 2019, from 88,120 MWh to 84,584 MWh, the largest percent decrease since 2009. Both the weather and COVID-19 contributed to the significant change. Based on the weather normalized demand analysis, 3.4 of the 4.0 percent decrease in load was related to COVID-19.
- PJM average hourly day-ahead demand in 2020, including load, DECs and up to congestion transactions, decreased by 5.7 percent from 2019, from 112,588 MWh to 106,209 MWh.

Market Behavior

- **Supply and Demand: Load and Spot Market.** Companies that serve load in PJM do so using a combination of self supply, bilateral market purchases and spot market purchases. In 2020, 16.1 percent of real-time load was supplied by bilateral

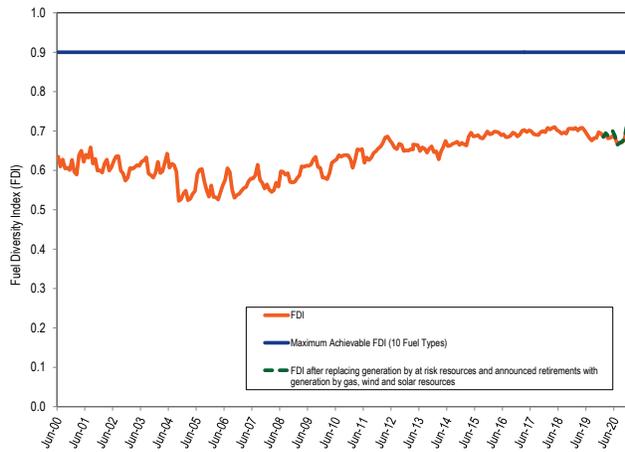
contracts, 24.7 percent by spot market purchases and 59.2 percent by self supply. Compared to 2019, reliance on bilateral contracts increased by 0.8 percentage points, reliance on spot market purchases decreased by 0.1 percentage points and reliance on self supply decreased by 0.7 percentage points.

- **Generator Offers.** In day-ahead market offers, generators define the commitment status and the dispatch status of their units. In the day-ahead market in 2020, 21.8 percent of MW were offered as must run, 32.1 percent were offered as economic minimum MW for dispatchable units, 45.0 percent were offered as dispatchable MW, and 1.0 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 increased by 2.7 percent and cleared MW decreased by 16.0 percent in 2020. The hourly average submitted decrement offer MW increased by 24.4 percent and cleared MW increased by 16.6 percent in 2020. The hourly average submitted up to congestion bid MW decreased by 23.8 percent and cleared MW decreased by 12.4 percent in 2020.

Market Performance

- **Generation Fuel Mix.** In 2020, coal units provided 19.3 percent, nuclear units 34.2 percent and natural gas units 39.8 percent of total generation. Compared to 2019, generation from coal units decreased 20.6 percent, generation from natural gas units increased 6.7 percent and generation from nuclear units decreased 0.8 percent. The trend toward more energy from natural gas and less from coal accelerated in 2020.
- **Fuel Diversity.** The fuel diversity of energy generation in 2020, measured by the fuel diversity index for energy (FDI_e), decreased 1.5 percent compared to 2019.

Figure 7 Fuel diversity index for monthly generation: June 2000 through December 2020



- Marginal Resources.** In the PJM Real-Time Energy Market in 2020, coal units were 17.5 percent and natural gas units were 72.3 percent of marginal resources. In 2019, coal units were 24.4 percent and natural gas units were 69.4 percent of marginal resources.

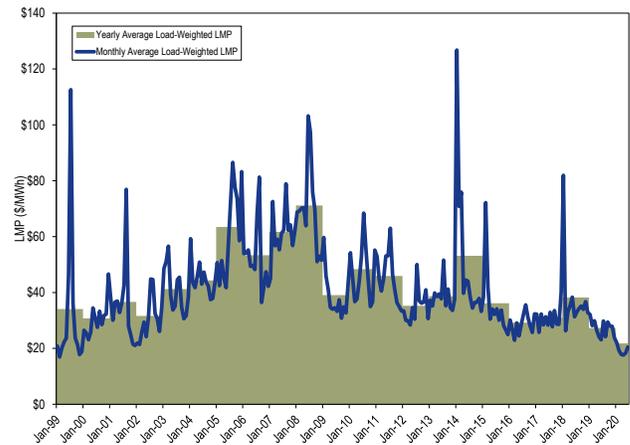
In the PJM Day-Ahead Energy Market in 2020, up to congestion transactions were 51.4 percent, INCs were 13.2 percent, DECs were 18.8 percent, and generation resources were 16.5 percent of marginal resources. In 2019, up to congestion transactions were 57.4 percent, INCs were 12.8 percent, DECs were 17.0 percent, and generation resources were 12.7 percent of marginal resources.

- Prices.** PJM real-time and day-ahead energy market prices were at the lowest level in the history of PJM markets during 2020. Both the weather and COVID-19 played a role in this significant drop in prices.

PJM load-weighted, average, real-time LMP in 2020 decreased 20.3 percent from 2019, from \$27.32 per MWh to \$21.77 per MWh.

PJM load-weighted, average day-ahead LMP in 2020 decreased 21.4 percent from 2019, from \$27.23 per MWh to \$21.40 per MWh.

Figure 8 Real-time, monthly and annual, load-weighted, average LMP: 1999 through 2020



- Components of LMP.** In the PJM Real-Time Energy Market in 2020, 23.7 percent of the load-weighted LMP was the result of coal costs, 41.5 percent was the result of gas costs and 1.7 percent was the result of the cost of emission allowances.

In the PJM Day-Ahead Energy Market, in 2020, 24.4 percent of the load-weighted LMP was the result of coal costs, 18.8 percent was the result of gas costs, 15.2 percent was the result of INC offers, 24.0 percent was the result of DEC bids, and 3.0 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 the average day-ahead and real-time prices was \$0.33 per MWh in 2020, and -\$0.01 per MWh in 2019. 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 nine intervals with five minute shortage pricing in 2020. There were no emergency actions that resulted in Performance Assessment Intervals in 2020.
- There were 1,819 five minute intervals, or 1.7 percent of all five minute intervals in 2020 for which at least one RT SCED solution showed a shortage of reserves, and 592 five minute intervals,

or 0.6 percent of all five minute intervals in 2020 for which more than one RT SCED solution showed a shortage of reserves. PJM triggered shortage pricing for nine 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.** For six out of the top 10 congested facilities (by real-time binding hours) in 2020, 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 1.3 percent in 2019 to 1.6 percent in 2020. In the real-time energy market, for units committed to provide energy for local constraint relief, offer-capped unit hours decreased from 1.7 percent in 2019 to 1.0 percent in 2020. 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.

In 2020, 10 control zones experienced congestion resulting from one or more constraints binding for 100 or more hours. 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 remained at 0.0 percent in 2019 and 2020. In the real-time energy market, for units committed for reliability reasons, offer-capped unit hours remained at 0.0 percent in 2019 and 2020.

Table 10 Offer capping statistics for energy and reliability: 2016 to 2020

Year	Real-Time		Day-Ahead	
	Unit Hours Capped	MWh Capped	Unit Hours Capped	MWh Capped
2016	0.4%	0.3%	0.1%	0.1%
2017	0.4%	0.4%	0.1%	0.2%
2018	1.0%	0.8%	0.2%	0.3%
2019	1.7%	1.3%	1.3%	0.9%
2020	1.0%	1.1%	1.6%	1.3%

- **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.
- **Markup Index.** The markup index is a summary measure of participant offer behavior for individual marginal units. In 2020, in the PJM Real-Time Energy Market, 98.2 percent of marginal units had offer prices less than \$50 per MWh. While markups in the real-time market were generally low, some marginal units did have substantial markups. The highest markup for any marginal unit in 2020 was more than \$450 per MWh when using unadjusted cost-based offers.

In 2020, in the PJM Day-Ahead Energy Market, 99.2 percent of marginal generating units had offer prices less than \$50 per MWh. Markups in the day-ahead market were generally low. The highest markup for any marginal unit in the day-ahead market in 2020 was more than \$70 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 2020.

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 2020, the unadjusted markup component of LMP was \$0.50 per MWh or 2.3 percent of the PJM load-weighted, average LMP. August had the highest unadjusted peak markup component, \$2.88 per MWh, or 9.7 percent of the real-time, peak hour load-weighted, average LMP. There were 35 hours in 2020 where the positive markup contribution to the PJM system wide, load-weighted, average LMP exceeded the 99th percentile of the hourly markup contribution or \$30.70 per MWh.

In the PJM Day-Ahead Energy Market, INCs, DECs and UTCs have zero markups. In 2020, the unadjusted markup component of LMP resulting from generation resources was -\$0.11 per MWh or -0.5 percent of the PJM day-ahead load-weighted, average LMP. August had the highest unadjusted peak markup component, \$0.70 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 5.2 percent of marginal unit intervals in 2020 the marginal unit had local market power as determined by the TPS test and a positive markup, compared to 10.0 percent of marginal unit

intervals in 2019. The fact that units with market power had a positive markup 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.

- **Markup and Aggregate Market Power.** In the summer of 2020, 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 Q3, 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 Q3, 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 Q3, 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 Q3, 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 Q3, 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.)
- any unit that is derated in the energy market below its committed ICAP without an outage that reflects the derate. (Priority: Medium. New recommendation. 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. New recommendation. 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.)

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

- 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.^{69 70} (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

⁶⁹ 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.

⁷⁰ 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>>.

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.)
- 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 Q1, 2020. 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 continue to enhance its posting of market data to promote market efficiency. (Priority: Medium. First reported 2005. 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: Not 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 Q3, 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 Q3, 2020. Status: Not adopted.)

Section 3 Conclusion

The MMU analyzed key elements of PJM energy market structure, participant conduct and market performance in 2020, 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 2020 decreased by 4.0 percent from 2019, from 88,120 MWh to 84,584 MWh, the largest percent decrease since 2009. Both the weather and COVID-19 contributed to the significant change. Based on the weather normalized demand analysis, 3.4 of the 4.0 percent decrease in load was related to COVID-19. 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.⁷¹ 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.

⁷¹ The MMU reviews PJM's application of the TPS test and brings issues to the attention of PJM.

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 fixed 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 2020 generally reflected supply-demand fundamentals, although the behavior of some participants both routinely and during high demand periods represents economic withholding. Economic withholding is the ability to substantially increase markups in energy offers in tight market conditions. 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 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. The underlying problem that fast start pricing and PJM's reserve pricing approach are attempting to address is

actually scarcity pricing, including the impact of operator actions on the definition of scarcity. Prices do not reflect market conditions when the market is tight, because PJM is not implementing scarcity pricing when there is scarcity. 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. Implementing scarcity pricing when there is scarcity is a basic first step. Targeted increases to the demand for reserves when the market is tight would address price formation in the energy market.

When the real-time security constrained economic dispatch (RT SCED) solution indicates a shortage of reserves, it should be used in calculating real-time prices and those prices should be applied to the market interval for which RT SCED calculated the shortage and during which resources followed associated dispatch instructions. There are significant issues with operator discretion and reluctance to approve RT SCED cases indicating shortage of reserves, and in using these cases to calculate prices. While it is appropriate for operators to ensure that cases that use erroneous inputs are not approved and not allowed to set prices, 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. There are also issues with the alignment of RT SCED cases used for resource dispatch and the RT SCED cases used to calculate real-time prices. Alignment of resource dispatch with pricing and settlements requires reducing the RT SCED ramp time to five minutes to match the five minute settlement interval. PJM should fix its current operating practices and ensure consistency and transparency regarding approval of RT SCED cases for resource dispatch and pricing so that market participants can have confidence in the market design to produce accurate and efficient price signals. PJM has a plan to make these changes, and PJM should prioritize implementing it. These issues are even more critical now that PJM settles real-time energy transactions on a five minute basis and will soon implement fast start pricing.

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 reserve pricing proposal.

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. When combined with PJM's failure to address the energy and ancillary services offset in the capacity market, PJM's ORDC filing is not consistent with efficient market design and is even more clearly 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 2020 or prior years. In 2020, 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 31.2 percent in 2016 to 64.3 percent in 2020. 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 placed competitive pressure on less efficient generators, and the market reliably served load with less congestion, less uplift, and less markup in marginal offers than in 2019. 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 2020.

Overview: Section 4, Energy Uplift

Energy Uplift Credits

- **Types of credits.** In 2020, energy uplift credits were \$90.9 million, including \$9.3 million in day-ahead generator credits, \$58.2 million in balancing generator credits, \$19.4 million in lost opportunity cost credits, and \$3.4 million in local constraint control credits.
- **Types of units.** In 2020, coal units received 90.6 percent of all day-ahead generator credits. During the same time period, combustion turbines received 91.2 percent of all balancing generator credits and 95.1 percent of lost opportunity cost credits.
- **Economic and Noneconomic Generation.** In 2020, 87.6 percent of the day-ahead generation eligible for operating reserve credits was economic and 66.8 percent of the real-time generation eligible for operating reserve credits was economic.
- **Day-Ahead Unit Commitment for Reliability.** In 2020, less than 0.1 percent of the total day-ahead generation MWh was scheduled as must run for reliability by PJM, of which 74.4 percent received energy uplift payments.
- **Concentration of Energy Uplift Credits.** The top 10 units receiving energy uplift credits received 17.0 percent of all credits. The top 10 organizations received 71.8 percent of all credits. The HHI for day-ahead operating reserves was 8387, the HHI for balancing operating reserves was 3582 and the HHI for lost opportunity cost was 5457, all of which are classified as highly concentrated.
- **Lost Opportunity Cost Credits.** Lost opportunity cost credits increased by \$2.2 million or 12.9 percent, in 2020 compared to 2019, from \$17.1 million to \$19.4 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 94.0 percent of the \$19.4 million. The day-ahead generation paid LOC credits for this reason increased by 534.2 GWh or 70.3 percent during 2020, compared to 2019, from 759.9 GWh to 1,294.1 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 that total \$3.5 million, of which PJM has agreed and resettled 39.1 percent.

Energy Uplift Charges

- **Energy Uplift Charges.** Total energy uplift charges increased by \$2.4 million, or 2.7 percent, in 2020 compared to 2019, from \$88.5 million to \$90.9 million.
- **Energy Uplift Charges Categories.** The increase of \$2.4 million in 2020 was comprised of a \$6.2 million decrease in day-ahead operating reserve charges, an \$8.8 million increase in balancing operating reserve charges, and a \$0.1 million decrease in reactive services charges.
- **Average Effective Operating Reserve Rates in the Eastern Region.** Day-ahead load paid \$0.012 per MWh, real-time load paid \$0.040 per MWh, a DEC paid \$0.341 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.329 per MWh. In November and December 2020, which were the only months of the year that UTCs were allocated uplift charges, a UTC paid \$0.305 per MWh.
- **Average Effective Operating Reserve Rates in the Western Region.** Day-ahead load paid \$0.012 per MWh, real-time load paid \$0.030 per MWh, a DEC paid \$0.296 per MWh and an INC and any load, generation or interchange transaction deviation paid \$0.285 per MWh in 2020. In November and December 2020, which were the only months of the year that UTCs were allocated uplift charges, a UTC paid \$0.224 per MWh.
- **Reactive Services Rates.** JCPL, PPL, and EKPC Control Zones were the three zones with the highest local voltage support rates, excluding reactive capability payments. JCPL had a rate of \$0.008 per MWh, PPL had a rate of \$0.004 per MWh, and EKPC had a rate of \$0.004.

Geography of Charges and Credits

- In 2020, 89.1 percent of all uplift charges allocated regionally (day-ahead operating reserves and balancing operating reserves) were paid by transactions at control zones, 3.8 percent by

transactions at hubs and aggregates, and 7.2 percent by transactions at interchange interfaces.

- In 2020, generators in the Eastern Region received 36.3 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In 2020, generators in the Western Region received 61.1 percent of all balancing generator credits, including lost opportunity cost and canceled resources credits.
- In 2020, external generators received 2.6 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 Q3, 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 operating reserves 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 operating reserves, 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 2018.⁷²)
- 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 operating reserve confidentiality rules in order to allow the disclosure of complete information about the level of 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.⁷³)
- 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

⁷² 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 2, Section 3: "Energy Market" at "Internal Bilateral Transactions" for an analysis of the impact of this change on virtual bidding activity.

⁷³ 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).

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 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. Fast start pricing will affect uplift calculations.⁷⁴

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, 2019.⁷⁵ 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.⁷⁶ The uplift payments for UTCs began on November 1, 2020. Up to congestion transactions did not pay energy uplift charges in the first ten months of 2020.⁷⁷

⁷⁴ FERC Docket No. ER19-2722.

⁷⁵ 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.

⁷⁶ See 172 FERC ¶ 61,046.

⁷⁷ 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).

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 \$3.5 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.

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.⁷⁸

Under RPM, capacity obligations are annual.⁷⁹ 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.⁸⁰ First, Second, and Third Incremental Auctions are conducted 20, 10, and three months prior to the delivery year.⁸¹ 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.⁸²

The 2020/2021 RPM Third Incremental Auction and the 2021/2022 RPM Second Incremental Auction were conducted in 2020.

RPM prices are locational and may vary depending on transmission constraints and local supply and demand conditions.⁸³ 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

⁷⁸ The terms *PJM Region*, *RTO Region* and *RTO* are synonymous in this report and include all capacity within the PJM footprint.

⁷⁹ 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.

⁸⁰ See 126 FERC ¶ 61,275 at P 86 (2009).

⁸¹ See Letter Order, FERC Docket No. ER10-366-000 (January 22, 2010).

⁸² See 126 FERC ¶ 61,275 at P 88 (2009). There have been no Conditional Incremental Auctions.

⁸³ 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.

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.

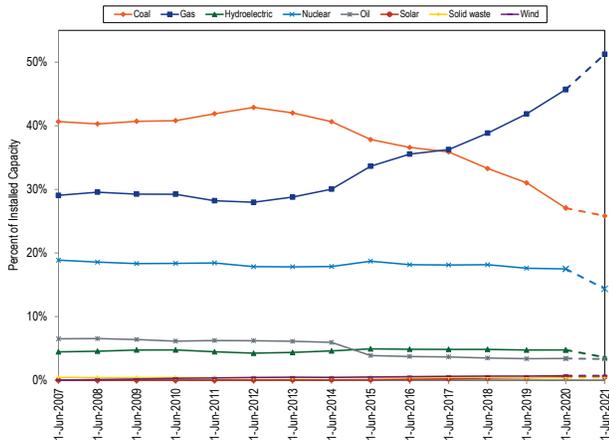
Table 11 RPM reserve margin: June 1, 2016, to June 1, 2021^{84 85}

	Generation and DR RPM Committed Less Deficiency UCAP (MW)	Forecast Peak Load	FRR Peak Load	PRD	RPM Peak Load	IRM	Pool Wide Average EFORd	Generation and DR RPM Committed Less Deficiency ICAP (MW)	Reserve Margin in Excess of IRM		Projected Replacement Capacity using Cleared Buy Bids		Projected Reserve Margin
									Reserve Margin	Percent	ICAP (MW)	UCAP (MW)	
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	164,267.3	149,482.9	11,717.7	510.0	137,255.2	14.7%	5.22%	173,314.3	26.3%	11.6%	15,882.6	6,818.8	21.0%

Market Structure

- **RPM Installed Capacity.** In 2020, RPM installed capacity decreased 486.0 MW or 0.3 percent, from 184,722.8 MW on January 1 to 184,236.8 MW on December 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 December 31, 2020, 45.6 percent was gas; 27.0 percent was coal; 17.5 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.

Figure 9 Percent of installed capacity (By fuel source): June 1, 2007 through June 1, 2021



84 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.

85 These reserve margin calculations do not consider Fixed Resource Requirement (FRR) load.

- **Market Concentration.** In the 2020/2021 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. In the 2021/2022 RPM Second Incremental Auction, two participants in the EMAAC LDA market passed the TPS test.⁸⁶ 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.^{87 88 89}
- **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

- **2020/2021 RPM Third Incremental Auction.** Of the 521 generation resources that submitted Capacity Performance offers, the MMU calculated unit specific offer caps for zero generation resources (0.0 percent).
- **2021/2022 RPM Second Incremental Auction.** Of the 276 generation resources that submitted Capacity Performance offers, the MMU calculated unit specific offer caps for zero generation resources (0.0 percent).

Market Performance

- **The 2020/2021 RPM Third Incremental Auction and the 2021/2022 RPM Second Incremental Auction**

were conducted in 2020.⁹⁰ 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.

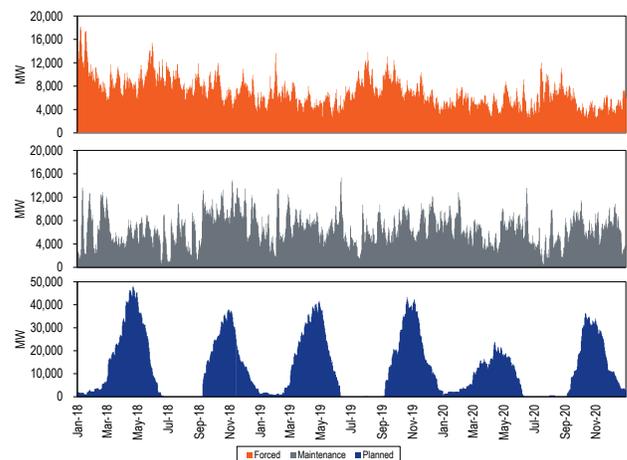
Reliability Must Run Service

- 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 2020 was 6.3 percent, an increase from 5.5 percent in 2019.⁹¹

Figure 10 Outages (MW): Forced, maintenance and planned outages 2018 through 2020



86 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).
 87 See OATT Attachment DD § 6.5.
 88 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).
 89 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).

90 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).
 91 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 February 1, 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.

- **Generator Performance Factors.** The PJM aggregate equivalent availability factor in 2020 was 84.8 percent, an increase from 83.5 percent in 2019.

Recommendations⁹²

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.^{93 94} (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.^{95 96} 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

⁹² 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.

⁹³ See also Comments of the Independent Market Monitor for PJM, Docket No. ER14-503-000 (December 20, 2013).

⁹⁴ 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).

⁹⁵ See PJM Interconnection, LLC, Docket No. ER12-513-000 (December 1, 2011) ("Triennial Review").

⁹⁶ See the 2019 State of the Market Report for PJM, Volume 2, Section 7: Net Revenue.

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 reviewed. (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.⁹⁷ (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.⁹⁸ (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.)

⁹⁷ Brief of the Independent Market Monitor for PJM, Docket No. EL16-49, ER18-1314-000, -001; EL18-178 (October 2, 2018).

⁹⁸ 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 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. New recommendation. 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.⁹⁹ The result of an overstated market seller offer cap is to permit the exercise of market power, as occurred in the 2021/2022 BRA. That complaint remains pending. 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 2020. 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.^{100 101 102 103 104 105} In 2019 and 2020, 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 15,882.6 ICAP MW on June 1, 2021, based on current positions.¹⁰⁶ A majority of capacity investments in PJM were financed by market sources.¹⁰⁷ 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 2,711.8 MW of additional capacity that cleared in RPM auctions for the 2020/2021 through 2021/2022 Delivery Years, 2,613.4 MW (96.4 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

100 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).

101 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).

102 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).

103 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).

104 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).

105 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).

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

107 "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).

99 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).

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. These subsidies were all 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.

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 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 FRR rules should 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 is considering the application of the Effective Load Carrying Capability (ELCC) approach to defining a dynamic and market

based method for determining the capacity contribution of intermittent resources. 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. Implementing ELCC incorrectly, based on average rather than 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.

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.

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.

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.¹¹⁴

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.¹¹⁵ Demand response resources participate in the synchronized reserve market. Demand response resources participate in the regulation market.

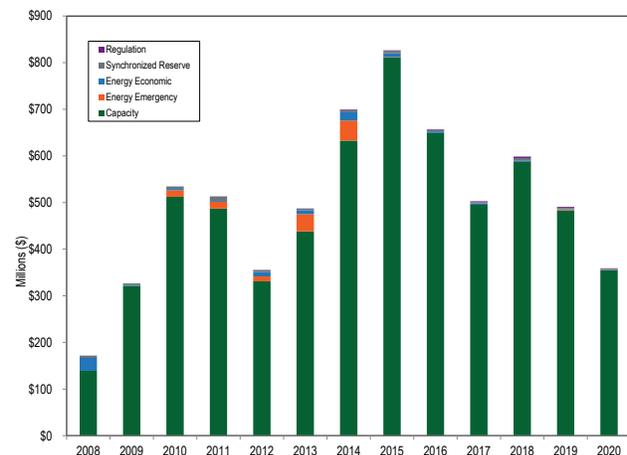
Total demand response revenue decreased by \$131.4 million, 26.8 percent, from \$490.5 million in 2019 to \$359.1 million in 2020. Emergency demand response revenue accounted for 99.1 percent of all demand response revenue, economic demand response for 0.1 percent, demand response in the synchronized reserve market for 0.4 percent and

demand response in the regulation market for 0.4 percent.

Total emergency demand response revenue decreased by \$128.2 million, 26.5 percent, from \$483.3 million in 2019 to \$355.1 million in 2020. This decrease consisted entirely of capacity market revenue.¹¹⁶

Economic demand response revenue decreased by \$0.7 million, 70.0 percent, from \$1.0 million in 2019 to \$0.3 million in 2020.¹¹⁷ Demand response revenue in the synchronized reserve market decreased by \$0.4 million, 14.3 percent, from \$2.8 million in 2019 to \$2.4 million in 2020. Demand response revenue in the regulation market decreased by \$1.0 million, 41.7 percent, from \$2.4 million in 2019 to \$1.4 million in 2020.

Figure 11 Demand response revenue by market: 2008 through 2020



- 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,

¹¹⁴ See Monitoring Analytics, LLC, "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, 2008).

¹¹⁵ 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.

¹¹⁶ 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.

¹¹⁷ Economic credits are synonymous with revenue received for reductions under the economic load response program.

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.¹¹⁸

- **Demand Response Market Concentration.** The ownership of economic load response resources was highly concentrated in 2019 and 2020. The HHI for economic resource reductions increased by 796 points from 8261 in 2019 to 9056 in 2020. 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.

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.¹¹⁹ (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

¹¹⁸ PJM Manual 28: Operating Agreement Accounting, § 11.2.2, Rev. 84 (Dec. 17 2020).

¹¹⁹ See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

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.¹²⁰ (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.¹²¹)
- 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

¹²⁰ 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-c.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.

¹²¹ 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.

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.¹²² The MMU proposal was based on the BGE load forecasting program and the Pennsylvania Act 129 Utility Program.^{123 124} 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 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.¹²⁵ 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.

122 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>>.

123 *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).

124 *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).

125 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).

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 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.¹²⁶ 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 lower in 2020 than in 2019.
- In 2020, average energy market net revenues decreased by 17 percent for a new combustion turbine (CT), 19 percent for a new combined cycle (CC), 51 percent for a new coal plant (CP), 22 percent for a new nuclear plant, 49 percent for a new diesel (DS), 27 percent for a new onshore wind installation, 22 percent for a new offshore wind installation and 25 percent for a new solar installation compared to 2019.
- The prices of natural gas, coal, and oil fell in 2020. The marginal costs of a new CC and a new CT were less than the marginal cost of a new CP in 2020.
- Based on Western Hub prices, the spark spread in 2020 decreased by 1 percent while the spark spread standard deviation decreased by 46 percent. The dark spread decreased by 17 percent while the dark spread standard deviation decreased by 46 percent, and the quark spread decreased by 27 percent while the quark spread standard deviation decreased by 46 percent.
- In 2020, capacity market revenue accounted for 55 percent of total net revenues for a new CT, 44 percent for a new CC, 82 percent for a new CP, 20 percent for a new nuclear plant, 88 percent for a new DS, 10 percent for a new onshore wind installation, 19 percent for a new offshore wind installation and 8 percent for a new solar installation.
- In 2020, no new CT, CC, CP, nuclear, or DS units would have received sufficient net revenue to cover levelized total costs in any zone as a result of lower energy prices.

¹²⁶ 577 U.S. 260 (2016).

Figure 12 New entrant CC net revenue and 20-year levelized total cost by LDA (Dollars per installed MW-year): 2014 through 2020

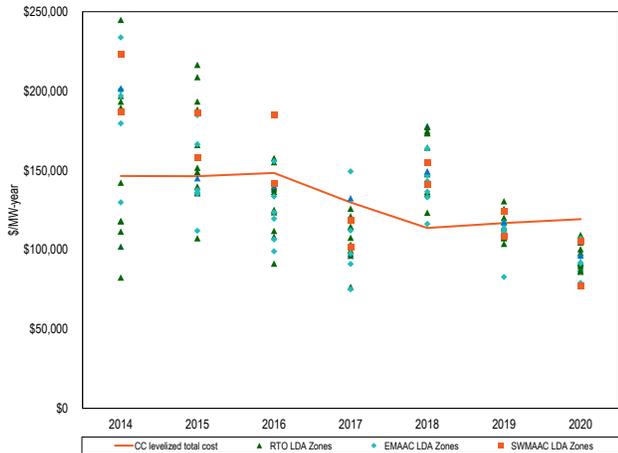


Figure 13 New entrant CP net revenue and 20-year levelized total cost by LDA (Dollars per installed MW-year): 2014 through 2020

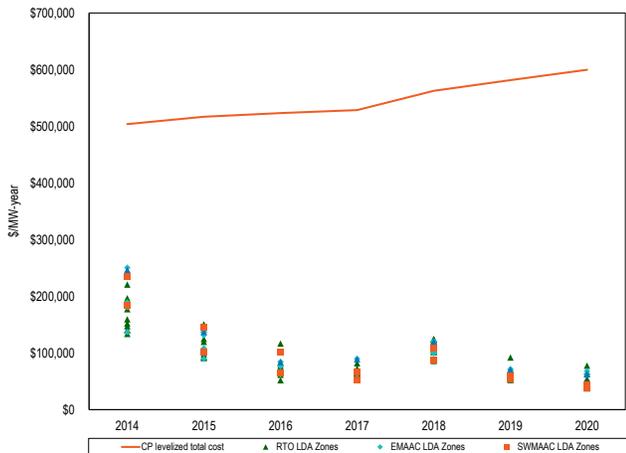
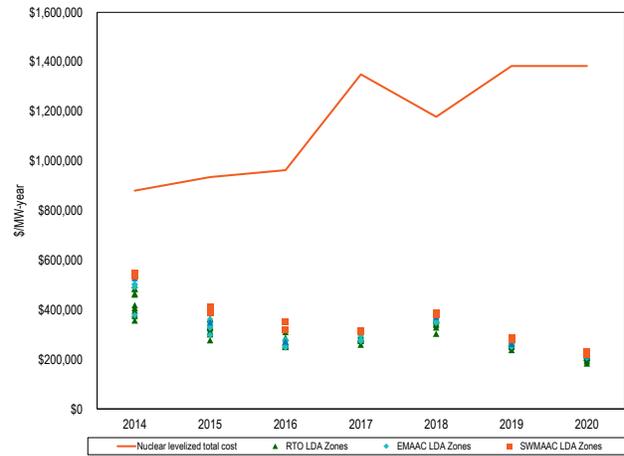


Figure 14 New entrant nuclear plant net revenue and 20-year levelized total cost by LDA (Dollars per installed MW-year): 2014 through 2020



- In 2020, a new entrant onshore wind installation would not have received sufficient net revenue to cover levelized total costs in any of the four zones analyzed. Net revenues would have covered between 34 and 37 percent of levelized total costs of a new entrant onshore wind installation in AEP, APS, ComEd and PENELEC. Renewable energy credits accounted for at least 29 percent of the total net revenue of an onshore wind installation.
- In 2020, a new entrant offshore wind installation in AECO would not have received sufficient net revenue to cover levelized total costs. Net revenues would have covered 19 percent of levelized total costs. Renewable energy credits accounted for 30 percent of the total net revenue of an offshore wind installation.
- In 2020, a new entrant solar installation would have covered more than 100 percent of levelized total costs in four of the five zones analyzed. Renewable energy credits accounted for at least 68 percent of the total net revenue of a solar installation.
- In 2020, most units did not achieve full recovery of avoidable costs through net revenue from energy markets alone, illustrating the critical role of the PJM Capacity Market in providing incentives for continued operation and investment. In 2020, capacity revenues were sufficient to cover the shortfall between energy revenues and avoidable costs for the majority of units and technology types in PJM, with the exception of some coal units and some nuclear units.

- Using a forward analysis, a total of 4,751 MW of coal, CT, diesel, and oil fired capacity are at risk of retirement, in addition to the units that are currently planning to retire. The 4,751 MW at risk of retirement include 2,361 MW of coal, 227 MW of CT, and 2,841 MW of other capacity.
- Negative prices do not have a significant impact on total nuclear unit market revenue. Since 2014, negative prices have affected nuclear plants' annual gross revenues by an average of 0.1 percent.¹²⁷

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

¹²⁷ 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 the comparison.

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.¹²⁸ On May 22, 2020, the EPA published its determination that MATS is not appropriate and necessary based on a cost-benefit analysis.¹²⁹ The list of coal steam units subject to MATS, however, remains in place.¹³⁰ All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS.
- **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.¹³¹ On October 15, 2020, the EPA proposed to revise upward the good neighbor obligations under the 2008 ozone NAAQS for 12 states, including 10 PJM states.¹³²
- **NSR.** On August 1, 2019, the EPA proposed to reform the New Source Review (NSR) permitting program.¹³³ 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.

¹²⁸ *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).

¹²⁹ 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.

¹³⁰ *Id.* at 31291.

¹³¹ CAA § 110(a)(2)(D)(i)(I).

¹³² *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. 68964 (Oct. 30, 2020).

¹³³ *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).

- **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.¹³⁴ 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, which ACE had replaced.¹³⁵
- **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.¹³⁶
- **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.¹³⁷

- **Coal Ash.** The EPA administers the Resource Conservation and Recovery Act (RCRA), which governs the disposal of solid and hazardous waste.¹³⁸ 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 York, Rhode Island, and Vermont that applies to power generation facilities. New Jersey rejoined on January 1, 2020.¹³⁹ Virginia joined RGGI on January 1, 2021, and Pennsylvania is preparing to join.^{140 141} The auction price in the December 2, 2020, auction for the 2018/2020 compliance period was \$7.41 per ton, or \$8.17 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 126.5 percent for a new combustion turbine (CT) unit, \$16.71 per MWh or 124.6 percent for a new combined cycle (CC) unit and \$43.15 per MWh or 156.2 percent for a new coal plant (CP) in 2020.

State Renewable Portfolio Standards

- **RPS.** In PJM, nine 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 December 31, 2020, Delaware, Illinois, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, and Washington, DC had renewable portfolio standards. Virginia had a voluntary RPS in 2020, but a new mandatory RPS

¹³⁴ See 40 CFR § 63.6640(f).

¹³⁵ American Lung Association et al. v. EPA, No. 19-1140.

¹³⁶ 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).

¹³⁷ *County of Maui v. Hawaii Wildlife Fund*, Slip. Op. No. 18-260 (April 23, 2020).

¹³⁸ 42 U.S.C. §§ 6901 et seq.

¹³⁹ "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>.

¹⁴⁰ "Statement on Virginia Greenhouse Gas Rule," RGGI, (July 8, 2020) <<https://www.rggi.org/news-releases/rggi-releases>>.

¹⁴¹ 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/>>.

became effective on January 1, 2021. Indiana had voluntary renewable portfolio standards. Kentucky, Tennessee and West Virginia did not have renewable portfolio standards.

- **RPS Cost.** The cost of complying with RPS, as reported by the states, is \$4.5 billion over the five year period from 2014 through 2018, an average annual RPS compliance cost of \$893.1 million. The compliance cost for 2018, the most recent year with complete data, was \$986.9 million.

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 December 31, 2020, 93.9 percent of coal steam MW had some type of flue-gas desulfurization (FGD) technology to reduce SO₂ emissions, while 99.9 percent of coal steam MW had some type of particulate control, and 94.8 percent of fossil fuel fired capacity had NOX emission control technology. All coal steam units in PJM are compliant with the state and federal emissions limits established by MATS.

Renewable Generation

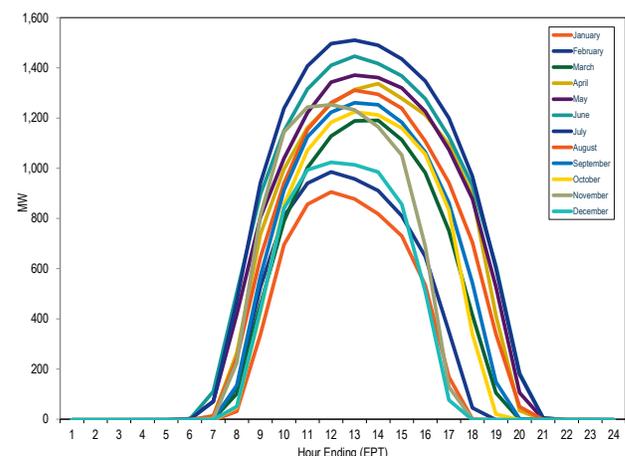
- **Renewable Generation.** Wind and solar generation was 3.7 percent of total generation in PJM in 2020. RPS Tier I generation was 5.2 percent of total generation in PJM and RPS Tier II generation was 2.1 percent of total generation in PJM in 2020. Only Tier I generation is defined to be renewable but Tier 1 includes some carbon emitting generation.

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.)

Figure 15 Average hourly real-time generation of solar units: 2020



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.¹⁴² 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 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 \$6.17 per tonne in Washington, DC to \$18.36 per tonne in New Jersey. The price of carbon implied by SREC prices ranges from \$60.97 per tonne in Pennsylvania to \$883.41 per tonne in Washington, DC. The effective prices for carbon compare to the RGGI clearing price in December 2020 of \$8.17 per tonne and to the social cost of carbon which is estimated in the range of \$50 per tonne.¹⁴³ 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.¹⁴⁴ 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.

¹⁴² 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.")

¹⁴³ "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>.

¹⁴⁴ 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.

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 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 five year period from 2014 through 2018 for the nine jurisdictions that had RPS was \$893.1 million, or a total of \$4.5 billion over five years. The RPS compliance cost for 2018, the most recent year for which there is complete data, was \$986.9 million.¹⁴⁵ 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 \$7.41 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 \$7.41 per short ton would be about \$1.4 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

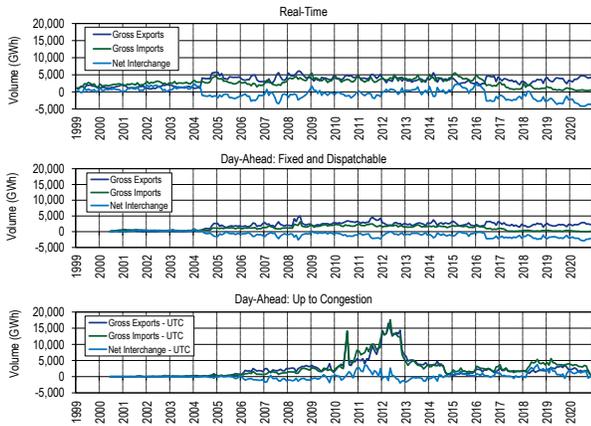
Interchange Transaction Activity

- **Aggregate Imports and Exports in the Real-Time Energy Market.** In 2020, PJM was a monthly net exporter of energy in the real-time energy market in all months.¹⁴⁶ In 2020, the real-time net interchange was -41,630.2 GWh. The real-time net interchange in 2019 was -31,674.1 GWh.

¹⁴⁵ 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.

¹⁴⁶ 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.

Figure 16 Scheduled import and export transaction volume history: January 1, 1999 through December 31, 2020



- **Aggregate Imports and Exports in the Day-Ahead Energy Market.** In 2020, PJM was a monthly net exporter of energy in the day-ahead energy market in all months. In 2020, the total day-ahead net interchange was -15,414.6 GWh. The day-ahead net interchange in 2019 was -7,174.9 GWh.
- **Aggregate Imports and Exports in the Day-Ahead and the Real-Time Energy Market.** In 2020, gross imports in the day-ahead energy market were 538.7 percent of gross imports in the real-time energy market (492.5 percent in 2019). In 2020, gross exports in the day-ahead energy market were 104.4 percent of the gross exports in the real-time energy market (138.5 percent in 2019).
- **Interface Imports and Exports in the Real-Time Energy Market.** In 2020, there were net scheduled exports at 15 of PJM’s 19 interfaces in the real-time energy market.
- **Interface Pricing Point Imports and Exports in the Real-Time Energy Market.** In 2020, there were net scheduled exports at 10 of PJM’s 17 interface pricing points eligible for real-time transactions in the real-time energy market.^{147 148}
- **Interface Imports and Exports in the Day-Ahead Energy Market.** In 2020, there were net scheduled

exports at 15 of PJM’s 19 interfaces in the day-ahead energy market.

- **Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In 2020, there were net scheduled exports at nine of PJM’s 18 interface pricing points eligible for day-ahead transactions in the day-ahead energy market.¹⁴⁹
- **Up To Congestion Interface Pricing Point Imports and Exports in the Day-Ahead Energy Market.** In 2020, up to congestion transactions were net exports at four of PJM’s 18 interface pricing points eligible for day-ahead transactions in the day-ahead energy market.¹⁵⁰
- **Inadvertent Interchange.** In 2020, net scheduled interchange was -41,630 GWh and net actual interchange was -41,716 GWh, a difference of 86 GWh. In 2019, the difference was 128 GWh. This difference is inadvertent interchange.
- **Loop Flows.** In 2020, the Northern Indiana Public Service (NIPS) Interface had the largest loop flows of any interface with -1,623 GWh of net scheduled interchange and -11,906 GWh of net actual interchange, a difference of 10,283 GWh. In 2020, the SouthIMP interface pricing point had the largest loop flows of any interface pricing point with 3,433 GWh of net scheduled interchange and 24,369 GWh of net actual interchange, a difference of 20,936 GWh.

Interactions with Bordering Areas

PJM Interface Pricing with Organized Markets

- **PJM and MISO Interface Prices.** In 2020, 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 67.9 percent of the hours.
- **PJM and New York ISO Interface Prices.** In 2020, the direction of the hourly flow was consistent with the real-time hourly price differences between the PJM/

¹⁴⁷ In the first five months of 2020, there was one interface pricing point eligible for day-ahead transaction scheduling only (NIPSCO).

¹⁴⁸ On June 1, 2020, PJM retired the CPLEIMP, CPLEEXP, DUKIMP, DUKEXP and NIPSCO interface pricing points. On October 1, 2020, PJM retired the Northwest interface pricing point. On November 3, 2020, PJM retired the NCMPAIMP and NCMPAEXP interface pricing points. These retirements reduced the number of real-time interface pricing points to 10.

¹⁴⁹ On June 1, 2020, PJM retired the CPLEIMP, CPLEEXP, DUKIMP and DUKEXP and NIPSCO interface pricing points. On October 1, 2020, PJM retired the Northwest interface pricing point. On November 3, 2020, PJM retired the NCMPAIMP and NCMPAEXP interface pricing points. These retirements reduced the number of day-ahead interface pricing points to 10.

¹⁵⁰ On June 1, 2020, PJM retired the CPLEIMP, CPLEEXP, DUKIMP and DUKEXP and NIPSCO interface pricing points. On October 1, 2020, PJM retired the Northwest interface pricing point. On November 3, 2020, PJM retired the NCMPAIMP and NCMPAEXP interface pricing points. These retirements reduced the number of day-ahead interface pricing points to 10.

NYIS Interface and the NYISO/PJM proxy bus in 49.9 percent of the hours.

- **Neptune Underwater Transmission Line to Long Island, New York.** In 2020, 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 70.0 percent of the hours.
- **Linden Variable Frequency Transformer (VFT) Facility.** In 2020, 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 61.4 percent of the hours.
- **Hudson DC Line.** In 2020, 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 58.5 percent of the hours.

Interchange Transaction Issues

- **PJM Transmission Loading Relief Procedures (TLRs).** PJM issued two TLRs of level 3a or higher in 2020, compared to two such TLRs issued in 2019.
- **Up To Congestion.** The average number of up to congestion bids submitted in the day-ahead energy market decreased by 6.6 percent, from 52,046 bids per day in 2019 to 48,618 bids per day in 2020. The average cleared volume of up to congestion bids submitted in the day-ahead energy market decreased by 12.5 percent, from 500,819 MWh per day in 2019, to 438,170 MWh per day in 2020.

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.)
- 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.)
- 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.

Prior to the integration of NIPSCO with MISO, transactions sourcing or sinking in the NIPSCO balancing authority were eligible to receive the real-time NIPSCO interface pricing point. Starting May 1, 2004, when NIPSCO integrated with MISO, all real-time transactions sourcing or sinking in NIPSCO are represented on the NERC Tag as sourcing or sinking in MISO, and thus receive the MISO interface pricing point in the real-time energy market. For this reason, it was no longer

possible to receive the NIPSCO interface pricing point in the real-time energy market after the integration of NIPSCO into MISO. The MMU has recommended that PJM terminate the NIPSCO interface pricing point since 2013. The NIPSCO pricing point is a pricing point that could no longer be used to price actual transactions and did not reflect actual price formation. On June 1, 2020, PJM terminated the NIPSCO interface pricing point.

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. On June 1, 2020, PJM terminated the CPLEIMP, CPLEEXP, DUKIMP and DUKEXP interface pricing points. It was not clear why PJM did not also terminate the NCMPAIMP and NCMPAEXP interface pricing points at that time. On October 1, 2020, PJM terminated the Northwest interface pricing point. But following this termination, 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. On November 3, 2020, PJM terminated the NCMPAIMP and NCMPAEXP interface pricing points. The MMU continues to recommend the termination of the Southeast and Southwest interface pricing points, and the Ontario interface pricing point. These pricing points can either no longer be used to price actual transactions, are inappropriately used to support special agreements, or are pricing points that are noncontiguous to the PJM footprint that create 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.¹⁵¹

PJM determines the primary reserve requirement based on the most severe single contingency 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. In 2020, the average primary reserve requirement was 2,454.3 MW in the RTO Zone and 2,429.6 MW in the MAD Subzone.

Tier 1 Synchronized Reserve

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 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

¹⁵¹ See PJM, "Manual 10: Pre-Scheduling Operations," § 3.1.1 Day-ahead Scheduling (Operating Reserve, Rev. 39 (Nov. 19, 2019)).

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 2020, there was an average hourly supply of 2,039.2 MW of tier 1 available in the RTO Zone and an average hourly supply of 957.9 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 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.¹⁵² 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 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.

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. This is stricter than the NERC standard of the greater of 80 percent of the largest single contingency or 900 MW.¹⁵³

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 2020, the supply of daily offered and eligible tier 2 synchronized reserve was 30,576.8 MW in the RTO Zone of which 4,919.9 MW was located in the MAD Subzone.
- **Demand.** The average hourly synchronized reserve requirement was 1,705.4 MW in the RTO Reserve Zone and 1,684.9 MW for the Mid-Atlantic Dominion Reserve Subzone. The hourly average cleared tier 2 synchronized reserve was 218.3 MW in the MAD Subzone and 415.6 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 2020.

The average HHI for tier 2 synchronized reserve in the RTO Zone was 5439 which is classified as highly concentrated. The MMU calculates that the three pivotal supplier test would have been failed in 39.2 percent of intervals in 2020.

¹⁵² See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 4.2.10 Settlements, Rev. 112 (January 5, 2021).

¹⁵³ NERC (June 2, 2020) <NERC Reliability Standard BAL 002-2 Glossary_of_Terms.pdf>.

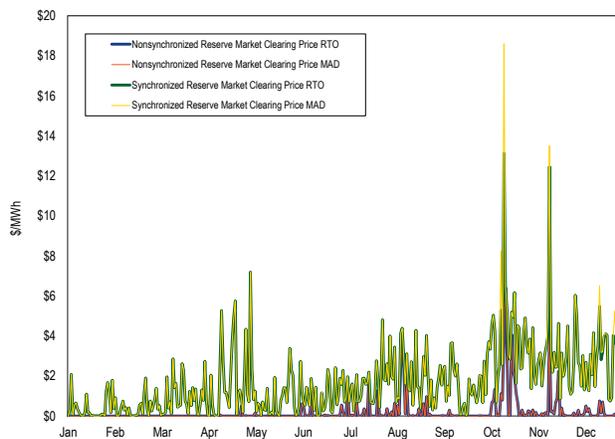
Market Conduct

- **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 \$1.71 per MW in 2020. The weighted average price for tier 2 synchronized reserve for all cleared intervals in the RTO Synchronized Reserve Zone was \$1.62 per MW in 2020.

Figure 17 Daily average market clearing prices (\$/MW) for synchronized reserve and nonsynchronized reserve: 2020



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 2020, the average supply of eligible and available nonsynchronized reserve was 1,548.0 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.¹⁵⁴
- **Market Concentration.** The MMU calculates that the three pivotal supplier test would have been failed in 99.8 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 \$0.19 in 2020.

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.

¹⁵⁴ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 5b.2.2 Non-Synchronized Reserve Zones and Levels, Rev. 112 (Jan. 5, 2021). "Because Synchronized Reserve may be utilized to meet the Primary Reserve requirement, there is no explicit requirement for non-synchronized reserves."

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.¹⁵⁵ 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 online units. In 2020, the average available hourly DASR was 52,303.9 MW.
- **Demand.** The DASR requirement is the sum of the PJM requirement and the Dominion requirement based on the VACAR reserve sharing agreement. For the PJM RTO between November 2019 through October 2020, the DASR daily requirement was 5.07 percent of peak load forecast. For November 2020 through October 2021, the DASR requirement was 4.78 percent of peak load forecast. The average hourly DASR MW purchased in 2020 was 4,911.5 MW, a reduction from the 5,594.9 hourly MW in 2019.
- **Concentration.** The three pivotal supplier test would have failed in zero hours in 2020.

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 2020, 39.4 percent of daily unit offers were above \$0.00 and 16.4 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 2020.

¹⁵⁵ See PJM, "Manual 11: Energy & Ancillary Services Market Operations," § 11.2.7 Day-Ahead Scheduling Reserve Performance, Rev. 112 (Jan. 5, 2021).

Market Performance

- **Price.** In 2020, the weighted average DASR price for all hours when the DASRMCP was above \$0.00 was \$1.75.

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 2020, the average hourly offered supply of regulation for nonramp hours was 720.9 performance adjusted MW (721.3 effective MW). This was a decrease of 64.6 performance adjusted MW (a decrease of 67.0 effective MW) from 2019. In 2020, the average hourly offered supply of regulation for ramp hours was 1,017.4 performance adjusted MW (1,058.9 effective MW). This was a decrease of 97.9 performance adjusted MW (a decrease of 60.8 effective MW) from 2019, when the average hourly offered supply of regulation was 1,115.3 performance adjusted MW (1,119.7 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 492.0 hourly average performance adjusted actual MW in 2020. This is an increase of 22.5 performance adjusted actual MW from 2019, when the average hourly total regulation cleared performance adjusted actual MW for nonramp hours were 469.5 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 702.5 hourly average performance adjusted actual MW in 2020. This is a decrease of 25.3 performance adjusted actual MW from 2019, where the average hourly regulation cleared MW for ramp hours were 727.8 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 1.45 in 2020 (1.53 in 2019). The ratio of the average hourly offered supply of regulation to average hourly regulation demand (performance adjusted cleared MW) for nonramp hours was 1.47 in 2020 (1.67 in 2019).

- **Market Concentration.** In 2020, the three pivotal supplier test was failed in 93.5 percent of hours. In 2020, the actual MW weighted average HHI of RegA resources was 2488 which is highly concentrated and the weighted average HHI of RegD resources was 1853 which is moderately concentrated. The weighted average HHI of all resources was 1410, 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.¹⁵⁶ In 2020, there were 230 resources following the RegA signal and 53 resources following the RegD signal.

¹⁵⁶ See the 2019 *State of the Market Report for PJM*, Vol. 2, Appendix F "Ancillary Services Markets."

Market Performance

- **Price and Cost.** The weighted average clearing price for regulation was \$13.55 per MW of regulation in 2020, a decrease of \$2.72 per MW, or 16.7 percent, from the weighted average clearing price of \$16.27 per MW in 2019. The weighted average cost of regulation in the 2020 was \$16.73 per MW of regulation, a decrease of 17.6 percent, from the weighted average cost of \$20.31 per MW in 2019.
- **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).¹⁵⁷

In 2020, total black start charges were \$64.9 million, including \$64.7 million in revenue requirement charges and \$0.228 million in operating reserve 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 operating reserve charges are paid to units scheduled in the day-ahead energy market or committed

¹⁵⁷ OATT Schedule 1 § 1.3BB.

in real time to provide black start service under the ALR option or for black start testing. Black start zonal charges in 2020 ranged from \$0.04 per MW-day in the BGE Zone (total charges were \$139,118) to \$2.94 per MW-day in the PENELEC Zone (total charges were \$4,335,964).

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. The CRF values were later added to the black start rules. The capital recovery factor (CRF) defines the revenue requirement associated with the capital costs of black start units. The CRF is a rate, multiplied by the relevant capital investment, which defines the annual payment needed to provide a return on and of capital for the investment over a defined time period. CRFs were and are calculated using a standard financial model that incorporates the weighted average cost of capital and its components, including the rate of return on equity and the interest rate on debt and the capital structure, in addition to depreciation and taxes. For example, a five year CRF will allow the recovery of 100 percent of the investment plus a return over five years. The CRF is not a black box. The basis for the CRF was clear when the CRF values were calculated in 2007 and the basis has been explained again in the PJM stakeholder process.¹⁵⁸ Any market participant should be able to calculate CRF rates using the same assumptions.

As a result of the significant changes to the federal tax code in December 2017, the CRF (capital recovery factor) tables in PJM OATT Attachment DD § 6.8(a) and Schedule 6A are not correct. The CRF table includes assumptions about tax rates that are no longer correct. 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. The CRF values are significantly too high as a result. 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

¹⁵⁸ "Black Start Issues," presented at the August 6, 2020, and September 3, 2020, PJM Operating Committee Meetings, and revised on September 9, 2020. The presentations can be found at: <<https://www.monitoringanalytics.com/reports/Presentations/2020.shtml>>.

and would avoid any potential delay in procuring additional black start resources. PJM could file the changes under FPA Section 205.

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.

New CRF rates, incorporating the tax code changes, should be implemented immediately. The new 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.

For the future, the CRF rates should be updated at least annually to reflect changes in federal or state taxes, including depreciation treatment and tax rates.

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 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 to ensure that the commitment to provide service matches the obligation of customers to pay 100 percent of the fixed and variable costs of the black start units over accelerated time periods.

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.¹⁵⁹ 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 5.68 percent from \$336.3 million in 2019 to \$355.4 million in 2020. Reactive capability charges increased 5.74 percent from \$335.8 million in 2019 to \$355.0 million in 2020. Total reactive service charges in 2020 ranged from \$0 in the RECO and OVEC Zones, to \$49.0 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.^{160 161}

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.¹⁶² 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. NERC uses a threshold value (L_{10}) equal to 250.8 MW/0.1 Hz and has selected four events between June 1, 2020 and December 31, 2020 as well as several events in the first two months of 2021 to evaluate. Evaluation will continue in 2021 when further recommendations

will be discussed within PJM and the NERC Operating Committee.

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

¹⁵⁹ OATT Schedule 2.

¹⁶⁰ See 157 FERC ¶ 61,122 (2016).

¹⁶¹ See 164 FERC ¶ 61,224 (2018).

¹⁶² OATT Attachment O § 4.7.2 (Primary Frequency Response).

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, but the software setting the prices is partially, but not fully clearing the 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.¹⁶³)
- 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.¹⁶⁴ FERC rejected.¹⁶⁵)

- 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.¹⁶⁶)
- 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.¹⁶⁷)
- The MMU recommends enhanced documentation of the implementation of the regulation market design. (Priority: Medium. First reported 2010. Status: Not adopted. FERC rejected.¹⁶⁸)
- 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 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.)

¹⁶⁴ 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.

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

¹⁶⁶ *Id.*

¹⁶⁷ *Id.*

¹⁶⁸ *Id.*

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

- 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 PJM be more explicit and transparent about why tier 1 biasing is used in defining demand in the tier 2 synchronized reserve market. The MMU recommends that PJM define rules for estimating tier 1 MW, define rules for the use and amount of tier 1 biasing and identify the rule based reasons for each instance of biasing. (Priority: Medium. First reported 2012. Status: Adopted April 2019.)
- 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. New recommendation. 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. New recommendation. 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 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. (Priority: High. First reported Q2, 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 2019.¹⁶⁹ 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.¹⁷⁰ (Priority: Medium. New recommendation. Status: Not adopted.)

¹⁶⁹ 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.

¹⁷⁰ 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.¹⁷¹ 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, 2017.¹⁷² 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. 755.¹⁷³ The MMU and PJM separately filed requests for rehearing, which were denied by order issued March 26, 2020.¹⁷⁴

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

¹⁷¹ 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).

¹⁷² 18 CFR § 385.211 (2017)

¹⁷³ 162 FERC ¶ 61,295.

¹⁷⁴ 170 FERC ¶ 61,259.

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 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 decreased by \$54.7 million or 9.4 percent, from \$583.3 million in 2019 to \$528.6 million in 2020.

Table 12 Total congestion costs (Dollars (Millions)): 2008 through 2020

	Congestion Costs (Millions)			Total PJM Billing	Percent of PJM Billing
	Congestion Cost	Percent Change			
2008	\$2,052	NA		\$34,300	6.0%
2009	\$719	(65.0%)		\$26,550	2.7%
2010	\$1,423	98.0%		\$34,770	4.1%
2011	\$999	(29.8%)		\$35,890	2.8%
2012	\$529	(47.0%)		\$29,180	1.8%
2013	\$677	28.0%		\$33,860	2.0%
2014	\$1,932	185.5%		\$50,030	3.9%
2015	\$1,385	(28.3%)		\$42,630	3.2%
2016	\$1,024	(26.1%)		\$39,050	2.6%
2017	\$698	(31.9%)		\$40,170	1.7%
2018	\$1,310	87.8%		\$49,790	2.6%
2019	\$583	(55.5%)		\$39,200	1.5%
2020	\$529	(9.4%)		\$33,640	1.6%

- **Day-Ahead Congestion.** Day-ahead congestion costs decreased by \$51.5 million or 7.2 percent, from \$714.0 million in 2019 to \$662.5 million in 2020.
- **Balancing Congestion.** Negative balancing congestion costs increased by \$3.2 million or 2.5 percent, from -\$130.7 million in 2019 to -\$133.9 million in 2020. Negative balancing explicit charges decreased by \$5.7 million, from -\$83.3 million in 2019 to -\$77.6 million in 2020.
- **Real-Time Congestion.** Real-time congestion costs decreased by \$3.0 million or 0.4 percent, from \$752.3 million in 2019 to \$749.3 million in 2020.
- **Monthly Congestion.** Monthly total congestion costs in 2020 ranged from \$16.0 million in April to \$81.7 million in July.
- **Geographic Differences in CLMP.** Differences in CLMP among eastern, southern and western control zones in PJM were primarily a result of congestion on the Bagley – Graceton Line, the Conastone – Graceton Line, the Three Mile Island Transformer, the Conastone – Peach Bottom Line, 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 2020. The number of congestion event hours in the day-ahead energy market was about four times the number of congestion event hours in the real-time energy market.

Day-ahead congestion frequency decreased by 24.1 percent from 103,140 congestion event hours in 2019 to 78,239 congestion event hours in 2020.

Real-time congestion frequency increased by 4.1 percent from 21,122 congestion event hours in 2019 to 21,984 congestion event hours in 2020.

- **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.¹⁷⁵ Day-ahead, congestion event hours decreased on all types of facilities except interfaces. The congestion event hours on the PA Central Interface increased from 872 hours in 2019 to 1,412 hours in 2020.

The Bagley – Graceton Line was the largest contributor to congestion costs in 2020. With \$81.7 million in total congestion costs, it accounted for 15.5 percent of the total PJM congestion costs in 2020.

- **CT Price Setting Logic and Closed Loop Interface Related Congestion.** CT Price Setting Logic caused -\$0.4 million of day-ahead congestion in 2020 and -\$1.7 million of balancing congestion in 2020. None of the closed loop interfaces was binding in 2020 or 2019.
- **Zonal Congestion.** AEP had the largest zonal congestion costs among all control zones in 2020. AEP had \$92.7 million in zonal congestion costs, comprised of \$112.3 million in zonal day-ahead congestion costs and -\$19.6 million in zonal balancing congestion costs.

Marginal Loss Cost

- **Total Marginal Loss Costs.** Total marginal loss costs decreased by \$163.5 million or 25.5 percent, from

\$642.0 million in 2019 to \$478.5 million in 2020. The loss MWh in PJM decreased by 891.3 GWh or 5.9 percent, from 15,208.5 GWh in 2019 to 14,317.2 GWh in 2020. The loss component of real-time LMP in 2020 was \$0.01, compared to \$0.02 in 2019.

- **Monthly Total Marginal Loss Costs.** Monthly total marginal loss costs in 2020 ranged from \$22.5 million in April to \$67.0 million in July.
- **Day-Ahead Marginal Loss Costs.** Day-ahead marginal loss costs decreased by \$170.3 million or 24.4 percent, from \$696.5 million in 2019 to \$526.3 million in 2020.
- **Balancing Marginal Loss Costs.** Negative balancing marginal loss costs decreased by \$6.8 million or 12.4 percent, from -\$54.5 million in 2019 to -\$47.7 million in 2020.
- **Total Marginal Loss Surplus.** The total marginal loss surplus decreased in 2020 by \$45.8 million or 22.5 percent, from \$203.7 million in 2019, to \$157.9 million in 2020.

System Energy Cost

- **Total System Energy Costs.** Total system energy costs increased by \$116.2 million or 26.7 percent, from -\$435.2 million in 2019 to -\$319.0 million in 2020.
- **Day-Ahead System Energy Costs.** Day-ahead system energy costs increased by \$127.2 million or 24.1 percent, from -\$528.6 million in 2019 to -\$401.4 million in 2020.
- **Balancing System Energy Costs.** Balancing system energy costs decreased by \$15.0 million or 15.8 percent, from \$94.9 million in 2019 to \$79.9 million in 2020.
- **Monthly Total System Energy Costs.** Monthly total system energy costs in 2020 ranged from -\$42.5 million in July to -\$15.9 million in April.

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

¹⁷⁵ 172 FERC ¶ 61,046 (2020).

geographic distribution of incremental bids and offers and the geographic and temporal distribution of load.

Total congestion in 2020 was lower than congestion in any year from 2008 through 2019. This was the combined result of weather conditions and demand reductions due to COVID-19.

The monthly total congestion costs ranged from \$16.0 million in April to \$81.7 million in July in 2020.

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 seven months of the 2020/2021 planning period was 55.8.8 percent. The cumulative offset of congestion by ARRs for the 2011/2012 planning period through the first seven months of the 2020/2021 planning period, using the rules effective for each planning period, was 74.9 percent. Load has been underpaid by \$2.2 billion from the 2011/2012 planning period through the first seven months of the 2020/2021 planning period.

Overview: Section 12, Planning

Generation Interconnection Planning

Existing Generation Mix

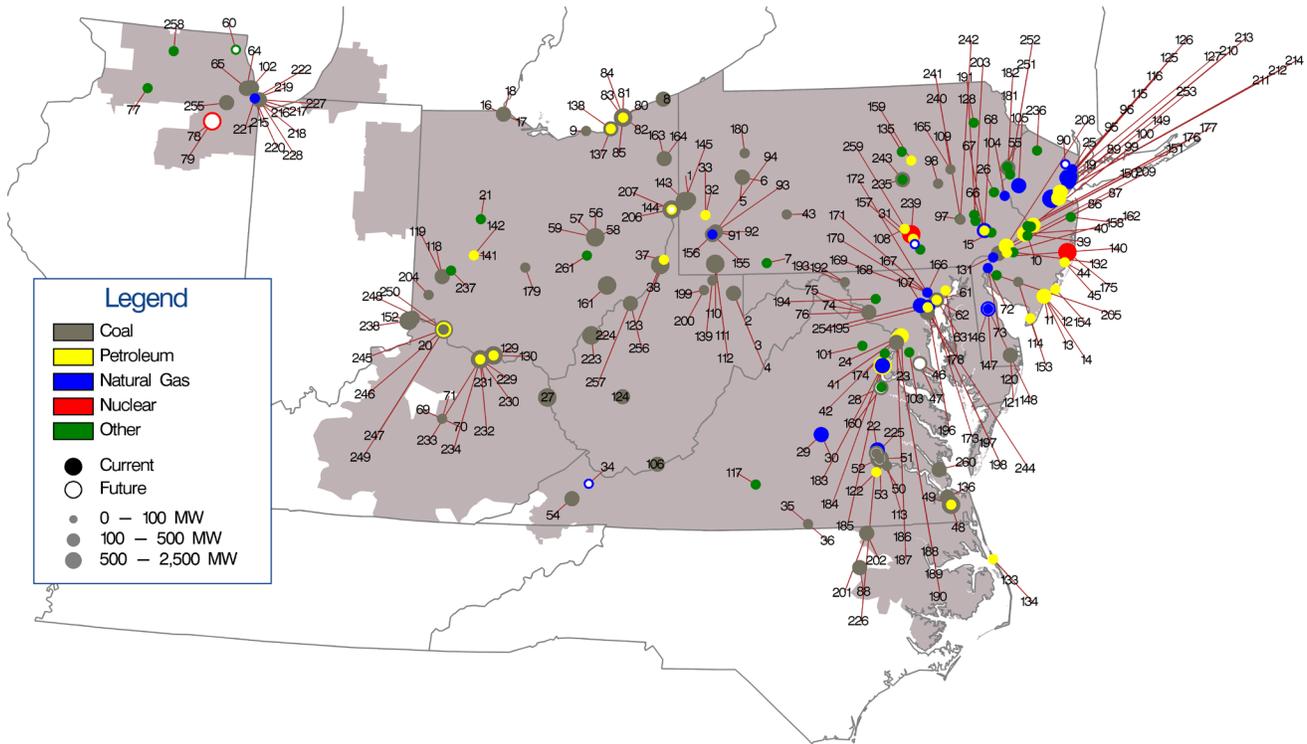
- As of December 31, 2020, PJM had a total installed capacity of 198,129.0 MW, of which 50,230.8 MW (25.4 percent) are coal fired steam units, 50,602.0 MW (25.5 percent) are combined cycle units and 33,452.6 MW (16.9 percent) are nuclear units. This measure of installed capacity differs from capacity market installed capacity because it includes energy only units, excludes all external units, and uses nameplate values for solar and wind resources.
- Of the 198,129.0 MW of installed capacity, 72,244.4 MW (36.5 percent) are from units older than 40 years, of which 37,578.4 MW (52.0 percent) are coal fired steam units, 532.0 MW (0.7 percent) are combined cycle units and 16,184.6 MW (22.4 percent) are nuclear units.

Generation Retirements¹⁷⁶

- There are 44,181.3 MW of generation that have been, or are planned to be, retired between 2011 and 2024, of which 32,084.1 MW (72.6 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 2020, 3,255.0 MW of generation retired. The largest generator that retired in 2020 was the 786.0 MW Possum Point 5 oil fired steam unit located in the Dominion Zone. Of the 3,255.0 MW of generation that retired, 786.0 MW (24.1 percent) were located in the Dominion Zone.
- As of December 31, 2020, there are 4,163.9 MW of generation that have requested retirement after December 31, 2020, of which 1,794.5 MW (43.1 percent) are located in the ComEd Zone. Of the generation requesting retirement in the ComEd Zone, 1,786.5 MW (99.6 percent) are nuclear units.

¹⁷⁶ See PJM. Planning. "Generator Deactivations," (Accessed on December 31, 2020) <<http://www.pjm.com/planning/services-requests/gen-deactivations.aspx>>.

Figure 18 Map of unit retirements: 2011 through 2024



Generation Queue¹⁷⁷

- There were 126,818.9 MW in generation queues, in the status of active, under construction or suspended, at the end of 2019. In 2020, the AF2 and AG1 queue windows closed, and the AG2 queue window opened. 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 December 31, 2020, there were 173,581.3 MW in generation queues, in the status of active, under construction or suspended, an increase of 46,762.4 MW (36.9 percent) from the end of 2019.¹⁷⁸
- As of December 31, 2020, 5,821 projects, representing 657,391.2 MW, have entered the queue process since its inception in 1998. Of those, 953 projects, representing 73,137.3 MW, went into service. Of the projects that entered the queue process, 2,983 projects, representing 410,672.5 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 December 31, 2020, 173,581.3 MW were in generation request queues in the status of active, under construction or suspended. Based on historical completion rates, 37,214.3 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 3,169 projects entered from January 2015 through December 2020, 2,380 projects (75.1 percent) were renewable. Of the 969 projects entered in 2020, 768 projects (79.3 percent) were renewable. Renewable projects make up

¹⁷⁷ See PJM. Planning. "New Services Queue," (Accessed on December 31, 2020) <<https://www.pjm.com/planning/services-requests/interconnection-queues.aspx>>.

¹⁷⁸ The queue totals in this report are the winter net MW energy for the interconnection requests ("MW Energy") as shown in the queue.

78.6 percent of all projects in the queue and those projects account for 74.8 percent of the nameplate MW currently active, suspended or under construction in the queue as of December 31, 2020.

But of the 129,844.9 MW of renewable projects in the queue, only 6,487.5 MW (5.0 percent) of capacity resources are expected to go into service, based on both historical completion rates and average derate factors for wind and solar.

Figure 19 Map of unit additions (less than 20 MW): 2011 through 2020

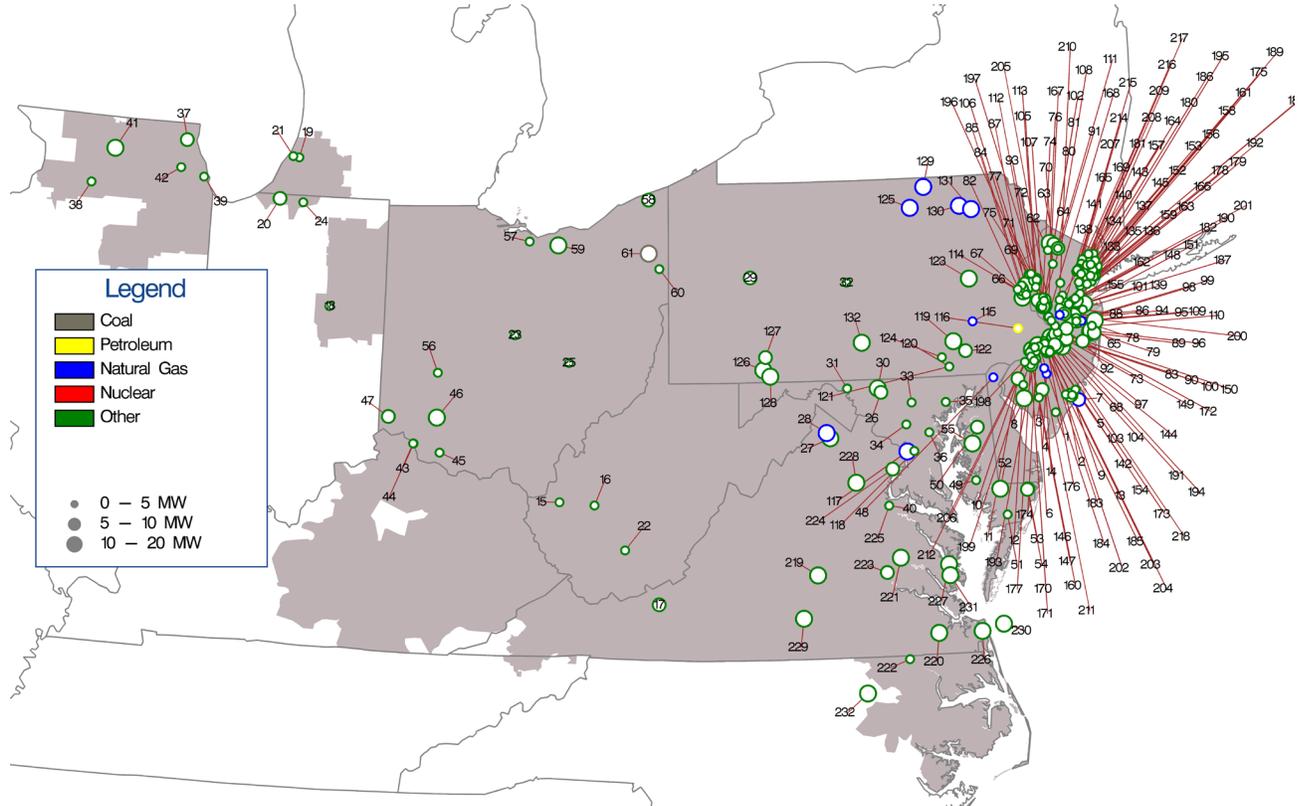
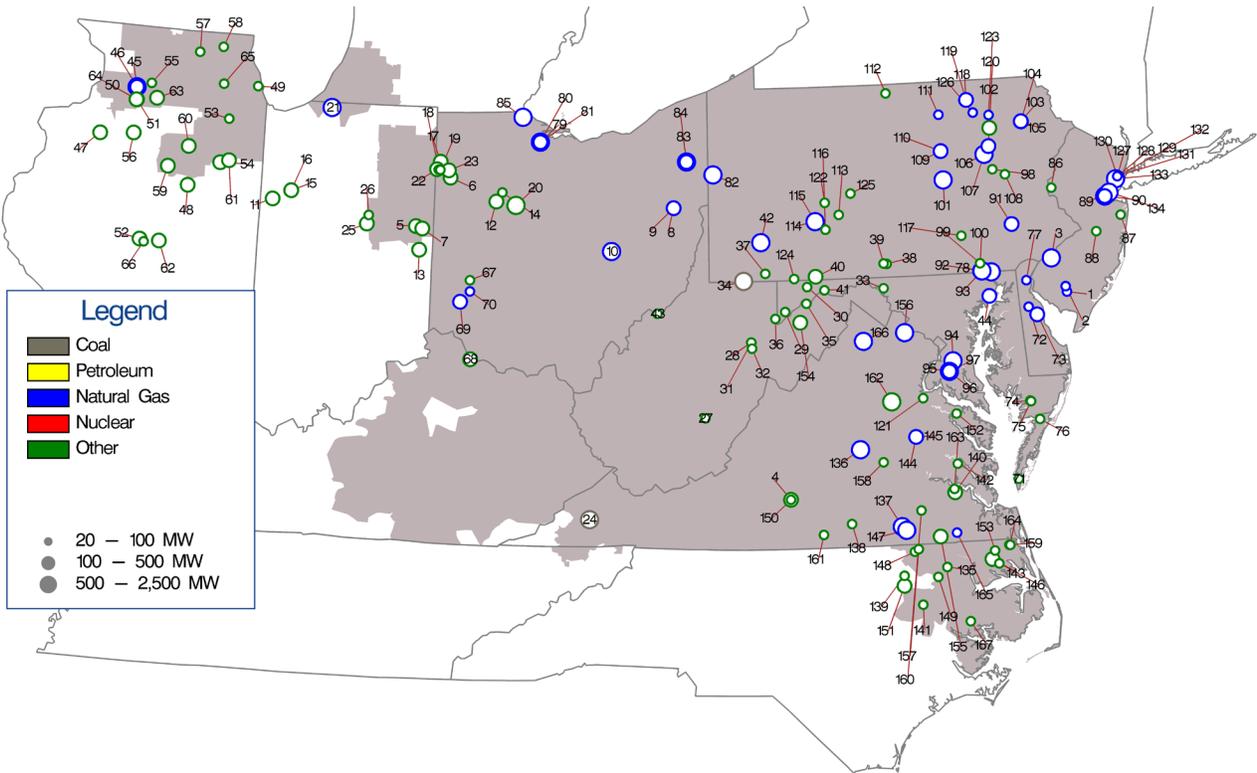


Figure 20 Map of unit additions (20 MW or greater): 2011 through 2020



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 December 31, 2020, PJM has completed four market efficiency cycles under Order No. 1000.¹⁷⁹

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.

¹⁷⁹ 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.”¹⁸⁰ Supplemental projects are exempt from the competitive planning process.
- The average number of supplemental projects in each expected in service year increased by 715.0 percent, from 20 for years 1998 through 2007 (pre Order No. 890¹⁸¹) to 163 for years 2008 through 2020 (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.¹⁸²

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.¹⁸³

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.¹⁸⁴ In 2020, the PJM Board approved \$235.2 million in upgrades. As of December 31, 2020, the PJM Board has approved \$37.8 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

¹⁸⁰ See PJM, “Transmission Construction Status,” (Accessed on December 31, 2020) <<http://www.pjm.com/planning/rtep-upgrades-status/construct-status.aspx>>.

¹⁸¹ 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).

¹⁸² 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).

¹⁸³ 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).

¹⁸⁴ Supplemental Projects, including the end of life subset of supplemental projects, do not require PJM Board of Managers authorization.

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 December 31, 2020, 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.¹⁸⁵
- There were 11,827 transmission outage requests submitted in the first seven months of 2020/2021 planning period. Of the requested outages, 75.9 percent of the requested outages were planned for less than or equal to five days and 9.2 percent of requested outages were planned for greater than 30 days. Of the requested outages, 43.9 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.¹⁸⁶ (Priority: Low. First reported 2013. Status: Partially adopted, 2012.)
- The MMU recommends that rules be implemented to ensure that CIRs are terminated within one year if units cannot qualify to be capacity resources and, if requested, after one CP must offer exception to permit the issue of CP status to be addressed. (Priority: Low. First reported 2018. Status: Adopted, 2019.)

¹⁸⁵ See PJM, "PJM Manual 03: Transmission Operations," Rev. 58 (November 19, 2020).

¹⁸⁶ 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. New recommendation. 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 Q3, 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. New recommendation. 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.¹⁸⁷ (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 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

¹⁸⁷ See the 2015 State of the Market Report for PJM, Volume 2, Section 12: Generation and Transmission Planning, at p. 463, Cost Allocation Issues.

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 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 ARRs

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 seven months of the 2020/2021 planning period, ARRs offset only 55.8 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 \$2.2 billion from the 2011/2012 planning period through the first seven months of the 2020/2021 planning period. The cumulative offset for that period was 74.9 percent of total congestion.
- **Revenue Adequacy.** For the first seven 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 \$511.2 million, while PJM collected \$681.4 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 seven months of the 2020/2021 planning period, PJM allocated a total of 13,601.8 MW of residual ARRs with a total target allocation of \$5.7 million, down from 14,390.3 MW in the first seven months of the 2019/2020 planning period, with a total target allocation of \$5.6 million.

- **ARR Reassignment for Retail Load Switching.** There were 21,833 MW of ARRs associated with \$290,500 of revenue that were reassigned in the first seven months of the 2020/2021 planning period. There were 24,341 MW of ARRs associated with \$404,700 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 86.0 percent of prevailing flow and 88.9 percent of counter flow FTRs for January through December, 2020. Financial entities owned 75.4 percent of all prevailing and counter flow FTRs, including 68.7 percent of all prevailing flow FTRs and 83.9 percent of all counter flow FTRs during the period from January through December 2020. Self scheduled FTRs account for 3.9 percent of all FTRs held.
- **Market Concentration.** For prevailing flow obligation FTRs in the Monthly Balance of

Planning Period Auctions for the first seven months of the 2020/2021 planning period, all market periods were unconcentrated. For counter flow obligation FTRs for the first seven months of the 2020/2021 planning period, 87.3 of periods were unconcentrated and 12.7 percent of periods were moderately concentrated. 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 seven months of the 2020/2021 planning period, total participant FTR sell offers were 12,730,496 MW.
- **Buy Bids.** The total FTR buy bids from the Monthly Balance of Planning Period FTR Auctions for the first seven months of the 2020/2021 planning were 27,360,901 MW.
- **FTR Forfeitures.** Total FTR forfeitures were \$2.2 million for the first seven months of the 2020/2021 planning period.
- **Credit.** There were seven collateral defaults in 2020, for a total of \$82,019. There were 27 payment defaults in 2020 not involving GreenHat Energy, LLC for a total of \$113,643. GreenHat Energy accrued payment defaults of \$14.8 million in 2020 for a total of \$161.8 million in defaults to date, which will continue to accrue through May 2021, including the auction liquidation costs.¹⁸⁸ 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 \$179.3 million.

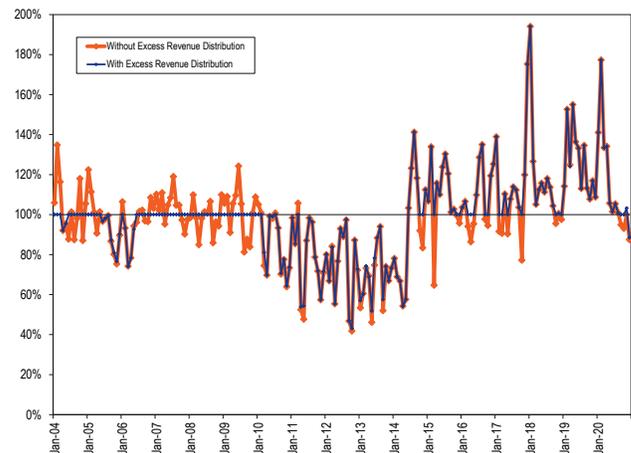
Market Performance

- **Quantity.** In the first seven months of the 2020/2021 planning period, Monthly Balance of Planning Period FTR Auctions cleared 4,200,340 MW (15.4 percent) of FTR buy bids and 2,085,566 MW (16.4 percent) of FTR sell offers. For the first seven months of the 2019/2020 planning period, Monthly Balance

of Planning Period FTR Auctions cleared 2,690,460 (15.9 percent) of FTR buy bids and 1,390,171 MW (21.1 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 seven 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 \$31.6 million in the first seven months of the 2020/2021 planning period, down from \$42.6 million for the same time period in the 2019/2020 planning period.
- **Revenue Adequacy.** FTRs were paid at 99.6 percent of the target allocation level for the first seven months of the 2020/2021 planning period, including the distribution of the current surplus revenue.

Figure 21 FTR payout ratio by month, excluding and including excess revenue distribution: 2004 through 2020



- **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 seven months of 2020/2021 planning period, physical entities made \$39.1 million profits on FTRs purchased directly (not self scheduled), up from \$4.5 million profits for the same time period in the 2019/2020 planning period and financial entities made \$141.3 million, up from \$25.0 million profits for the same time period in the 2019/2020 planning period.

¹⁸⁸ 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.

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 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 Q3, 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 Q2, 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.¹⁸⁹ (Priority: High. First reported 2015. Status: Not adopted.)

¹⁸⁹ 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.)

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.¹⁹⁰ The FERC order of September 15, 2016, introduced a subsidy to FTR holders at the expense of ARR holders.¹⁹¹ 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.

A subsequent rule change was implemented that modified the allocation of surplus auction revenue to the benefit of 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.¹⁹² 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 seven months of the 2020/2021 planning period, ARRs and FTRs offset 55.8 percent of total congestion.

The complex machinations 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.

¹⁹⁰ Such subsidies have been suggested repeatedly. See FERC Dockets Nos. EL13-47-000 and EL12-19-000.

¹⁹¹ See 156 FERC ¶ 61,180 (2016), *reh'g denied*, 156 FERC ¶ 61,093 (2017).

¹⁹² 163 FERC ¶61,165 (2018).