UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

LS Power Development, LLC	)	Docket No. EL24-91-000
	)	
v.	)	
	)	
PJM Interconnection, L.L.C. and Monitoring	)	
Analytics, LLC, as the Independent Market	)	
Monitor for PJM	)	
	)	
	)	

ANSWER OF THE INDEPENDENT MARKET MONITOR FOR PJM

Pursuant to Rule 213 of the Commission's Rules and Regulations,[1] Monitoring Analytics, LLC, acting in its capacity as the Independent Market Monitor ("Market Monitor") for PJM Interconnection, L.L.C. ("PJM"),[2] submits this answer to the complaint filed on March 20, 2024, by LS Power Development, LLC, ("LS Power") ("Complaint"). The Complaint seeks requests that the Commission "find that PJM and the IMM have violated provisions in the Operating Agreement relating to the determination of opportunity cost adders ("OCAs") and have otherwise determined OCAs in an unjust and unreasonable manner, and require, prospectively, that PJM and the IMM make necessary improvements

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[1]   18 CFR § 385.213 (2023); Combined Notice of Filings #1, Docket No. EL24-91-000, et al. (March 21, 2024).

[2]   Capitalized terms used herein and not otherwise defined have the meaning used in the PJM Open Access Transmission Tariff ("OATT"), the PJM Operating Agreement ("OA") or the PJM Reliability Assurance Agreement ("RAA").

in their procedures."[3] LS Power has failed to demonstrate that OCAs have been calculated in an unjust and unreasonable manner, or that PJM or the Market Monitor have otherwise incorrectly applied the rules. The requested relief incorrectly assumes that the proposed changes are not existing practices. There is no need for the requested relief. The Complaint should be denied.

I. COMMENTS

A. Overview

The Market Monitor has always supported the concept of an opportunity cost in cost-based energy market offers for environmentally constrained resources. The Market Monitor played a central role in the development of the opportunity cost concept in PJM and in the development of the detailed calculations of opportunity cost. The PJM stakeholders and PJM explicitly recognized that the Market Monitor's opportunity cost calculator ("OCC" or "IMM OCC" or "standard OCC") was superior to the PJM calculator and added provisions to Manual 15 that provided for a PJM audit. The logic used in the Market Monitor's calculator has been explained numerous times in the stakeholder process and PJM members engaged in a lengthy review process and voted to use the Market Monitor's calculator rather than PJM's calculator, resulting in the standard OCC.[4] Correctly calculated opportunity cost adders (OCAs) in cost-based offer are an essential part of competitive offers. The PJM markets work best when all units make competitive offers. Such cost-based offers are only relevant when units have market power. The opportunity cost calculations are an essential part of market power mitigation.

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[3]　　Complaint at 39.

[4]　　On February 20, 2020, PJM presented a proposed rule package to the Markets and Reliability Committee that called for the suspension of the PJM OCC. On March 26, 2020, the proposed rule package was endorsed by the Markets and Reliability Committee.

The Market Monitor is also committed to transparency. The Complaint ignores the many conversations that Market Monitor staff had with LS Power in an effort to explain the operation of the standard OCC. Most of the assertions of nontransparency are based on affidavits from consultants with no direct experience of the issues in the Complaint, who apparently were not aware of the details of all the conversations and written communications between the Market Monitor and LS Power, and who made no effort to contact the Market Monitor to attempt to understand the Market Monitor's perspective. LS Power has no knowledge of the extent and nature of Market Monitor communications with other market participants about the standard OCC.

It is clear from the affidavits of Mr. Griffiths and Dr. Sotkiewicz that, despite their protestations to the contrary, they do understand the logic and details of the standard OCC. LS Power and its consultants impute errors to the Market Monitor that are based on unavoidable uncertainty about the PJM dispatch of units for transmission constraints, that are based on incorrect data and information provided by LS Power to the Market Monitor, and that are based on a misunderstanding of general opportunity cost logic unrelated to the specific standard OCC details.

The Market Monitor has made some mistakes in the implementation of the OCC which are identified in this filing, some of which were identified by LS Power and some of which were identified by the Market Monitor. The mistakes were promptly addressed when identified, and most did not have a significant impact on the OCAs. The Market Monitor is confident in the OCC but recognizes that continued improvement is possible and will continue to work on improving the OCC.

LS Power has not demonstrated harm from any specified, alleged error by the Market Monitor in calculating OCAs.

Nonetheless, given the Market Monitor's ongoing commitment to transparency, without admitting to any allegation raised in the Complaint, the Market Monitor proposes several additional steps intended to increase participants' understanding of the standard OCC. It is important that participants understand the standard OCC logic. Additional

education will also make it clear that the standard OCC depends on the provision of accurate and timely information by participants of relevant pollutants that affect unit availability, accurate emission rates for those pollutants, accurate run hours and output, and complete environmental permits.

There is nothing in the Complaint that could not have been addressed in the stakeholder process. The Cost Development Subcommittee is intended to address issues like LS Power's misunderstandings and ensure that all market participants are aware of any issues and can participate in discussions of issues in an open forum.

B. Complaint

The Complaint (at 20–22) makes a series of hyperbolic and unsupported allegations. The Complaint does not allege that the current calculations of OCAs are incorrect, but only that it results in OCAs that "can" be grossly understated.

There are only two specific elements in the Complaint: that the OCAs do not "reasonably approximate" actual opportunity costs; and that there is not adequate opportunity to address disputes or adequate transparency associated with the OCC. The Market Monitor responds to and denies the specific allegations about the calculated opportunity costs for the specific units stated in the Complaint. The Market Monitor responds to and denies the allegations related to communications, the opportunity to contest OCAs and the transparency of the OCC.

The Complaint alleges that LS Power is forced to submit offers with understated OCAs for prolonged periods to the detriment of system reliability. The Complaint fails to support the allegation of understated OCAs for prolonged periods or that there was harm to individual units or system reliability. The Complaint does not even attempt to support with facts the allegation that system reliability is affected. The Complaint does not appear to recognize that OCAs determine the price paid to a unit only when a unit is offer capped, only when a unit is dispatched on its cost-based offer, and only when that unit is marginal on its cost-based offer. The Complaint fails to recognize that, as a result, the OCA adders

have had only a very limited impact on the identified LS Power units. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** The Complaint (at 20-39) only specifically alleges issues with the OCAs for the Chambersburg units and the Rockford units, although the Aurora units are discussed in the Griffiths affidavit. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** Even if the OCAs were incorrect, which they were not, there was not a significant impact on the units cited in the Complaint.

The only actual loss alleged in the Complaint is for the Chambersburg units and alleges a loss of **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** although all the details of the calculation are not provided and the alleged loss is based on a misunderstanding of the OCC and the uncertainty of congestion.

The Complaint does not explain why LS Power does not mention the OCAs at its 33 other units with OCAs. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

LS Power's own offers are not consistent with the allegations in the Complaint. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** While cost-based offers could include the OCAs, price-based offers were at whatever level LS Power preferred. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

The Complaint asserts that sellers have no way to seek corrections to what they believe are inaccurate OCAs. That is incorrect. The material submitted by LS Power documents extensive discussions and demonstrates that this assertion is incorrect. The additional material cited by the Market Monitor and included as attachments further documents those discussions and further demonstrates that the assertion is incorrect.

C. The Complaint Alleges: "The IMM Calculator Has Resulted in Unjust and Unreasonable OCAs that Fail to Reasonably Approximate Opportunity Costs, Resulting in Harm to Individual Sellers and the PJM Market as a Whole."

LS Power has not supported these allegations. The Market Monitor denies each of the allegations and explains why in detail with supporting facts.

The Complaint alleges that the standard OCC is flawed and results in LS Power being forced to offer at below actual opportunity cost for extended periods. LS asserts that

the calculated OCAs result in harm to individual sellers. That harm has not been supported with facts or evidence and is not correct.

LS Power supports these general claims with assertions about the OCAs for Rockford and for Chambersburg (at 22-23). The rest of the specific complaint is general statements about the importance of accurate OCAs.

LS Power asserts that the standard OCC calculations for Rockford overstated the available run hours for the resource. LS asserts that it was the Market Monitor's fault the LS Power could not identify an issue. LS Power asserts that Rockford had understated OCAs for the entire summer season of 2022.

LS Power asserts that the Market Monitor made a simple error by assuming that Rockford could run for **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** and that only after LS and PJM explained the issue did the Market Monitor address it. The alleged issue with the Rockford units is not based on facts. The Griffiths affidavit (at 30) acknowledges that the "LS Power's team previously agreed with the IMM that it made sense to model CO to limit the administrative burden." This sentence is not correct. It should say that the LS Power team chose to submit emissions data for CO only. The Market Monitor routinely encourages market participants to submit emission data for all relevant emissions and to identify the emissions limits that market participants believe are binding. The choice to submit a single pollutant is a choice made by the market participant. Mr. Griffiths' claim that the Market Monitor ignored his request regarding modeling additional pollutants is not correct.

LS Power asserts that the Market Monitor's calculations for Chambersburg resulted in the dispatch of Chambersburg for "almost all hours in early May 2023."

LS Power misunderstands and misstates the issue related to Chambersburg. The Chambersburg (Guilford) situation illustrates a fundamental issue with any opportunity cost calculator. There were no substantive issues with the standard OCC as applied to Chambersburg. The OCAs are added only to cost-based offers. Cost-based offers are only relevant when PJM offer caps a unit, that offer capping uses the cost-based offer, and the

unit is marginal. By definition, no opportunity cost calculator can predict when PJM will offer cap a unit to control a transmission constraint, by day and by hour. The opportunity cost calculator uses forward fuel and energy prices and historical temporal and locational differences to estimate when a unit will be dispatched. PJM's dispatch decisions based on actual transmission constraints override that forward looking optimal economic dispatch. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

In the Complaint and throughout the affidavits, LS Power and its consultants carefully explain why it is important to have accurate OCAs because they contribute to price formation. The Complaint, in multiple places, extends the point to assert that if OCAs are too low, valuable MWh could be used that will not be available later and could cause reliability issues. The Complaint never supports that assertion. The assertion is unsupportable. The Complaint ignores the fact that under CEJA, PJM has the authority to dispatch units for transmission constraints and for reliability, regardless of whether the units have exceeded their CEJA limits. The Aurora and Rockford plants are subject to CEJA. The Complaint cites to the Sotkiewicz affidavit for the allegation that incorrectly low OCAs could lead to premature retirement of units. There is no evidence to support the assertion that the calculated OCAs will lead to premature retirement. For the units subject to CEJA, the limit on run hours and associated market revenues results from CEJA and not from the standard OCC. The actual impact of OCA adders on the revenues of LS Power units is extremely limited. LS Power has not asserted any revenue impact for any unit except Chambersburg.

> **D. The Complaint Alleges: "It is Unjust and Unreasonable for PJM and the IMM Not to Provide Transparency and Timely Review With Respect to OCA Determinations."**

The Complaint alleges (at 27) that "sellers lack needed transparency regarding OCA determinations and the IMM calculator."

LS Power has not supported this allegation. The Market Monitor denies this allegation.

The assertion (at 27) that transparency was "lost with the transition from the PJM Calculator to the IMM Calculator" is not supported. LS Power cites several inapposite cases related to transparency, yet fails to complain that the code that runs PJM's market clearing process in the energy market that affects billions of dollars annually is similarly not available for participants to "vet."[5] In addition, LS Power fails to mention that PJM posted a long list of all the shortcomings of the PJM Calculator, PJM agreed that the standard OCC is better, and that the stakeholders agreed, after a lengthy process, that the standard OCC is better.[6]

The Complaint alleges (at 26) that "asset owners in PJM cannot provide meaningful input because they are not given insight into the OCA calculation process."

LS Power has not supported this allegation. The Market Monitor denies this allegation.

The assertion that asset owners cannot provide meaningful input is demonstrably incorrect, as even Mr. Griffith's partial recounting of the history illustrates. Dr. McDonald informs us that communication is a good thing and that unit owners understand their own resources but has no relevant facts to add about the process in PJM because he was not involved and did not attempt to come to a balanced view of the facts.

The Market Monitor is engaged in ongoing communications with all units owners that request an OCA. LS Power has no knowledge of the activities of other asset owners, although Dr. Sotkiewicz consults for and represents JPower USA, the owner of other CEJA units in the PJM stakeholder process.

LS Power's lack of certainty (at 30) about how certain issues have been addressed is based on a failure to have read all the communications from the Market Monitor.

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[5]   *PJM Interconnection, L.L.C.*, 94 FERC ¶ 61,081 at 61,370 (2001).

[6]   *See* Attachment B.

The Market Monitor would be happy to present additional technical sessions to interested stakeholders, to provide hypothetical examples and to post answers to questions in writing in an effort to improve understanding for all stakeholders.

E. The Complaint Fails to Demonstrate Any Flaw in the Schedule 2 to the OA or Improper Implementation of Schedule 2 to the OA.

The Complaint states (at 36): "PJM and the IMM have … given the IMM sole discretion to determine OCAs and therefore, permissible cost-based energy offers, in violation of the Commission's regulations[Footnote omitted] and Order No. 719.[Footnote omitted]." The Complaint cites Commission regulations stating that "[a] Commission-approved independent system operator or regional transmission organization may not permit its Market Monitoring Unit, whether internal or external, … to conduct prospective mitigation," and that "[a] Commission-approved independent system operator or regional transmission organization may permit its Market Monitoring Unit to provide the inputs required for the Commission-approved independent system operator or regional transmission organization to conduct prospective mitigation."[7] The Complaint relies on a case that required that a provision "vest[ing] final authority in the MMU to determine the EFORd for a generator" was "at odds with Order No. 719 because it involves the MMU in tariff administration."

The provision at issue in this case, Section 5 of Schedule 2 to the OA, does not vest any authority in the Market Monitor or provide a role for the Market Monitor in tariff implementation. Nothing in the provision indicates that PJM is not responsible for implementing Section 5 to Schedule 2 to the OA, which is consistent with the authority relied on in the Complaint. The Complaint fails to demonstrate any defect in Schedule 2 to the OA.

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7   *See* 18 CFR § 35.28(g)(3)(iii)(A)&(B) (2023).

The Complaint also fails to provide any evidence that the provision has not been properly implemented by PJM. The Market Monitor denies the allegations. Nothing in the Commission's regulations or Order No. 719 prohibits PJM from allowing the Market Monitor to make calculations, provided that PJM has responsibility for the implementation of those values. The true concern expressed in the Complaint (at 38–39) is that PJM has accepted the Market Monitor's opportunity cost calculator and rejected LS Power's attempt to convince PJM to overrule its results. PJM is not required to disagree with the Market Monitor's calculations as it implements the tariff. PJM can and has from time to time disagreed with the Market Monitor's recommended approach in the course of PJM's implementation of the tariff. The Complaint fails to meet its burden to show that PJM has improperly implemented Schedule 2 to the OA.

F. Relief Requested

LS Power requests relief based on the unsupported allegation that the application of the standard OCC is not just and reasonable. None of the requested relief is supported because the application of the standard OCC continues to be just and reasonable.

Nonetheless, in the interests of clarity and transparency, and without admitting any allegation in the Complaint, the Market Monitor proposes several steps going forward that are responsive to the LS Power requests.

1. Application of the Standard OCC Will Continue to Be Transparent

The Market Monitor will continue to present technical education to one or more stakeholder meetings on the operation of the standard OCC. The Market Monitor will post examples of OCC results for hypothetical units that illustrate potential outcomes for a range of circumstances. The Market Monitor is committed to helping all stakeholders understand the OCA calculations. The data used in the calculations are purchased from private vendors subject to confidentiality restrictions and are also available to anyone to purchase. The

optimizer is a commercial product also available to anyone to purchase. No additional information about the actual code is needed for full transparency.[8]

2. The Market Monitor Will Continue to Explain the Application of the Standard OCC.

The Market Monitor will continue to explain the application of the standard OCC to specific units. The Market Monitor will continue to attempt to provide timely responses to requests for clarification.

3. Market Participants Can Propose Alternative OCA Methods if They Show that the Standard OCC Does Not Create Accurate Results.

Section 5 of Schedule 2 to the OA currently provides: "[A] Market Participant may submit a request to PJM for consideration and approval of an alternative method of calculating its Energy Market Opportunity Cost if the standard methodology described herein does not accurately represent the Market Participant's Energy Market Opportunity Cost." The ability to request alternative methods is predicated on a showing the standard methodology does not create accurate results.

Participants should not have the ability to propose other ways to calculate opportunity costs without meeting the requirement in the rules that standard OCC does not create accurate results for them. PJM must agree that the need for an alternative method has been demonstrated and approve the alternative OCC. The Market Monitor should have an opportunity to raise concerns about any such proposal with PJM, and, if necessary, with the Commission.

The Complaint does not show that LS Power or other participants have been unable to submit such requests. The Complaint does not show that any proposal has been supported by a showing that the standard OCC does not create accurate results. It is unlikely that a participant could make such a showing but that must be evaluated on a case

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8   *Astoria Generating Co. L.P. v. NYISO*, 139 FERC ¶ 61,244 (2012).

by case basis. The standard OCC is a general model that can and does incorporate any relevant facts about units. A uniform approach should be applied to all participants to ensure nondiscriminatory treatment and to ensure transparency for all.

Opportunity cost adders can be used to engage in physical and financial withholding and noncompetitive offers and market outcomes. Participants should not have the ability to set their own offer caps. Market participants are required to follow market rules governing cost-based offers because such offers are used to help protect the markets against the exercise of market power.

The Complaint fails to show that standard OCC fails to generate accurate results for LS Power or any other participant. Nothing in any part of the Complaint has made any fact based or even specific suggestion about how a generator's own OCC would be better or improve on the basic logic of the standard OCC. LS Power has not proposed an alternate OCC. The standard OCC is a general model that is customized for every single generator by incorporating unit specific inputs, provided by the generation owners.

4. **Procedures Governing PJM's Annual Review of the Standard OCC Are in Place.**

PJM has procedures in place.

5. **Market Participants Can Continue to Seek Review of OCA Determinations**

The Market Monitor continues to be available to discuss OCA determinations in detail with market participants.

G. **Technical and Factual Issues**

The Market Monitor has responded to the parts of the affidavits that are explicitly cited in the Complaint. The Market Monitor also responds to some of the other incorrect statements and conclusions offered in the three affidavits attached to the complaint. The Market Monitor denies all of the allegations in the three affidavits.

1. Response to Dr. Sotkiewicz.

A comparison of the IMM opportunity cost calculator (IMM OCC or OCC or standard OCC) and the PJM opportunity cost calculator (PJM OCC) was the subject of a stakeholder process that begin in May 2017 and culminated in April 2020 with the suspension of the PJM OCC and the designation of the IMM OCC as the sole active and approved standard OCC. Key events during this stakeholder process include:

- On March 27, 2017, the Markets and Reliability Committee approved an issue charge that designated a special session of the Market Implementation Committee under the title "Opportunity Cost Calculator Issue" (MIC Special Session OC).[9]

- At the May 23, 2017, meeting of the MIC Special Session OC, the Market Monitor and PJM presented education materials describing the two opportunity cost calculators.[10]

- In a memo to PJM on September 26, 2018, the Market Monitor memorialized the details of an agreement between the Market Monitor and PJM on opportunity cost operating procedures.[11]

- On October 24, 2018, PJM issued a market notice stating that the IMM OCC was an approved alternative method of calculating Energy Market Opportunity Costs and Non-Regulatory Opportunity Costs as specified in the PJM Operating Agreement Schedule 2, Section 1.1(a).[12]

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[9]   *See* Attachment A.

[10]   *See* Attachment B.

[11]   *See* Attachment C.

[12]   *See* Attachment D.

- PJM's October 24, 2018 market notice also included a summary of the differences in the two models which is provided here:[13]

  - "The IMM calculator models a unit's Minimum Down Time operating parameter. The PJM calculator does not use this parameter."
  - "The IMM calculator models a unit's start up emissions and coordinates duct burner operation with base load operation. The PJM calculator does not."
  - "The IMM calculator uses an additional scalar to line up the day of the week between the historical LMPs and the forecasted LMPs. The PJM calculator does not."
  - "The IMM calculator uses the Platt's balance of the month fuel forward for the current month. The PJM calculator uses the Platt's forwards for all months including the current month."
  - "The IMM calculator uses an optimization method as opposed to the block margin solution method used in the PJM calculator."
  - "The IMM calculator simultaneously enforces all rolling period emission limits. PJM calculator may require a solution for each limitation in order to determine the most constrained limit."
  - "The IMM calculator derives the shadow price of the binding constraint by taking the difference in generator revenue from an initial run and a subsequent run that restricts the operating hours within the constrained period by one hour; the shadow price is the marginal opportunity cost adder. The PJM calculator uses the margin of the lowest block added before the run hour limitation is reached."

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[13]   *Id.*

- "The IMM calculator uses historical bidding behavior to determine the expected unit offer behavior when calculating opportunity cost. The PJM calculator is based on unit cost as documented in M-15."

- On February 15, 2019, PJM Manual 15 was revised to include a description of the IMM OCC in Section 12-7.

- On February 20, 2020, PJM presented a proposed rule package to the Markets and Reliability Committee that called for the suspension of the PJM OCC. The proposal also included requirements that additional details on the IMM OCC be added to Manual 15 and that PJM perform an annual review of the IMM OCC to ensure compliance with the PJM Operating Agreement and Manual 15.

- On March 26, 2020, the proposed rule package was endorsed by the Markets and Reliability Committee and Manual 15 was revised on April 24, 2020, to reflect the updated provisions.

Clearly the comparison of the PJM and IMM OCC calculators has been fully vetted and received the full attention of the PJM stakeholders. Further consideration by the Commission is not warranted. The Market Monitor maintains its position that the PJM OCC does not produce accurate results. From the long list of differences provided in the PJM market message, the two principal deficiencies of the PJM OCC are the inability to handle rolling constraints and the use of the block margin approach rather than a standard optimization method. Dr. Sotkiewicz admits these deficiencies (at 52).

Dr. Sotkiewicz addresses several mathematical details of the IMM OCC. The IMM OCC uses a mixed integer programming solver to determine the maximum revenue net of short run marginal cost that result from identified operating and environmental constraints.[14] Both Mr. Griffiths and Dr. Sotkiewicz object to the level of detail provided in

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[14] The Market Monitor agrees with Dr. Sotkiewicz that footnote 2 in Section 12.7 of PJM Manual 15 should say "mixed integer programming" rather than "integer programming."

Manual 15. The Market Monitor does not oppose the inclusion of additional details but the opportunity cost optimization program is long and complex. Therefore choices have to be made on the level of detail to include. The Market Monitor has on two occasions been asked to provide details of the calculator for Manual 15, the initial creation of Section 12.7 in February 2019 and the clarifications and detail added in April 2020. A third update was added in June 2023. Each time the manual revisions were reviewed and approved by stakeholders.

The shadow price described in the Manual 15 is conceptually a discrete equivalent of the shadow price calculated in linear and non linear programming optimizations with continuous variables. The goal of the IMM OCC is to value the opportunity of a constrained resource to earn a profit in the future. Given perfect foresight, the nominal value of this opportunity is the difference between the net revenue the resource would earn if not required by PJM to produce energy (unconstrained) and the net revenue the resource would earn if required by PJM to produce energy (constrained). The shadow price term as defined in Section 12.7.1, "the marginal decrease in the net revenue due to a one hour equivalent decrease in the binding environmental or operation limit" represents the marginal value of this opportunity.[15] The approach used in the IMM OCC achieves the same result as the PJM OCC that ranks the blocks of energy margins for simple problems with zero start cost, one calendar year limit on run hours and only one hour minimum run time. The IMM OCC uses integer variables for modeling commitment and run time decisions. Dr. Sotkiewicz (at 26) argues that in a integer problem, "the only possibility for obtaining meaningful shadow prices is in this setting is to solve the MIP to optimality, and then insert the optimal integer variables in as equality constraints and resolve the problem as a conventional linear or concave program to derive the set of shadow prices that are consistent with all the constraints in the optimization problem." However, the shadow

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[15]   *PJM Manual 15: Cost Development Guidelines, Rev. 44*, § 12.7.1, (August 1, 2023).

prices associated with the non-integer decision variables do not fully account for the total forgone opportunity cost. This is true even for the Security Constrained Unit Commitment (SCUC) problem used by PJM today to solve the Day Ahead Scheduling, Pricing and Dispatch (DA SPD) and Intermediate term Security Constrained Economic Dispatch (IT-SCED). The shadow prices associated with power balance, transmission, loss and reserve constraints do not fully account for the total cost of committing a unit. In PJM's energy market, generation resources that do not fully recover their total cost (start, no load and variable cost) are made whole through out of the market uplift payments. The IMM OCC avoids this issue by accounting for the total forgone opportunity cost calculated as net of energy market revenues and total operating costs including start and no load costs. In the IMM OCC optimization, start and run decisions are controlled by integer variables.

The Market Monitor's approach to calculating shadow prices, including the use of the shadow price corresponding to the earliest binding constraint, is the best method for determining the marginal opportunity cost. Mr. Griffiths and Dr. Sotkiewicz suggest two alternatives. One suggestion is to employ a unit commitment coupled with a unit dispatch similar to the optimization used to clear the day-ahead market. This approach requires that the commitment be held static when determining the marginal impact of the constraint limit. In addition to this approach resulting in potentially inadequately compensating the unit for the forgone opportunity, the Market Monitor routinely finds in its calculations the redispatch caused by tightening the emissions limit includes recommitment. In other words, the most profitable response to a tightening of the emission limit is often to generate in a different set of hours. Dr. Sotkiewicz's suggested alternative of using a two step approach similar to the solving of DA SPD does not correctly value the constrained generator's opportunity cost. The second suggestion is to choose the largest shadow price as the marginal opportunity cost when multiple constraints are binding. But the largest shadow price for nested compliance periods is the shadow price associated with the earliest binding constraint. The IMM OCC looks forward one year and the remaining portions of the rolling periods are nested. For example, for a resource subject to 12 month rolling

emission limits, the revenue net of operating cost is maximized over a one year period. The optimization is constrained by the level of emissions in the current month, the level of emissions in the current month and the next month, the level of emissions in the current month and the next two months, and so on with the 12th constraint being the level of emissions in the current month and the next 11 months. Consider two compliance periods CP1 and CP2 with CP1 ending before CP2, and assume both constraints are binding. The shadow price for the first binding constraint, CP1, is obtained by reducing the emission limit and resolving the optimization. But note that CP1 is contained in CP2, and therefore any redispatch that is available for the calculation of the CP1 shadow price is also available for the CP2 shadow price calculation and the CP2 shadow price can be no larger than the CP1 shadow price.

There are two additional technical issues that should be addressed. Dr. Sotkiewicz misreads (at 73–74) a condition for commitment in Manual 15, Section 12.7.9. The Manual 15 language states: "For a generator with a minimum runtime of one hour or less, the Opportunity Cost Calculator will commit the unit only in the case that the revenue net of startup and hourly operating cost for the first hour is greater than $0 or the revenue net of startup and hourly operating cost for the first hour plus the next hour is greater than $0." The language describes conditions that must hold for the unit to be committed. It does not require the unit be committed when the conditions hold, as posited by Dr. Sotkiewicz. Lastly, Dr. Sotkiewicz states (at 87) that "the IMM's methodology can result in negative [opportunity cost adders]." This is not an accurate statement. If a unit has a binding emission limit, then the IMM OCC computes the difference in net revenues from two constrained optimizations.[16] In the first constrained optimization problem, the emission limit is as prescribed in the relevant operating permit or governing legislation. In the second constrained optimization problem, the emission limit is lowered. Any commitment

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[16]   If the unit does not have a binding emission limit, then clearly the opportunity cost is $0.

and dispatch that is possible in the second optimization is also possible in the first optimization and therefore it cannot be true that second optimization produces a higher net revenue than the first optimization.

2. Response to Mr. Griffiths

Mr. Griffiths' characterization of the issues regarding the opportunity cost adders for Aurora, Rockland and Guilford is not accurate. The Market Monitor responded in a timely manner and worked diligently to resolve the issues. There is very little regarding the IMM OCC that is not transparent.

It is the responsibility of the unit owners to enter the resource parameters for the IMM OCC in the Market Monitor's Member Information Reporting Application (MIRA). Designated representatives of the generator's owners have access to MIRA and are expected to review and update the parameters on a weekly basis. The only relevant data inputs that a market participant cannot access are the LMP and gas futures data which the Market Monitor is unable to share due to vender restrictions. A description of the IMM OCC is provided in PJM Manual 15, Section 12.7. The Market Monitor has on occasion provided education sessions on the calculator and the education materials are available online.[17] The Griffiths and Sotkiewicz affidavits indicate that they both have a good understanding of how the IMM OCC works. The description provided in the Griffiths affidavit (at 9-10) is, with a few minor exceptions, accurate.

The Market Monitor was responsive to LS Power's inquiries. The Market Monitor met with LS Power on April 5, May 13 and May 25, 2022, to discuss opportunity cost calculations. LS Power's approach to calculating opportunity costs was the subject of the first meeting in April. The concerns with the Aurora units were introduced at the May 13th

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[17]   *See* Attachment B.

meeting. After the May 13th meeting, the Market Monitor reviewed the LS Power calculations and responded with a memo on May 25th.[18]

The Market Monitor found the following: **{BEGIN CUI//PRIV}**

- REDACTED **{END CUI//PRIV}**

The Market Monitor continued its study of the LS Power opportunity cost model. While investigating the volatility of the opportunity cost adder of a different resource in mid-June, the Market Monitor found a flaw in the calculation of the shadow price. The shadow price is the impact on the optimal revenue net of operating cost during the binding compliance period after reducing the emission limit by a one hour of emissions. In the implementation, the model forced a redispatch that reduced the MWh produced during the binding compliance period by the level of the economic maximum (ECOMAX). The Market Monitor discovered that in certain cases, the optimal dispatch after the reduction in MWh was actually leading to very small reductions in the emissions, and in some case an increase in emissions. The Market Monitor updated the implementation by forcing the redispatch to reduce the emissions during the binding compliance period by an emissions level equal to the product of the ECOMAX and the hourly emissions rate. In most cases these two implementations produce the same value but in a few isolated cases, the results can be significantly different. The updated implementation was effective on June 23, 2022. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** The Market Monitor considered the Aurora issue resolved at that time. The Market Monitor took several weeks to identify and resolve the issue. There was little impact on the identified Aurora units. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

 {BEGIN CUI//PRIV} REDACTED **{END CUI//PRIV}**

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[18]   *See* Attachment A-2 to the Griffiths affidavit.

The alleged issue with the Rockford units is not based on facts. The Griffiths affidavit (at 30) acknowledges that the "LS Power's team previously agreed with the IMM that it made sense to model CO to limit the administrative burden." This sentence is not correct. It should say that the LS Power team chose to submit emissions data for CO only. The Market Monitor routinely encourages market participants to submit emission data for all relevant emissions and to identify the emissions limits that market participants believe are binding. The choice to submit a single pollutant is a choice made by the market participant. Mr. Griffiths claim that the Market Monitor ignored his request regarding modeling additional pollutants is not correct. Mr. Griffiths indicates (at 31) that the IMM did not respond to an email that is attached to the Griffiths affidavit as Attachment A-8. In fact, the Market Monitor responded within an hour of receiving the email from LS Power.[19] The email response from the Market Monitor discusses the process for adding four additional pollutants and the data the Market Monitor needs from LS Power. LS Power provided the data the following week on July 26, 2022. The additional pollutants were included in the production model for the August 11th run of the IMM OCC. The dissatisfaction expressed by Mr. Griffiths (at 36) regarding the resolution of the Rockford issue is misdirected, as it was a result of LS Power's failure to identify and provide data related to additional pollutants. LS Power's decision to only model CO was the reason for the low adders for the Rockford units. Mr. Griffiths cites (at 36) a range of adders **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** prior to inclusion of additional pollutants. Mr. Griffiths fails to mention that adders for the three Rockford units ranged **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** for the week of July 18. They dropped to the levels cited in the Griffiths affidavit after LS Power updated the CO emission rates in MIRA. Mr. Griffiths (at 37) claims it took the Market Monitor over four months to resolve

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[19]   *See* Attachment E.

the issues. That is incorrect. The additional pollutants for the Rockford units were added to the IMM OCC two weeks and two days after receiving the data from LS Power.

The Aurora issue was resolved within six weeks of the May 13th meeting when the issue was first brought to the Market Monitor's attention. Mr. Griffiths implies (at 37) that it was only after contacting PJM that the Market Monitor agreed to include the additional pollutants. This is incorrect. As soon as LS Power provided the data, the Market Monitor reviewed the information and in two weeks and two days the additional pollutants were added to the OCC. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

{BEGIN CUI//PRIV} REDACTED **{END CUI//PRIV}** The forward LMP method used in the IMM OCC is documented in PJM Manual 15, Section 12.7.[20] Congestion can be reflected in the forward LMPs in two ways, through the monthly basis differential factor that captures the difference between the LMP at the generator bus and the PJM Western Hub LMP or through the hourly volatility factors that are intended to capture the hourly price fluctuations. The hourly LMP forecast at the generator bus is equal to the product of the PJM Western Hub monthly forward price, the monthly basis differential factor and the hourly volatility factor. The monthly basis differential factor and hourly volatility factor are based on historical LMPs at the generator bus and the PJM Western Hub over the three year period preceding the run date of OCC. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** It is unusual that the IMM OCC under dispatches a unit relative to the actual dispatch. It is more common for the dispatch of IMM OCC to exceed the actual dispatch of a unit because the market participant can use the price offer to control the dispatch whereas the IMM OCC assumes a cost based offer and optimal dispatch. This is not a flaw in the OCC but reflects the unavoidable fact that the combination of forward prices and historical spreads may not accurately capture the dispatch for transmission constraints. The reverse also happens

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[20]   The LMP forecast is essentially the same as the approach described in Manual 15, Section 12.5 which is referred to by Mr. Griffiths in footnote 4.

when the unexpected congestion is incorporated in historical spreads. More frequent updates to the OCA for units that are experiencing unexpected dispatch related to transmission constraints could address this issue, at least in part. It is not realistic to expect PJM to be able to accurately forecast the degree to which every unit will be dispatched for transmission constraints over the next 12 months.

The Griffiths affidavit focuses on the parameter inputs and certain modeling aspects of the IMM OCC. While these are relevant issues, these issues collectively did not have a significant impact on the OCA **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** Characterizing the modeling of the VOM ($ per hour) and start up cost parameter inputs as errors in the IMM OCC is not correct. The parameter inputs in MIRA allow the market participants to submit VOM in $ per MWH or $ per MMBtu or $ per hour. Most market participant submit the VOM either as $ per MWH or $ per MMBtu. A few market participants also populate the $ per hour VOM field. How the IMM OCC models the $ per hour VOM is referred to in the Griffiths affidavit as the no load cost issue. In 2023, the $ per hour VOM parameter was modeled in the IMM OCC by first converting the number to a $ per MWh value by dividing by the economic maximum then adding to the other component of VOM ($ per MWh) and the delivered fuel cost ($ per MWh) to obtain the hourly operating cost. As explained in an email to Mr. Griffiths, this modeling approach would introduce a small error in the operating cost only in the event the resource is dispatched at the economic minimum.[21] The Market Monitor updated the IMM OCC to reflect the alternative design requested by Mr. Griffiths where the $ per hour VOM parameter is directly input as a parameter in the optimization model. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}** [22] Mr. Griffiths did identify an error in the conversion of the $ per hour VOM to $ per MWh. In accounting for the two Chambersburg units, the Market

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[21]   *See* Attachment A-14 to the Griffiths Affidavit.

[22]   *Id*.

Monitor mistakenly summed the $ per hour VOM amounts for the two units, and then later multiplied by the number of units, and therefore doubled the VOM amount over the correct amount. This issue was brought to the Market Monitor's attention on June 1, 2023. This was a Thursday which is the day of the weekly opportunity cost adder run. The Market Monitor corrected the input data units, reran the IMM OCC, and posted the corrected OCAs all on the same day, Thursday, June 1. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

Characterizing the start up cost modeling as an error is not correct. The IMM OCC uses a 12 month average historical start up cost. This calculation does include the correct non fuel portion of the resource's start up offer but can overestimate or underestimate the fuel related start up costs depending on the relationship between the historical average fuel price and forward monthly fuel price. The Market Monitor agrees that the IMM OCC should be updated to more accurately reflect the forward fuel price in the start up cost.

The emission data issue for the Chambersburg units is similar to the Rockford issue. Mr. Griffiths characterizes this as a simple correction to the emission parameters that should have been immediately accepted but LS Power changed the method and the data source that LS Power had previously used to compute the plant emission rates. The proposed data source, EPA CEMS data, did not align with the data that had been previously submitted. It took some time to work through the related issues, and the updated emission parameters were accepted. **{BEGIN CUI//PRIV}** REDACTED **{END CUI//PRIV}**

II. ADMISSIONS AND DENIALS PURSUANT TO RULE 213(C)(2)(i)

Pursuant to Rule 213(c)(2)(i),[23] the Market Monitor admits or denies the alleged material facts stated in the Complaint as follows: to the extent that any allegation set forth in the Complaint is not specifically admitted in this answer, it is denied.

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[23]   18 CFR § 385.213(c)(2)(i).

III. AFFIRMATIVE DEFENSES PURSUANT TO RULE 213(C)(2)(ii)

The Market Monitor's affirmative defenses are set forth above in this answer, and include the following, subject to amendment and supplementation.[24]

1. LS Power fails to satisfy its burden of proof under Section 206 of the FPA,[25] and fails to demonstrate that PJM or the Market Monitor have violated or failed to properly implement any Commission order, Tariff, or any other Commission-jurisdictional governing document.

2. Even if the Commission were to reach the question of remedies in this proceeding, it cannot grant LS Power's requested relief. The relief requested is vague and inappropriate for inclusion in a compliance directive. The relief requested fails to correctly describe existing rules and practices and fails to identify specific changes needed to existing rules and practices.

IV. CONCLUSION

The Market Monitor respectfully requests that the Commission afford due consideration to this answer as it resolves the issues raised in this proceeding.

Respectfully submitted,

Jeffrey W. Mayes

Joseph E. Bowring
Independent Market Monitor for PJM
President
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Eagleville, Pennsylvania 19403

General Counsel
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24   *See* 18 CFR § 385.213(c)(2)(ii).

25   16 U.S.C. § 824e.

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Dated: April 19, 2024

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Eagleville, Pennsylvania,
this 19th day of April, 2024.

Jeffrey W. Mayes
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Attachment A – PUBLIC

Problem Statement and Issue Charge

Opportunity Cost Calculator

Problem Statement

The current rules pertaining to the calculation of costs used in cost-based offers into the energy market allow Market Sellers to include an opportunity cost under certain conditions, such as environmental limitations. PJM developed an opportunity cost calculator, which is included in Markets Gateway, to enable Market Sellers to calculate an opportunity cost. Separately, Monitoring Analytics has developed its own opportunity cost calculator. There is some question about whether the two different opportunity cost calculators produce the same or comparable results and whether either calculator captures all scenarios.

When PJM implemented CP, it established potential penalties for failure to deliver during emergencies. The opportunity cost calculators were not updated to reflect the penalty rates. As such, the opportunity cost calculator may be calculating an opportunity cost that is too low as the resource approaches a run hour limitation.

Key Work Activities

The following are some key work activities that should be undertaken in any stakeholder initiative to address the above stated problems.

1. Educate interested stakeholders on opportunity costs.
2. Compare the opportunity cost tools and identify if there are any differences in the results and the reasons for the differences.
3. Identify any modifications to each opportunity cost calculator needed to make the results comparable or fill any existing gaps.
4. Identify modifications needed to address how immature units are to be treated.
5. Identify modifications to incorporate non-performance charge rates into opportunity cost calculators, where appropriate.
6. Identify and propose any tariff or manual changes needed to implement revisions.

Issue Charge

Stakeholder Group Assignment

This work should be assigned to the MIC.

Expected Deliverables

Possible Tariff, RAA and/or manual changes along with recommendations to modify the opportunity cost calculators.

Expected Overall Duration of Work

The goal is to complete work and make recommendations to the MRC by the December 2017 MRC meeting.

Decision-Making Method

Tier 1, consensus (unanimity) on a single proposal.

Attachment B - PUBLIC

Opportunity Cost Calculator

MIC Special Session
Opportunity Cost
Calculator Issue
May 23, 2017

Devendra Canchi
Luis Gómez
John Hyatt

Monitoring Analytics

PJM Operating Agreement

- **Schedule 2(a) - Two types of limitations may result in opportunity costs**
  - **"energy or environmental limitations imposed on the generating unit by Applicable Laws and Regulations (as defined in the PJM Tariff)"**
  - **"limited number of starts or available run hours resulting from (i) the physical equipment limitations of the unit, for up to one year, due to original equipment manufacturer recommendations or insurance carrier restrictions, or (ii) a fuel supply limitation, for up to one year, resulting from an event of Catastrophic Force Majeure"**

Monitoring Analytics

PJM Operating Agreement

- ## Schedule (a) – Opportunity Cost Calculation

  "… unit-specific Energy Market Opportunity Costs are calculated by forecasting Locational Marginal Prices based on future contract prices for electricity using PJM Western Hub forward prices, taking into account historical variability and basis differentials for the bus at which the generating unit is located for the prior three year period immediately preceding the relevant compliance period, and subtract therefrom the forecasted costs to generate energy at the bus at which the generating unit is located, as specified in more detail in PJM Manual 15. If the difference between the forecasted Locational Marginal Prices and forecasted costs to generate energy is negative, the resulting Energy Market Opportunity Cost shall be zero."

Monitoring Analytics

PJM Manual 15

- **Calculation of expected hourly LMPs**
  - **Monthly forward prices for the PJM Western Hub**
  - **To reflect locational and hourly differences, hourly basis differentials and hourly volatility scalars are calculated using the most recent three years of LMP data**

Monitoring Analytics

PJM Manual 15

- **Calculation of expected fuel costs**
  - **Daily delivered fuel price forecasts**
    - ○ **Fuel monthly forward prices and/or contract fuel prices, and transportation costs applicable to specific unit are converted to daily prices using the most recent three years of data**

Monitoring Analytics

PJM Manual 15

- **Unit offers consistent with Manual 15 cost-based short run marginal energy cost, no load cost, and start-up cost**

- **Participant supplies heat rate, variable O&M, projected fuel delivery charges and parameters including notification time, minimum run time and minimum down time**

Monitoring Analytics

PJM Manual 15 - Calculation

- **Optimization and Adder Determination**
  - Margins equal net revenue (LMP minus offer)
  - Compute margins for blocks of hours with run time durations corresponding to the minimum run time, up to twice the minimum run time
  - Compute the average margin for each block of hours
  - Sort the average block margin values from highest to lowest
  - OC adder is equal to the average block margin corresponding to the first or lowest block that would be foregone if the unit ran currently

Monitoring Analytics

MMU OCC Constraint Definition

- **The MMU obtains a copy of the documentation that defines the output restriction.**

- **In the case of an environmental limitation, Market Participants provide the Market Monitor with a copy of the permit that typically specifies the limits on NO_X, SO_2, CO_2, or CO**

- **For physical equipment limitations, Market Participants provide the Market Monitor with documentation from the equipment manufacturer or insurance carrier**

Monitoring Analytics

MMU OCC Constraint Definition

- **Market Participants supply MMU with emissions rates and current emissions levels**

- **MMU confirms inputs**

- **MMU checks back with Market Participants to compare actual emissions rates and levels**

Monitoring Analytics

MMU OCC Constraint Definition

- **Example Environmental Permit:**
  - **NO_x limit, 100 Tons/Yr**
  - **SO_2 limit, 5 Tons/Yr**
  - **CO_2 limit, 80 Tons/Yr**
  - **Limits enforced on rolling 12 months basis**
- **Thirty-six (36) constraints needed to model 3 restrictions on 12 month rolling basis**
- **Constraints must be enforced simultaneously**

Monitoring Analytics

MMU OCC Unit Offers

- **For units that offer in excess of short run marginal cost as defined in Manual 15, and are not subject to mitigation in the PJM energy dispatch, the MMU includes a margin equal to the adder actually used by the unit in its offers**

- **Reflecting the actual offer behavior of the unit results in run hours consistent with actual run hours.**

Monitoring Analytics

MMU OCC Unit Offers

- **Use of an offer that is too low will overestimate expected generation and overestimate the opportunity cost adder**

- **Use of an offer that is too high will underestimate expected generation and underestimate the opportunity cost adder**

Monitoring Analytics

MMU OCC Optimization

- **Mixed Integer Programming (MIP) Optimization**
  - **Objective is to dispatch the unit based on forward power and fuel curves to maximize net revenue subject to the environmental or fuel limits, whether calendar year or rolling periods**
  - **Operational flexibility between economic minimum and economic maximum**
  - **Unit parameters are binding:**
    - **Start costs**
    - **Minimum run time and minimum down time**

Monitoring Analytics

MMU OCC Optimization

- **Three step algorithm for each forecast scenario**
  - **Step 1: Optimize w/o environmental/equipment limitation constraints**
  - **Step 2: Optimize with environmental/equipment limitation constraints**
    - **If the objective function value in Step 2 is less than the objective function value in Step 1, then continue to Step 3; otherwise OCC Adder = 0**
  - **Step 3: Determine the earliest compliance period that is binding in Step 2, and restrict the run time hours for that compliance period to be 1 hour less than the previous solution. Resolve the optimization**

MMU OCC Optimization Example

- **If running the OC Calculator on July 7 and limitations are enforced on a 12 month rolling basis, the first compliance period ends on July 31, the 2nd compliance period ends on August 31, etc.**

- **For Step 3, identify the compliance period with earliest end date that corresponds to a binding constraint in Step 2, reduce the run hours by one, then resolve the optimization**

Monitoring Analytics

MMU OCC Optimization

- **Marginal hourly opportunity cost is equal the decrease in the objective function (total margin) from the restriction to one less hour of operation**

- **The OC adder is the average of the three marginal hourly opportunity cost values**

- **The three values are based on the three optimization scenarios from the three calendar years of LMP and fuel price history used to develop the hourly LMP and daily fuel price scalars**

Possible Differences with PJM Approach

- **MMU models rolling constraints precisely**
- **MMU MIP optimization versus brute force block methodology**
- **MMU models unit flexibility that allows generation at economic minimum or economic maximum**
- **MMU uses actual offer behavior**
- **MMU includes all unit parameters, e.g. minimum down time constraint**
- **PJM does not check individual unit input details provided by participants or evaluate the opportunity cost adder results**

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Monitoring Analytics

Attachment C – PUBLIC

Monitoring Analytics

DATE:	**September 26, 2018**
TO:	**PJM**
FROM:	**IMM**
SUBJECT:	**Opportunity Cost Operating Procedure and Agreement**

MA agrees to explain the inputs and logic of MA's OCC to PJM in sufficient detail to demonstrate that it is compliant with Schedule 2 of the OA. MA agrees to explain the calculation of any unit specific opportunity cost to PJM, at PJM's request, in sufficient detail to demonstrate compliance with Schedule 2 of the OA.

MA will:

- Develop a MIRA application to permit participants to provide opportunity cost related information.
- Make the MIRA data available to PJM. The MIRA opportunity cost application will include the same access details as the MIRA fuel cost policy application.
- Inform PJM of all input data used in the calculation of opportunity costs for any specific unit.
- Provide the calculated opportunity cost to PJM.
- Inform PJM of the constraints applied in the opportunity cost calculation, e.g. minimum run times, minimum down times, start times, remaining tons of emissions under the relevant permit.
- Provide to PJM, upon request, margins and run hours for specific calculations of opportunity costs for specific units.
- Notify PJM of any significant changes to the calculation method.

PJM Interconnection LLC ("PJM") agrees that Monitoring Analytics, LLC's ("MA") Opportunity Cost Calculator (OCC) is MA's intellectual property. This agreement is not a license and gives PJM no right to use MA's OCC. PJM agrees that it will not attempt to reverse engineer MA's OCC and will not engage others to attempt to reverse engineer MA's OCC.

Understood and agreed.

Joseph Bowring

Frederick S. Bresler

Attachment D – PUBLIC

October 24, 2018

To: Market Sellers Using an Opportunity Cost Adder in Cost-Based Energy Market Offers

Re: PJM Approval of IMM Opportunity Cost Calculator as an Alternative Method

Background
This letter provides clarification on PJM-approved methods of calculating the Energy Market Opportunity Cost Adder or the Non-Regulatory Opportunity Cost Adder in Cost-Based Energy Market Offers and approval of the IMM Opportunity Cost Calculator as a PJM-approved alternative method **of** calculating Energy Market Opportunity Costs.

Market Sellers may include in the calculation of "other incremental operating costs" in cost-based energy market offers an amount reflecting the unit-specific Energy Market Opportunity Costs expected to be incurred if the generating unit is subject to operational limitations due to energy or environmental limitations, as described in Schedule 2 of the PJM Interconnection Operating Agreement.

Market Sellers may include in the calculation of "other incremental operating costs" in cost-based energy market offers an amount reflecting the unit-specific Non-Regulatory Opportunity Costs expected to be incurred if the generating unit is subject to operational limitations due to a physical equipment limitation due to an original equipment manufacturer recommendation, insurance carrier restriction, or a fuel supply limitation resulting from a Catastrophic Force Majeure, as described in Schedule 2 of the PJM Interconnection Operating Agreement.

The opportunity cost adder may be calculated by:

1. The Opportunity Cost Calculator available in Markets Gateway
2. A PJM-approved alternative method (See Operating Agreement, Schedule 2, section 1.1 (a))

PJM Review of the IMM Opportunity Cost Calculator
PJM staff, in cooperation with IMM staff, has performed an extensive review of the IMM's Opportunity Cost Calculator with the intent of analyzing the differences between the PJM and IMM calculators and determining if PJM could approve the use of the IMM calculator for use by Market Participants (see Market memo from August 7, 2018).

Based on this review PJM considers the IMM's Opportunity Cost Adder to be an approved alternative method of calculating Energy Market Opportunity Costs and Non-Regulatory Opportunity Costs (See Operating Agreement Schedule 2 Section 1.1(a)).   Usage of the adder produced by the IMM's calculator in a Market Participant's cost based energy offer is conditioned on the following process being followed:

- Market Participant will include PJM (via email at fuelcostpolicyanalysis@pjm.com) on the initial request to the IMM to utilize the IMM opportunity cost calculator. Operating Agreement Schedule 2 Section 1.1(a) requires Market Participants to submit a request to

PJM for consideration and approval of an alternative method for calculation opportunity cost.

- IMM will provide to PJM any and all results from its calculator provided to a Market Participant.
- IMM will alert PJM of any and all pending changes to the IMM calculator prior to implementation to allow PJM sufficient time to review the impact and results of such changes.

PJM has determined that the IMM's calculator is a valid alternative method for calculating opportunity costs. However, PJM does not believe the IMM Opportunity Cost Calculator directly adheres to the methodology for calculating Energy Market Opportunity Costs as documented in PJM Manual 15, Section 12. Specifically, the features and assumptions described below highlight the differences between the methodology described in Manual 15 (consistent with PJM's Opportunity Cost Calculator in Markets Gateway) and the IMM's Opportunity Cost Calculator.

- The IMM calculator models a unit's Minimum Down Time operating parameter. The PJM calculator does not utilize this parameter.
- The IMM calculator models a unit's start up emissions and coordinates duct burner operation with base load operation. The PJM calculator does not.
- The IMM calculator uses an additional scalar to line up the day of the week between the historical LMPs and the forecasted LMPs. The PJM calculator does not.
- The IMM calculator uses the Platt's balance of the month fuel forward for the current month. The PJM calculator uses the Platt's forwards for all months including the current month.
- The IMM calculator uses an optimization method as opposed to the block margin solution method utilized in the PJM calculator.
- The IMM calculator simultaneously enforces all rolling period emission limits. PJM calculator may require a solution for each limitation in order to determine the most constrained limit.
- The IMM calculator derives the shadow price of the binding constraint by taking the difference in generator revenue from an initial run and a subsequent run that restricts the operating hours within the constrained period by one hour; the shadow price is the marginal opportunity cost adder. The PJM calculator uses the margin of the lowest block added before the run hour limitation is reached.
- The IMM calculator utilizes historical bidding behavior to determine the expected unit offer behavior when calculating opportunity cost. The PJM calculator is based on unit cost as documented in M-15.

Additional questions on the PJM calculator can be addressed to Jennifer Freeman at Jennifer.Freeman@pjm.com.

Sincerely,
Glen Boyle
Manager, Operations Analysis and Compliance

Attachment E – CUI//PRIV

{BEGIN CUI//PRIV} REDACTED [END CUI//PRIV]