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July 31, 2020

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E. Room 1A
Washington, D.C. 20426

Re: *PJM Interconnection L.L.C., Docket No. ER20-2573-000*
        Enhancements to PJM Dispatch and Pricing

Dear Secretary Bose,

Pursuant to Section 205 of the Federal Power Act ("FPA"),[1] and Part 35 of the Federal Energy Regulatory Commission's ("FERC" or the "Commission") regulations,[2] PJM Interconnection, L.L.C. ("PJM") hereby submits for filing proposed revisions to the PJM Open Access Transmission Tariff ("Tariff"), Attachment K-Appendix, section 2.5, and to the identical corresponding provisions in the Amended and Restated Operating Agreement of PJM Interconnection, L.L.C. ("Operating Agreement"), Schedule 1, section 2.5.[3]

The Tariff and Operating Agreement revisions submitted herein are the product of a collaborative effort between PJM, the Independent Market Monitor for PJM ("IMM"), and PJM stakeholders, and are just and reasonable in that they will effectuate greater accuracy in the pricing and dispatch of resources in PJM's footprint, in furtherance of the Commission's overarching price

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[1] 16 U.S.C. § 824d (2018).

[2] 18 C.F.R. Part 35 (2020).

[3] The Tariff and Operating Agreement are currently located under PJM's "Intra-PJM Tariffs" eTariff title, available here: https://etariff.ferc.gov/TariffBrowser.aspx?tid=1731. Terms not otherwise defined herein shall have the same meaning as set forth in the Tariff, Operating Agreement, and the Reliability Assurance Agreement Among Load-Serving Entities in the PJM Region (the "RAA").

formation policy objectives.[4] As discussed below, the Tariff and Operating Agreement changes proposed in this filing were referred to in the PJM stakeholder process as the "short-term" reforms, and represent the first of three distinct sets of reforms—"short-term," "intermediate-term," and "long-term"—identified by PJM, the IMM, and PJM stakeholders to enhance the means by which PJM dispatches and prices resources in its footprint. While this FPA Section 205 filing relates only to the short-term reforms, PJM has included additional detail and background regarding the intermediate-term and long-term reforms to provide the Commission with a better understanding of the broader pricing and dispatch reform efforts in PJM. The proposal submitted herein was approved overwhelmingly by the PJM Markets and Reliability Committee ("MRC") through a sector-weighted vote of 5.0 out of a possible 5.0, and by the PJM Members Committee ("MC") via acclamation, with three objections and three abstentions.

PJM respectfully requests an effective date of October 15, 2020 for the proposed revisions to the Tariff and Operating Agreement, and an order from the Commission by no later than October 12, 2020.

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[4] *See, e.g.*, *Settlement Intervals and Shortage Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators*, 155 FERC ¶ 61,276 at P 53 (2016) ("Order No. 825") ("We adopt the NOPR proposal to require that each RTO/ISO settle energy transactions in its real-time markets at the same time interval it dispatches energy, as discussed below. We find that the settlement interval requirement for energy transactions will meet the Commission's price formation goals by more accurately reflecting the value of the service a resource provides to the system, which, in so doing, helps to ensure that rates are just and reasonable and not unduly discriminatory or preferential."). *See also PJM Interconnection, L.L.C.*, 170 FERC ¶ 61,018 at P 31 (2020) (the "January 23, 2020 Order") ("However, PJM may not be able to implement these separate dispatch and pricing runs in a way that is just and reasonable without first resolving the pricing and dispatch misalignment problem. If fast-start resources dispatched in a given market interval could be compensated with a price from a different market interval, prices may not accurately reflect the marginal cost of serving load.").

I.   BACKGROUND

A. Relevant PJM Pricing and Dispatch Applications

The primary price signal in both the PJM Day-ahead Energy Market and the Real-time Energy Market is Locational Marginal Price ("LMP"). Stated simply, LMP is the market clearing marginal price for energy at the location the energy is delivered or received.[5]

In the Real-time Energy Market, PJM uses an application called Real-Time Security Constrained Economic Dispatch ("RT SCED") to dispatch specific resources in order to maintain the system balance of energy and reserves over a near-term look-ahead period. RT SCED analyzes historical and current system information to anticipate generator performance to various requests, and to provide accurate information to PJM dispatchers regarding generator operating parameters under multiple scenarios. RT SCED also jointly optimizes energy and flexible synchronized reserves on online, dispatchable resources while honoring current Regulation assignments to ensure that PJM's system needs are met, and produces commitments that are sent to resource owners in real-time.

RT SCED produces dispatch solutions, or "cases." These RT SCED cases use load forecast and other system information that are effective for the look-ahead interval, rather than the time at which the case is executing, to achieve a dispatch solution that will adequately control for those forecasted conditions. Historically, an RT SCED case was *executed* automatically less than every five minutes, or manually by the PJM dispatcher on an ad hoc basis. This is distinguishable from *approval* of an RT SCED case, which is currently not automatic, but rather requires manual action by the PJM dispatcher. As explained in the attached Affidavit of Rebecca Carroll, Director of PJM

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[5] *See* Operating Agreement, Definitions I-L.

Dispatch, manual (as opposed to automatic) control over RT SCED case approval has historically provided PJM operators with the flexibility needed to address dynamically changing system conditions, and ensure compliance with several distinct North American Electric Reliability Corporation ("NERC") mandatory reliability standards.[6]

In coordination with RT SCED, PJM uses an incremental linear optimization program called the Locational Pricing Calculator ("LPC") to determine real-time LMP values and ancillary service clearing prices on a five-minute basis. To accomplish this, the LPC utilizes input data from the approved RT SCED case that was used to dispatch the PJM system at the time the LPC case was executed. The LPC calculates LMPs for each of the PJM nodes in the State Estimator[7] model, and for interface busses used as a proxy for transfers to and from PJM and external control areas.

B. PJM Five-Minute Dispatch and Pricing Stakeholder Process

On June 12, 2019, the PJM Market Implementation Committee ("MIC") approved an issue charge brought forward by the IMM.[8] The issue charge sought to examine, among other things, PJM's RT SCED case execution and approval process, and the criteria that PJM uses for selecting cases to be priced in the LPC.[9] PJM and its stakeholders have subsequently been engaged in the

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[6] *See* Affidavit of Rebecca Carroll on Behalf of PJM Interconnection, L.L.C. (the "Carroll Affidavit") at PP 11, 13-17.

[7] The PJM State Estimator uses actual operating conditions that exist on the power grid (as described by metered inputs) along with fundamental power system equations to calculate the remaining flows and conditions that are not metered. Since the State Estimator solution provides a complete and consistent model of actual operating conditions based upon observable (metered) input and an underlying mathematical model, it can be used to provide the basis for the LMP calculations.

[8] *See* Minutes from the June 12, 2019 MIC, available here: https://www.pjm.com/-/media/committees-groups/committees/mic/20190710/20190710-draft-minutes-mic-20190612.ashx

[9] *See* the "IMM Issue Charge," available here: https://www.pjm.com/-/media/committees-

key work activities outlined in the issue charge via special sessions of the MIC.
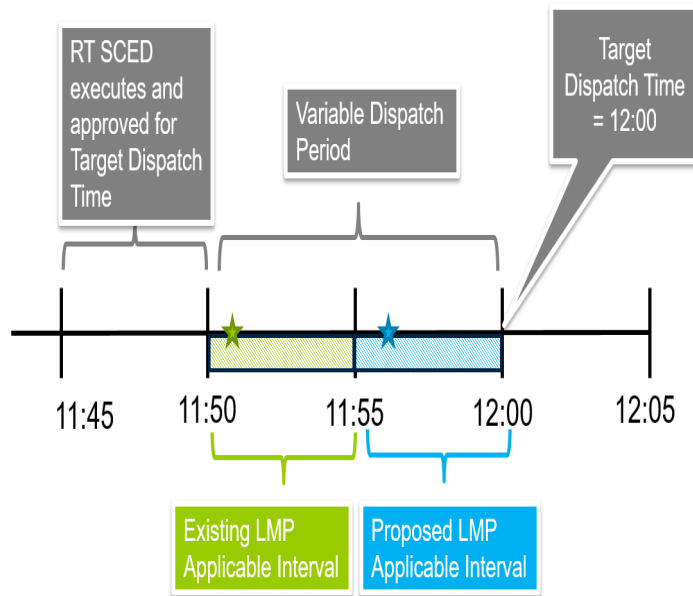
II. DESCRIPTION OF PROPOSED REVISIONS

As referenced above, the RT SCED application is responsible for dispatching resources for a future target dispatch time to maintain the system balance of energy and reserves over a ten-minute look-ahead period, based on forecasted system conditions. The future target dispatch time is ten minutes from the program's execution time, rounded up to the nearest five-minute interval. However, while RT SCED dispatches resources for a target interval that is roughly ten minutes in the future, under the current rules, LPC immediately assigns the prices associated with that future dispatch interval to the *current* interval.

Under the reforms filed herein, in lieu of assigning prices to the current interval, PJM proposes to change the LPC program to assign prices to a future interval, effectively calculating real-time LMPs, Regulation, and reserve clearing prices based on the latest-approved RT SCED program solution, referred to as the "reference case," for the *same future target time* that RT SCED is dispatching for, thereby aligning the future dispatch (RT SCED) with the corresponding target interval for pricing (LPC). If there is not an approved RT SCED solution for the same future target time, LPC will use the most recently-approved RT SCED solution prior to the target time as the reference case. In the event of an outage to RT SCED, LPC will use the RT SCED case that best represents the conditions over the outage period, as determined by the market operator.

In addition, PJM proposes to modify the effective time of the input data exported to RT SCED in order to support the alignment of dispatch and pricing. Specifically, data from multiple sources will be used, including, but not limited to, data regarding online and available resources,

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groups/committees/mic/20190612/20190612-item-02a-five-minute-pricing-issue-charge-rev2-clean.ashx

resource offers, forecasted load, scheduled interchange, as well as various other input parameters, effective for the period ending at the future dispatch target time. For example, resource offers, Regulation and inflexible Synchronized Reserve assignments from the 11:00 to 12:00 hour will be effective until the 12:00 future dispatch target time. Resource offers, Regulation, and inflexible Synchronized Reserve assignments for the 12:00 to 13:00 hour will be used as inputs to RT SCED for the future dispatch target time of 12:05 and onwards until 13:00.

These reforms can be visualized by the following diagram:

SCED Changes:

- Resource Offers, Regulation and inflexible SR assignments from 11:00 -12:00 hour will be effective through the 12:00 future dispatch target time.
- Resource Offers, Regulation and inflexible SR assignments from 12:00 -13:00 hour will be effective starting the 12:05 future dispatch target time through 13:00.

LPC Changes:

- Align LPC to use the latest approved RT SCED case for the same target time (interval ending)
- LPC case executed at a predefined time, shortly after the start of dispatch interval
  - I.e. the LMP for 11:55 - 12:00 is executed at 11:56:30

Diagram labels:

RT SCED executes and approved for Target Dispatch Time

Variable Dispatch Period

Target Dispatch Time = 12:00

11:45 11:50 11:55 12:00 12:05

Existing LMP Applicable Interval

Proposed LMP Applicable Interval

★ Existing LPC case execution time

★ Proposed LPC case execution time

As noted above, the Tariff and Operating Agreement revisions submitted herein are designed solely to implement the so-called "short-term" reforms. To effectuate the short-term reforms, PJM proposes to amend Tariff, Attachment K-Appendix, section 2.5, and the identical corresponding provisions in Operating Agreement, Schedule 1, section 2.5, in the following manner:

> *(e)   During the Operating Day, the calculation set forth in Operating Agreement, Schedule 1, section 2.5 shall be performed every five minutes, using the Office of the Interconnection's Real-time Price software program, producing the Real-time Prices* <u>for the current five minute interval</u> *based on* <u>forecasted</u> *system conditions* <u>and the latest approved PJM security-constrained economic dispatch solution with a target time</u> ~~*during the preceding interval*~~ <u>at the end of the current five minute interval.</u> <u>If no security-constrained economic dispatch solution was approved for the target time at the end of the current five minute interval, the Locational Marginal Price program will use the most recently approved security-constrained economic dispatch solution with a target time prior to the end of the Locational Marginal Price program five minute interval. If a technical problem with or malfunction of the security-constrained economic dispatch or Locational Marginal Price software programs exists, including but not limited to program failures or data input failures, the Office of the Interconnection will utilize the best available RT SCED solution to calculate LMPs.</u>

III.   JUSTIFICATION FOR PROPOSED REVISIONS

The Tariff and Operating Agreement revisions submitted herein to implement the short-term reforms are just and reasonable in that they will effectuate greater accuracy in the pricing and dispatch of resources in PJM's footprint, in furtherance of the Commission's overarching price formation policy objectives.

The Commission has previously identified alignment of pricing and dispatch as a core component of enhanced price formation. For example, in Order No. 825, the Commission identified two of the key goals of price formation as: (i) providing correct incentives for market participants to follow commitment and dispatch instructions, make efficient investments in facilities and equipment, and maintain reliability; and (ii) providing transparency so that market participants understand how prices reflect the actual marginal cost of serving load and the

operational constraints of reliably operating the system.[10] In response to a finding that certain RTOs/ISOs used hourly integrated prices for real-time settlement and five-minute dispatch instructions, the Commission adopted a requirement that each RTO/ISO settle energy transactions in its real-time markets at the same time interval it dispatches energy. The Commission found that such a requirement would "meet the Commission's price formation goals by more accurately reflecting the value of the service a resource provides to the system, which, in so doing, helps to ensure that rates are just and reasonable and not unduly discriminatory or preferential."[11] The Commission further explained that "providing the correct incentives for market participants to follow commitment and dispatch instructions, make efficient investments in facilities and equipment, maintain reliability, and increase transparency is fundamental to proper formation of energy prices, helping to ensure just and reasonable rates, terms and conditions of service."[12]

More recently, in its January 23, 2020 Order holding PJM's fast-start compliance proceeding in abeyance, the Commission identified misalignment between pricing and dispatch as having the potential to produce unjust and unreasonable outcomes upon implementation of fast-start pricing.[13]

By modifying LPC to use the approved RT SCED case for the same target time and making corresponding modifications to the effective time of the input data exported to RT SCED, the

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[10] Order No. 825 at P 5

[11] *Id*. at P 53.

[12] *Id*. at P 54.

[13] January 23, 2020 Order at P 31 ("However, PJM may not be able to implement these separate dispatch and pricing runs in a way that is just and reasonable without first resolving the pricing and dispatch misalignment problem. If fast-start resources dispatched in a given market interval could be compensated with a price from a different market interval, prices may not accurately reflect the marginal cost of serving load.").

short-term reforms effectuated through the proposed Tariff and Operating Agreement revisions will better align dispatch and pricing intervals by ensuring that prices appropriately reflect the costs of the marginal resources consistent with the future timing of the dispatch instructions they receive. With LPC using the reference RT SCED case from the same target time and the transition to the interval-ending concept, resources will now be compensated appropriately once those resources meet the target dispatch objective, thereby more accurately reflecting the marginal cost of serving the next increment of load and providing better incentives for resources to continue following PJM dispatch. These incentives are solidified because the calculated prices that determine real-time, five-minute settlements for generators will be better aligned with the timing of when they are expected to achieve their indicated dispatch levels.

IV.   ADDITIONAL INFORMATION REGARDING OTHER REFORM EFFORTS

As referenced above, PJM has worked closely with the IMM and PJM stakeholders to identify three distinct phases of reforms to its dispatch and pricing practices—the "short-term," "intermediate-term," and "long-term." While the Tariff and Operating Agreement revisions submitted herein are designed solely to effectuate the short-term reforms, PJM is including additional information regarding the intermediate-term and long-term reforms to provide the Commission with additional insight into the broader pricing and dispatch reform efforts in PJM.

PJM's approach to these three distinct sets of short, intermediate, and long-term reforms was forged by adherence to four guiding principles: (i) enhance rules, tools, and processes to automate dispatch decisions and minimize the need for operator discretion, but recognize the need to maintain this flexibility; (ii) enhance alignment of dispatch with settlement intervals to maximize market incentives; (iii) preserve PJM's ability to make decisions/exercise discretion as needed to maintain reliability; and (iv) ensure that any enhancements can meet solution time

requirements that align with dispatch best practices and five-minute pricing.[14]   Given the importance of operational considerations in formulating PJM's approach to addressing each of these reforms, PJM is providing the attached Affidavit of Rebecca Carroll, Director of PJM Dispatch, to provide additional factual background and insight.

A.   **The Intermediate-Term Reforms**

The intermediate-term reforms are designed to address key work activities identified in the IMM Issue Charge to examine, among other things, PJM's RT SCED case execution and approval process, and the criteria that PJM uses for selecting cases to be priced in the LPC. As referenced above, RT SCED cases have historically been automatically executed at a frequency of *less than* every five minutes, or whenever manually executed by PJM dispatchers. When this occurs, it can result in PJM dispatchers approving more than one RT SCED case per five-minute interval. This practice with respect to RT SCED stands in contrast to LPC, which, as referenced above, is automatically executed every five minutes. The difference between the execution times of these two distinct applications can lead to a scenario where only a subset of the approved RT SCED cases will be used by LPC to calculate LMPs, and subsequently used downstream in settlements.

Under the intermediate-term reforms, PJM proposed to change the frequency of automatically executed RT SCED cases from *less than* every five minutes to every five minutes, and began implementing this reformed practice operationally on June 22, 2020. As described in the Carroll Affidavit, the impact of this change has been immediate and positive.[15]   During the first six months of the year when the auto-execution in RT SCED was set at a value of less than

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[14] These principles were informed in part by the Commission's general policies regarding enhanced price formation, PJM's regulatory obligations, and feedback received during applicable stakeholder processes.

[15] Carroll Affidavit at P 9.

five minutes, an average of 76% of the RT SCED cases were priced by LPC. However, once the

auto-execution time was changed to five minutes, an average of 90% of the RT SCED cases were

priced by LPC.[16]

Importantly, under the intermediate-term reforms, PJM dispatchers will continue to have

the ability to execute cases manually when needed. As described in the Carroll Affidavit, this

flexibility will ensure that PJM dispatchers can quickly address dynamic system volatility caused

by unexpected operating conditions, thereby maintaining compliance with BAL-001-2.[17]

While PJM has implemented the intermediate-term reforms and has seen positive benefits

thus far, in the event that those benefits diminish, or a more optimal mechanism becomes available,

PJM will, through its stakeholder process, consult with the IMM and PJM stakeholders to explore

any necessary changes to the practices described herein.[18]

B.   The Long-Term Reforms

The long-term reforms involve more foundational changes to RT SCED's case approval

process and resource ramping methodology. As compared with the short and intermediate-term

reforms, these changes are more complex, and will require additional analysis to better understand

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[16] *Id*.

[17] *Id*. at P 10. *See also* NERC Reliability Standard BAL-001-2 at R1 and R2 ("The Responsible Entity shall operate such that the Control Performance Standard 1 (CPS1), calculated in accordance with Attachment 1, is greater than or equal to 100 percent for the applicable Interconnection in which it operates for each preceding 12 consecutive calendar month period, evaluated monthly; Each Balancing Authority shall operate such that its clock-minute average of Reporting ACE does not exceed its clock-minute Balancing Authority ACE Limit (BAAL) for more than 30 consecutive clock-minutes, calculated in accordance with Attachment 2, for the applicable Interconnection in which the Balancing Authority operates.").

[18] Given that the intermediate-term reforms consist of altering the technical setting of a specific software application, and the operational need for PJM dispatchers to retain flexibility to execute cases manually, as described in the Carroll Affidavit, PJM believes its manuals are the appropriate forum to include detail regarding the intermediate-term reforms.

their potential benefits and reliability impacts.

The first of the long-term reforms involves the automatic *approval* (as opposed to execution) of RT SCED cases. As referenced above, today PJM dispatchers manually approve all RT SCED cases. However, under the long-term reforms, if an RT SCED solution is not manually approved for a future dispatch target time within an allotted time (five minutes), the solution would be automatically approved.

As explained in the Carroll Affidavit, a transition to automatic RT SCED case approval—and any requisite flexibility outside of this automatic approval process that PJM dispatchers would need to retain—must be thoroughly analyzed to ensure that PJM can continue to meet its mandatory requirements as a NERC-registered Reliability Coordinator, Transmission Operator, and Balancing Authority.[19] Specifically, prior to making such a change, PJM must have confidence that it will be able to maintain operational compliance with BAL-002-3, BAL-003-1.1, IRO-006-5 and IRO-006-EAST-2, and PJM's obligations to re-dispatch for coordinated flowgates under the Joint Operating Agreements with the Midcontinent Independent System Operator, Inc. ("MISO") and the New York Independent System Operator, Inc. ("NYISO").[20] Additional analysis is particularly warranted given the 2016 event involving a Balancing Authority that was unable to manually override its automated dispatch instructions, resulting in a large negative ACE

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[19] Carroll Affidavit at PP 13-17. *See also* NERC Rules of Procedure, Appendix 5B – Statement of Compliance Registry Criteria (Rev. 6) at 1 ("Organizations listed in the Compliance Registry are responsible and will be monitored for compliance with applicable mandatory Reliability Standards. They will be subject to NERC's and the Regional Entities' Compliance Monitoring and Enforcement Programs."). *See also* NERC Compliance Registry at NCR00879, available here:
https://www.nerc.com/pa/comp/Registration%20and%20Certification%20DL/NERC_Compliance_Registry_Matrix_Excel.xlsx.

[20] *Id*.

of -3227 MW and a system frequency of 59.83 Hz.[21]

The second of the long-term reforms involves adjustments to RT SCED's ramping methodology. Currently, PJM's RT SCED uses a State Estimator MW solution as the initial or starting MW value when calculating a resource's dispatch basepoint, based on the inputs mentioned above. Each RT SCED solution is calculated independently based on these defined inputs. However, as part of the long-term reforms, the initial MW for each RT SCED solution would be adjusted for feasibility based on its previous RT SCED solution. What this means is that PJM's RT SCED would continue to have a ten-minute look ahead split into two five-minute blocks of time. The dispatch interval would only be for the *last* five-minutes (of the ten-minute look ahead). Over the *first* five minutes of the ten-minute look ahead, the State Estimator MWs would be used as the resource's starting point, ramped over five minutes to determine where the resource's output is with respect to the previous dispatch basepoint. If the unit can achieve its previous dispatch basepoint, then the previous dispatch basepoint will be used as the starting point for the second five-minutes (the dispatch interval). If the resource cannot achieve the previous dispatch MWs over the first five minutes, then the starting point for the dispatch period will be State Estimator MW, adjusted for ramp. This specific long-term reform can be visualized by the following diagram.

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[21] *Id*. at P 17 (citing NERC Lesson Learned – Dispatch Reduction in Generation Output Causes Frequency Deviation), available here:
https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20170401_Dispatched_Reducti
on_in_Generation_Output_Causes_Frequency_Deviation.pdf
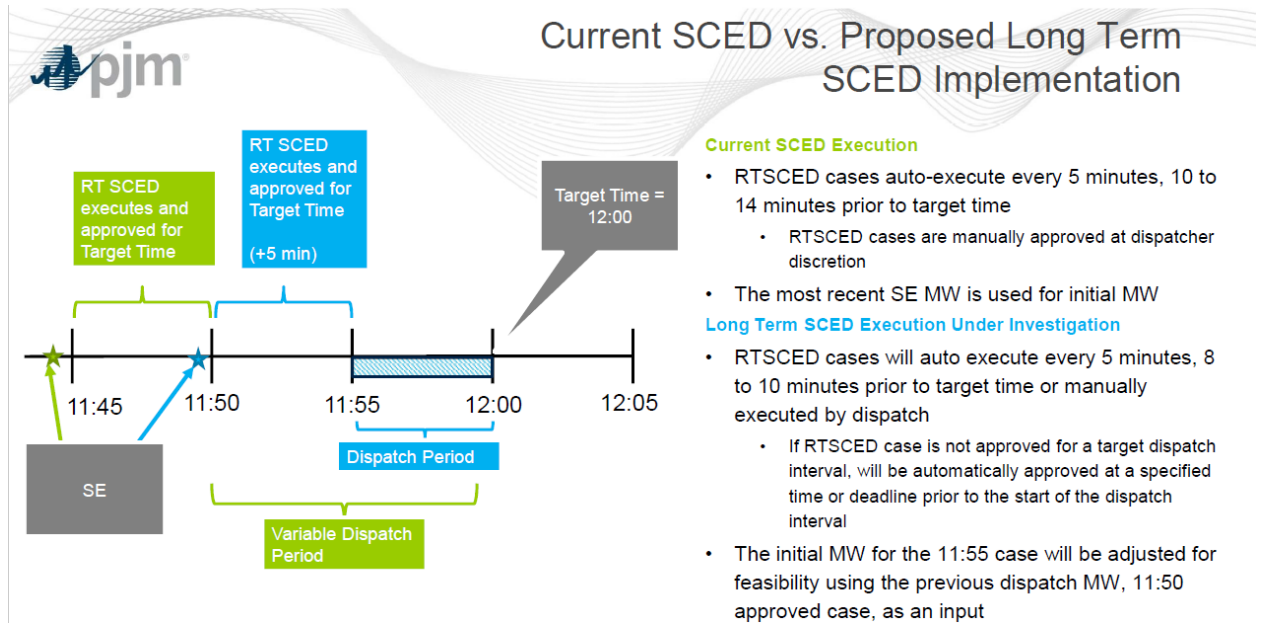
As in the case of the aforementioned auto-approval of RT SCED cases, PJM will need to closely evaluate this proposed long-term reform prior to implementing. As noted in the Carroll Affidavit, more examination is needed to determine when or if the previous RT SCED dispatch basepoint is accurate enough to be utilized as the initial MW in the RT SCED solution, to ensure that PJM does not run afoul of the operating and reporting requirements of BAL-001-2.[22]

V.   STAKEHOLDER ENDORSEMENT

On July 23, 2020, the PJM Markets and Reliability Committee ("MRC") endorsed the Tariff and Operating Agreement revisions proposed herein in a sector-weighted vote, with 5.0 out of 5.0 in favor. On that same day, the PJM Members Committee ("MC") similarly endorsed the Tariff and Operating Agreement revisions proposed herein by acclamation, with three objections and three abstentions.

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[22] *Id*. at P 19.

VI. EFFECTIVE DATE

PJM respectfully requests an effective date of October 15, 2020, for the proposed revisions

to the Tariff and Operating Agreement, and an order from the Commission by no later than October

12, 2020.

VII. COMMUNICATIONS

PJM requests that all communications regarding this filing be directed to the following

persons:

Craig Glazer	Thomas DeVita
Vice President – Federal Government Policy	Senior Counsel
PJM Interconnection, L.L.C.	PJM Interconnection, L.L.C.
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VIII. DOCUMENTS INCLUDED WITH THIS FILING

In accordance with the requirements of Order No. 714[23] and the Commission's eTariff

regulations, PJM hereby submits an eTariff XML filing package consisting of the following

materials:

1. This transmittal letter;

2. Attachment A – Revisions to the Tariff and Operating Agreement, in redlined format; and

3. Attachment B – Revisions to the Tariff and Operating Agreement, in clean format.

4. Attachment C – Affidavit of Rebecca Carroll on Behalf of PJM Interconnection, L.LC.[24]

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[23] *Electronic Tariff Filings*, 124 FERC ¶ 61,270 (2008).

[24] Pursuant to the Commission's May 8, 2020 Supplemental Notice Waiving Regulations in Docket No. AD20-11-000 (the "May 8, 2020 Notice"), PJM has omitted a notarized verification with this Affidavit. *See* May 8, 2020 Notice

IX.   SERVICE

PJM has served a copy of this filing on all PJM Members and on all state utility regulatory commissions in the PJM Region by posting this filing electronically. In accordance with the Commission's regulations,[25] PJM will post a copy of this filing to the FERC filings section of its internet site, located at the following link: http://www.pjm.com/documents/ferc-manuals.aspx with a specific link to the newly-filed document, and will send an e-mail on the same date as this filing to all PJM Members and all state utility regulatory commissions in the PJM Region[26] alerting them that this filing has been made by PJM today and is available by following such link.

X.   CONCLUSION

In accordance with the foregoing, PJM respectfully requests that the Commission accept the proposed revisions to the PJM Tariff and Operating Agreement, and permit an effective date of October 15, 2020, as discussed herein.

                                             Respectfully submitted,

                                             /s/   Thomas DeVita

Craig Glazer   Thomas DeVita
Vice President – Federal Government Policy   Senior Counsel
PJM Interconnection, L.L.C.   PJM Interconnection, L.L.C.
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                                             On behalf of
                                             PJM Interconnection, L.L.C

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at 1 ("Given the ongoing emergency conditions caused by COVID-19, there is good cause to waive through September 1, 2020, the Commission's regulations that require that filings with the Commission be notarized or supported by sworn declarations.").

[25] *See* 18 C.F.R §§ 35.2(e) and 385.2010(f)(3).

[26] PJM already maintains, updates, and regularly uses e-mail lists for all PJM members and affected commissions.

Attachment A

Revisions to the
PJM Open Access Transmission Tariff
and PJM Operating Agreement

(Marked / Redline Format)

Section(s) of the
PJM Open Access Transmission Tariff

(Marked / Redline Format)

2.5   Calculation of Real-time Prices.

(a)   The Office of the Interconnection shall determine *Locational Marginal Prices based on* the least costly means of obtaining energy to serve the next increment of load *and meet reserve requirements* (taking account of any applicable and available load reductions indicated on PRD Curves properly submitted by any PRD Provider) at each bus in the PJM Region represented in the *network model* and each Interface Pricing Point between PJM and an adjacent Control Area, based on the *operating* conditions *and the submitted energy offers as described in Tariff, Attachment K-Appendix, section 2.4. The process for the determination of Real-time Prices occurs in the Real-time Price software program, and is known as the pricing run for the Real-time Energy Market. The Real-time Price software program uses the input data from a reference real-time security constrained economic dispatch case as described in the PJM Manuals and performs the same optimization as the real-time security constrained economic dispatch program but additionally applies Integer Relaxation to Eligible Fast-Start Resources. The real-time security constrained economic dispatch program, which is considered the dispatch run for the Real-time Energy Market, performs* a real-time joint optimization of energy and reserves, given *operating* conditions, a set of energy offers, a set of reserve offers, a set of Operating Reserve Demand Curves, and any *monitored* transmission constraints that may exist.

(b)   *To determine operating conditions on the power grid in the PJM Region (including transmission constraints on external coordinated flowgates to the extent provided by Tariff, Attachment K-Appendix, section 1.7.6), the Office of the Interconnection shall use a computer model of the interconnected grid that uses available metered inputs regarding generator output, loads, and power flows to model remaining flows and conditions, producing a consistent representation of power flows on the network as an input into the real-time security constrained economic dispatch. The computer model employed for this purpose, referred to as the State Estimator program, is a standard industry tool and is described in Tariff, Attachment K-Appendix, section 2.3. The State Estimator solution used by the real-time security constrained economic dispatch will be used to obtain information regarding the output of generation supplying energy to the PJM Region, loads at buses in the PJM Region, transmission losses, and power flows on binding transmission constraints. Additional information used in the calculation, including Dispatch Rates and real time schedules for external transactions between PJM and other Control Areas and dispatch and pricing information from entities with whom PJM has executed a joint operating agreement, will be obtained from the Office of the Interconnection's dispatchers.*

(c)   *Using the prices at which energy is offered by Market Sellers and demand reductions are offered by Economic Load Response Participants, Pre-Emergency Load Response participants and Emergency Load Response participants to the PJM Interchange Energy Market, the Office of the Interconnection shall determine the offers of energy and demand reductions that will be considered in the calculation of Locational Marginal Prices. As described in Tariff, Attachment K-Appendix, section 2.4, every qualified offer for demand reduction and of energy by a Market Seller from resources that are dispatched by the Office of the Interconnection will be utilized in the calculation of Locational Marginal Prices, including, without limitation, qualified Real-time Energy Market offers from Economic Load Response Participants, Emergency Load Response and Pre-Emergency Load Response.*

(*d*) In performing *the Real-time Price* calculation, the Office of the Interconnection shall calculate the cost of serving an increment of load at each bus from each resource associated with an eligible energy offer *as described in Tariff, Attachment K-Appendix, section 2.4* as the sum of the following components of Locational Marginal Price: (1) System Energy Price, which is the price at which the Market Seller has offered to supply an additional increment of energy from a generation resource or decrease an increment of energy being consumed by an Economic Load Response Participant resource, (2) Congestion Price, which is the effect on transmission congestion costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource, based on the effect of increased generation from the resource on transmission line loadings, and (3) Loss Price, which is the effect on transmission loss costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource based on the effect of increased generation from or consumption by the resource on transmission losses. The *R*eal-time Prices at a bus shall be determined through the joint optimization program based on the lowest marginal cost to serve the next increment of load at the bus taking into account resource constraints, transmission constraints, marginal loss impact, and the applicable Operating Reserve Demand Curves. When the marginal energy megawatts is provided by converting a megawatts of reserves into a megawatts of energy, the resulting Locational Marginal Price takes into account the opportunity cost of that exchange.

(*e*) *During the Operating Day, the calculation set forth in Tariff, Attachment K-Appendix, section 2.5 shall be performed every five minutes, using the Office of the Interconnection's Real-time Price software program, producing the Real-time Prices* for the current five minute interval *based on* forecasted *system conditions* and the latest approved PJM security-constrained economic dispatch solution with a target time *during the preceding interval*at the end of the current five minute interval. If no security-constrained economic dispatch solution was approved for the target time at the end of the current five minute interval, the Locational Marginal Price program will use the most recently approved security-constrained economic dispatch solution with a target time prior to the end of the Locational Marginal Price program five minute interval. If a technical problem with or malfunction of the security-constrained economic dispatch or Locational Marginal Price software programs exists, including but not limited to program failures or data input failures, the Office of the Interconnection will utilize the best available RT SCED solution to calculate LMPs.

2.5.1 Declaration of Shortage Pricing

(*a*) *The Office of the Interconnection shall use its Real-time Price software program, to determine if the Office of the Interconnection is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage for the purposes of declaring shortage pricing as further described in the PJM Manuals. Shortage pricing shall exist until the Real-time Price software program is able to meet the specified reserve requirements.*

(*b*) *If a Primary Reserve shortage and/or Synchronized Reserve shortage exists and cannot be accurately forecasted by the Office of the Interconnection due to a technical problem,*

including but not limited to failures of data input into the Real-time Price software program, the Office of the Interconnection will utilize the best available alternate data sources to determine if a Reserve Zone or Reserve Sub-zone is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage.

(c)   The Office of the Interconnection shall issue day-ahead alerts to PJM Members of the possible need to use emergency procedures during the following Operating Day. Such emergency procedures may be required to alleviate real-time emergency conditions such as a transmission emergency or potential reserve shortage. The alerts issued by the Office of the Interconnection may include, but are not limited to, the Maximum Generation Emergency Alert, Primary Reserve Alert and/or Voltage Reduction Alert.   These alerts shall be issued to keep all affected system personnel informed of the forecasted status of the PJM bulk power system. The Office of the Interconnection shall notify PJM Members of all alerts and the cancellation thereof via the methods described in the PJM Manuals. The alerts shall be issued as soon as practicable to allow PJM Members sufficient time to prepare for such operating conditions. The day-ahead alerts issued by the Office of the Interconnection are for informational purposes only and by themselves will not impact price calculation during the Operating Day.

(d)   The Office of the Interconnection shall issue a warning of impending operating reserve shortage and other emergency conditions in real-time to inform members of actual capacity shortages or contingencies that may jeopardize the reliable operation of the PJM bulk power system. Such warnings will generally precede any associated action taken to address the shortage conditions.   The Office of the Interconnection shall notify PJM Members of the issuance and cancellation of emergency procedures via the methods described in the PJM Manuals. The warnings that the Office of the Interconnection may issue include, but are not limited to, the Primary Reserve Warning, Voltage Reduction Warning, and Manual Load Dump Warning.

The purpose of the Primary Reserve Warning is to warn members that the available Primary Reserve may be less than the Minimum Primary Reserve Requirement. If the Primary Reserve shortage condition was determined as described above, the applicable Reserve Penalty Factor is incorporated into the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price and Locational Marginal Price as applicable.

The purpose of the Voltage Reduction Warning is to warn PJM Members that the available Synchronized Reserve may be less than the Minimum Synchronized Reserve Requirement and that a voltage reduction may be required. Following the Voltage Reduction Warning, the Office of the Interconnection may issue a Voltage Reduction Action during which it directs PJM Members to initiate a voltage reduction. If the Office of the Interconnection issues a Voltage Reduction Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will

continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Voltage Reduction Action has been terminated.

The purpose of the Manual Load Dump Warning is to warn members that dumping load may be necessary to maintain reliability. Following the Manual Load Dump Warning, the Office of the Interconnection may commence a Manual Load Dump Action during which it directs PJM Members to initiate a manual load dump pursuant to the procedures described in the PJM Manuals. If the Office of the Interconnection issues a Manual Load Dump Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Manual Load Dump Action has been terminated.

Shortage pricing will be terminated in a Reserve Zone or Reserve Sub-Zone when demand and reserve requirements can be fully satisfied with generation and Economic Load Response Participant resources and any Voltage Reduction Action and/or Manual Load Dump Action taken for that Reserve Zone or Reserve Sub-Zone has also been terminated.

Section(s) of the
PJM Operating Agreement

(Marked / Redline Format)

2.5   Calculation of Real-time Prices.

(a)   The Office of the Interconnection shall determine *Locational Marginal Prices based on* the least costly means of obtaining energy to serve the next increment of load *and meet reserve requirements* (taking account of any applicable and available load reductions indicated on PRD Curves properly submitted by any PRD Provider) at each bus in the PJM Region represented in the *network model* and each Interface Pricing Point between PJM and an adjacent Control Area, based on the *operating* conditions *and the submitted energy offers as described in Operating Agreement, Schedule 1, section 2.4. The process for the determination of Real-time Prices occurs in the Real-time Price software program, and is known as the pricing run for the Real-time Energy Market. The Real-time Price software program uses the input data from a reference real-time security constrained economic dispatch case as described in the PJM Manuals and performs the same optimization as the real-time security constrained economic dispatch program but additionally applies Integer Relaxation to Eligible Fast-Start Resources. The real-time security constrained economic dispatch program, which is considered the dispatch run for the Real-time Energy Market, performs* a real-time joint optimization of energy and reserves, given *operating* conditions, a set of energy offers, a set of reserve offers, a set of Operating Reserve Demand Curves, and any *monitored* transmission constraints that may exist.

(b)   To determine operating conditions on the power grid in the PJM Region (including transmission constraints on external coordinated flowgates to the extent provided by Operating Agreement, Schedule 1, section 1.7.6), the Office of the Interconnection shall use a computer model of the interconnected grid that uses available metered inputs regarding generator output, loads, and power flows to model remaining flows and conditions, producing a consistent representation of power flows on the network as an input into the real-time security constrained economic dispatch. The computer model employed for this purpose, referred to as the State Estimator program, is a standard industry tool and is described in Operating Agreement, Schedule 1, section 2.3. The State Estimator solution used by the real-time security constrained economic dispatch will be used to obtain information regarding the output of generation supplying energy to the PJM Region, loads at buses in the PJM Region, transmission losses, and power flows on binding transmission constraints. Additional information used in the calculation, including Dispatch Rates and real time schedules for external transactions between PJM and other Control Areas and dispatch and pricing information from entities with whom PJM has executed a joint operating agreement, will be obtained from the Office of the Interconnection's dispatchers.

(c)   Using the prices at which energy is offered by Market Sellers and demand reductions are offered by Economic Load Response Participants, Pre-Emergency Load Response participants and Emergency Load Response participants to the PJM Interchange Energy Market, the Office of the Interconnection shall determine the offers of energy and demand reductions that will be considered in the calculation of Locational Marginal Prices. As described in Operating Agreement, Schedule 1, section 2.4, every qualified offer for demand reduction and of energy by a Market Seller from resources that are dispatched by the Office of the Interconnection will be utilized in the calculation of Locational Marginal Prices, including, without limitation, qualified Real-time Energy Market offers from Economic Load Response Participants, Emergency Load Response and Pre-Emergency Load Response.

(d)   In performing *the Real-time Price* calculation, the Office of the Interconnection shall calculate the cost of serving an increment of load at each bus from each resource associated with an eligible energy offer *as described in Operating Agreement, Schedule 1, section 2.4* as the sum of the following components of Locational Marginal Price: (1) System Energy Price, which is the price at which the Market Seller has offered to supply an additional increment of energy from a generation resource or decrease an increment of energy being consumed by an Economic Load Response Participant resource, (2) Congestion Price, which is the effect on transmission congestion costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource, based on the effect of increased generation from the resource on transmission line loadings, and (3) Loss Price, which is the effect on transmission loss costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource based on the effect of increased generation from or consumption by the resource on transmission losses. The *R*eal-time Prices at a bus shall be determined through the joint optimization program based on the lowest marginal cost to serve the next increment of load at the bus taking into account resource constraints, transmission constraints, marginal loss impact, and the applicable Operating Reserve Demand Curves. When the marginal energy megawatts is provided by converting a megawatts of reserves into a megawatts of energy, the resulting Locational Marginal Price takes into account the opportunity cost of that exchange.

(e)   *During the Operating Day, the calculation set forth in Operating Agreement, Schedule 1, section 2.5 shall be performed every five minutes, using the Office of the Interconnection's Real-time Price software program, producing the Real-time Prices* for the current five minute interval based on forecasted *system conditions* and the latest approved PJM security-constrained economic dispatch solution with a target time *during the preceding interval*at the end of the current five minute interval. If no security-constrained economic dispatch solution was approved for the target time at the end of the current five minute interval, the Locational Marginal Price program will use the most recently approved security-constrained economic dispatch solution with a target time prior to the end of the Locational Marginal Price program five minute interval. If a technical problem with or malfunction of the security-constrained economic dispatch or Locational Marginal Price software programs exists, including but not limited to program failures or data input failures, the Office of the Interconnection will utilize the best available RT SCED solution to calculate LMPs.

2.5.1 Declaration of Shortage Pricing

(*a*)   *The Office of the Interconnection shall use its Real-time Price software program, to determine if the Office of the Interconnection is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage for the purposes of declaring shortage pricing as further described in the PJM Manuals. Shortage pricing shall exist until the Real-time Price software program is able to meet the specified reserve requirements.*

(*b*)   *If a Primary Reserve shortage and/or Synchronized Reserve shortage exists and cannot be accurately forecasted by the Office of the Interconnection due to a technical problem, including but not limited to failures of data input into the Real-time Price software program, the Office of the Interconnection will utilize the best available alternate data sources to determine if a Reserve*

Zone or Reserve Sub-zone is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage.

(c)   The Office of the Interconnection shall issue day-ahead alerts to PJM Members of the possible need to use emergency procedures during the following Operating Day. Such emergency procedures may be required to alleviate real-time emergency conditions such as a transmission emergency or potential reserve shortage. The alerts issued by the Office of the Interconnection may include, but are not limited to, the Maximum Generation Emergency Alert, Primary Reserve Alert and/or Voltage Reduction Alert.   These alerts shall be issued to keep all affected system personnel informed of the forecasted status of the PJM bulk power system. The Office of the Interconnection shall notify PJM Members of all alerts and the cancellation thereof via the methods described in the PJM Manuals. The alerts shall be issued as soon as practicable to allow PJM Members sufficient time to prepare for such operating conditions. The day-ahead alerts issued by the Office of the Interconnection are for informational purposes only and by themselves will not impact price calculation during the Operating Day.

(d)   The Office of the Interconnection shall issue a warning of impending operating reserve shortage and other emergency conditions in real-time to inform members of actual capacity shortages or contingencies that may jeopardize the reliable operation of the PJM bulk power system. Such warnings will generally precede any associated action taken to address the shortage conditions.   The Office of the Interconnection shall notify PJM Members of the issuance and cancellation of emergency procedures via the methods described in the PJM Manuals. The warnings that the Office of the Interconnection may issue include, but are not limited to, the Primary Reserve Warning, Voltage Reduction Warning, and Manual Load Dump Warning.

The purpose of the Primary Reserve Warning is to warn members that the available Primary Reserve may be less than the Minimum Primary Reserve Requirement. If the Primary Reserve shortage condition was determined as described above, the applicable Reserve Penalty Factor is incorporated into the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price and Locational Marginal Price as applicable.

The purpose of the Voltage Reduction Warning is to warn PJM Members that the available Synchronized Reserve may be less than the Minimum Synchronized Reserve Requirement and that a voltage reduction may be required. Following the Voltage Reduction Warning, the Office of the Interconnection may issue a Voltage Reduction Action during which it directs PJM Members to initiate a voltage reduction. If the Office of the Interconnection issues a Voltage Reduction Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational

Marginal Price calculation, as applicable, until the Voltage Reduction Action has been terminated.

The purpose of the Manual Load Dump Warning is to warn members that dumping load may be necessary to maintain reliability. Following the Manual Load Dump Warning, the Office of the Interconnection may commence a Manual Load Dump Action during which it directs PJM Members to initiate a manual load dump pursuant to the procedures described in the PJM Manuals. If the Office of the Interconnection issues a Manual Load Dump Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Manual Load Dump Action has been terminated.

Shortage pricing will be terminated in a Reserve Zone or Reserve Sub-Zone when demand and reserve requirements can be fully satisfied with generation and Economic Load Response Participant resources and any Voltage Reduction Action and/or Manual Load Dump Action taken for that Reserve Zone or Reserve Sub-Zone has also been terminated.

Attachment B

PJM Open Access Transmission Tariff and PJM Operating Agreement

(Clean Format)

Section(s) of the
PJM Open Access Transmission Tariff

(Clean Format)

2.5   Calculation of Real-time Prices.

(a)   The Office of the Interconnection shall determine *Locational Marginal Prices based on* the least costly means of obtaining energy to serve the next increment of load *and meet reserve requirements* (taking account of any applicable and available load reductions indicated on PRD Curves properly submitted by any PRD Provider) at each bus in the PJM Region represented in the *network model* and each Interface Pricing Point between PJM and an adjacent Control Area, based on the *operating* conditions *and the submitted energy offers as described in Tariff, Attachment K-Appendix, section 2.4. The process for the determination of Real-time Prices occurs in the Real-time Price software program, and is known as the pricing run for the Real-time Energy Market. The Real-time Price software program uses the input data from a reference real-time security constrained economic dispatch case as described in the PJM Manuals and performs the same optimization as the real-time security constrained economic dispatch program but additionally applies Integer Relaxation to Eligible Fast-Start Resources. The real-time security constrained economic dispatch program, which is considered the dispatch run for the Real-time Energy Market, performs* a real-time joint optimization of energy and reserves, given *operating* conditions, a set of energy offers, a set of reserve offers, a set of Operating Reserve Demand Curves, and any *monitored* transmission constraints that may exist.

(b)   *To determine operating conditions on the power grid in the PJM Region (including transmission constraints on external coordinated flowgates to the extent provided by Tariff, Attachment K-Appendix, section 1.7.6), the Office of the Interconnection shall use a computer model of the interconnected grid that uses available metered inputs regarding generator output, loads, and power flows to model remaining flows and conditions, producing a consistent representation of power flows on the network as an input into the real-time security constrained economic dispatch. The computer model employed for this purpose, referred to as the State Estimator program, is a standard industry tool and is described in Tariff, Attachment K-Appendix, section 2.3. The State Estimator solution used by the real-time security constrained economic dispatch will be used to obtain information regarding the output of generation supplying energy to the PJM Region, loads at buses in the PJM Region, transmission losses, and power flows on binding transmission constraints. Additional information used in the calculation, including Dispatch Rates and real time schedules for external transactions between PJM and other Control Areas and dispatch and pricing information from entities with whom PJM has executed a joint operating agreement, will be obtained from the Office of the Interconnection's dispatchers.*

(c)   *Using the prices at which energy is offered by Market Sellers and demand reductions are offered by Economic Load Response Participants, Pre-Emergency Load Response participants and Emergency Load Response participants to the PJM Interchange Energy Market, the Office of the Interconnection shall determine the offers of energy and demand reductions that will be considered in the calculation of Locational Marginal Prices. As described in Tariff, Attachment K-Appendix, section 2.4, every qualified offer for demand reduction and of energy by a Market Seller from resources that are dispatched by the Office of the Interconnection will be utilized in the calculation of Locational Marginal Prices, including, without limitation, qualified Real-time Energy Market offers from Economic Load Response Participants, Emergency Load Response and Pre-Emergency Load Response.*

(d) In performing *the Real-time Price* calculation, the Office of the Interconnection shall calculate the cost of serving an increment of load at each bus from each resource associated with an eligible energy offer *as described in Tariff, Attachment K-Appendix, section 2.4* as the sum of the following components of Locational Marginal Price: (1) System Energy Price, which is the price at which the Market Seller has offered to supply an additional increment of energy from a generation resource or decrease an increment of energy being consumed by an Economic Load Response Participant resource, (2) Congestion Price, which is the effect on transmission congestion costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource, based on the effect of increased generation from the resource on transmission line loadings, and (3) Loss Price, which is the effect on transmission loss costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource based on the effect of increased generation from or consumption by the resource on transmission losses. The *R*eal-time Prices at a bus shall be determined through the joint optimization program based on the lowest marginal cost to serve the next increment of load at the bus taking into account resource constraints, transmission constraints, marginal loss impact, and the applicable Operating Reserve Demand Curves. When the marginal energy megawatts is provided by converting a megawatts of reserves into a megawatts of energy, the resulting Locational Marginal Price takes into account the opportunity cost of that exchange.

(e)   *During the Operating Day, the calculation set forth in Tariff, Attachment K-Appendix, section 2.5 shall be performed every five minutes, using the Office of the Interconnection's Real-time Price software program, producing the Real-time Prices* for the current five minute interval *based on* forecasted *system conditions* and the latest approved PJM security-constrained economic dispatch solution with a target time at the end of the current five minute interval*.* If no security-constrained economic dispatch solution was approved for the target time at the end of the current five minute interval, the Locational Marginal Price program will use the most recently approved security-constrained economic dispatch solution with a target time prior to the end of the Locational Marginal Price program five minute interval. If a technical problem with or malfunction of the security-constrained economic dispatch or Locational Marginal Price software programs exists, including but not limited to program failures or data input failures, the Office of the Interconnection will utilize the best available RT SCED solution to calculate LMPs*.*

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(b)   *If a Primary Reserve shortage and/or Synchronized Reserve shortage exists and cannot be accurately forecasted by the Office of the Interconnection due to a technical problem,*

including but not limited to failures of data input into the Real-time Price software program, the Office of the Interconnection will utilize the best available alternate data sources to determine if a Reserve Zone or Reserve Sub-zone is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage.

(c)   The Office of the Interconnection shall issue day-ahead alerts to PJM Members of the possible need to use emergency procedures during the following Operating Day. Such emergency procedures may be required to alleviate real-time emergency conditions such as a transmission emergency or potential reserve shortage. The alerts issued by the Office of the Interconnection may include, but are not limited to, the Maximum Generation Emergency Alert, Primary Reserve Alert and/or Voltage Reduction Alert.   These alerts shall be issued to keep all affected system personnel informed of the forecasted status of the PJM bulk power system. The Office of the Interconnection shall notify PJM Members of all alerts and the cancellation thereof via the methods described in the PJM Manuals. The alerts shall be issued as soon as practicable to allow PJM Members sufficient time to prepare for such operating conditions. The day-ahead alerts issued by the Office of the Interconnection are for informational purposes only and by themselves will not impact price calculation during the Operating Day.

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The purpose of the Primary Reserve Warning is to warn members that the available Primary Reserve may be less than the Minimum Primary Reserve Requirement. If the Primary Reserve shortage condition was determined as described above, the applicable Reserve Penalty Factor is incorporated into the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price and Locational Marginal Price as applicable.

The purpose of the Voltage Reduction Warning is to warn PJM Members that the available Synchronized Reserve may be less than the Minimum Synchronized Reserve Requirement and that a voltage reduction may be required. Following the Voltage Reduction Warning, the Office of the Interconnection may issue a Voltage Reduction Action during which it directs PJM Members to initiate a voltage reduction. If the Office of the Interconnection issues a Voltage Reduction Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will

continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Voltage Reduction Action has been terminated.

The purpose of the Manual Load Dump Warning is to warn members that dumping load may be necessary to maintain reliability. Following the Manual Load Dump Warning, the Office of the Interconnection may commence a Manual Load Dump Action during which it directs PJM Members to initiate a manual load dump pursuant to the procedures described in the PJM Manuals. If the Office of the Interconnection issues a Manual Load Dump Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Manual Load Dump Action has been terminated.

Shortage pricing will be terminated in a Reserve Zone or Reserve Sub-Zone when demand and reserve requirements can be fully satisfied with generation and Economic Load Response Participant resources and any Voltage Reduction Action and/or Manual Load Dump Action taken for that Reserve Zone or Reserve Sub-Zone has also been terminated.

Section(s) of the
PJM Operating Agreement

(Clean Format)

2.5   Calculation of Real-time Prices.

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(b)   *To determine operating conditions on the power grid in the PJM Region (including transmission constraints on external coordinated flowgates to the extent provided by Operating Agreement, Schedule 1, section 1.7.6), the Office of the Interconnection shall use a computer model of the interconnected grid that uses available metered inputs regarding generator output, loads, and power flows to model remaining flows and conditions, producing a consistent representation of power flows on the network as an input into the real-time security constrained economic dispatch. The computer model employed for this purpose, referred to as the State Estimator program, is a standard industry tool and is described in Operating Agreement, Schedule 1, section 2.3. The State Estimator solution used by the real-time security constrained economic dispatch will be used to obtain information regarding the output of generation supplying energy to the PJM Region, loads at buses in the PJM Region, transmission losses, and power flows on binding transmission constraints. Additional information used in the calculation, including Dispatch Rates and real time schedules for external transactions between PJM and other Control Areas and dispatch and pricing information from entities with whom PJM has executed a joint operating agreement, will be obtained from the Office of the Interconnection's dispatchers.*

(c)   *Using the prices at which energy is offered by Market Sellers and demand reductions are offered by Economic Load Response Participants, Pre-Emergency Load Response participants and Emergency Load Response participants to the PJM Interchange Energy Market, the Office of the Interconnection shall determine the offers of energy and demand reductions that will be considered in the calculation of Locational Marginal Prices. As described in Operating Agreement, Schedule 1, section 2.4, every qualified offer for demand reduction and of energy by a Market Seller from resources that are dispatched by the Office of the Interconnection will be utilized in the calculation of Locational Marginal Prices, including, without limitation, qualified Real-time Energy Market offers from Economic Load Response Participants, Emergency Load Response and Pre-Emergency Load Response.*

(d) In performing *the Real-time Price* calculation, the Office of the Interconnection shall calculate the cost of serving an increment of load at each bus from each resource associated with an eligible energy offer *as described in Operating Agreement, Schedule 1, section 2.4* as the sum of the following components of Locational Marginal Price: (1) System Energy Price, which is the price at which the Market Seller has offered to supply an additional increment of energy from a generation resource or decrease an increment of energy being consumed by an Economic Load Response Participant resource, (2) Congestion Price, which is the effect on transmission congestion costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource, based on the effect of increased generation from the resource on transmission line loadings, and (3) Loss Price, which is the effect on transmission loss costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by an Economic Load Response Participant resource based on the effect of increased generation from or consumption by the resource on transmission losses. The *R*eal-time Prices at a bus shall be determined through the joint optimization program based on the lowest marginal cost to serve the next increment of load at the bus taking into account resource constraints, transmission constraints, marginal loss impact, and the applicable Operating Reserve Demand Curves. When the marginal energy megawatts is provided by converting a megawatts of reserves into a megawatts of energy, the resulting Locational Marginal Price takes into account the opportunity cost of that exchange.

(e) *During the Operating Day, the calculation set forth in Operating Agreement, Schedule 1, section 2.5 shall be performed every five minutes, using the Office of the Interconnection's Real-time Price software program, producing the Real-time Prices* for the current five minute interval *based on* forecasted *system conditions* and the latest approved PJM security-constrained economic dispatch solution with a target time at the end of the current five minute interval. If no security-constrained economic dispatch solution was approved for the target time at the end of the current five minute interval, the Locational Marginal Price program will use the most recently approved security-constrained economic dispatch solution with a target time prior to the end of the Locational Marginal Price program five minute interval. If a technical problem with or malfunction of the security-constrained economic dispatch or Locational Marginal Price software programs exists, including but not limited to program failures or data input failures, the Office of the Interconnection will utilize the best available RT SCED solution to calculate LMPs.

2.5.1 Declaration of Shortage Pricing

(*a*) *The Office of the Interconnection shall use its Real-time Price software program, to determine if the Office of the Interconnection is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage for the purposes of declaring shortage pricing as further described in the PJM Manuals. Shortage pricing shall exist until the Real-time Price software program is able to meet the specified reserve requirements.*

(*b*) *If a Primary Reserve shortage and/or Synchronized Reserve shortage exists and cannot be accurately forecasted by the Office of the Interconnection due to a technical problem, including but not limited to failures of data input into the Real-time Price software program, the Office of the Interconnection will utilize the best available alternate data sources to determine if a Reserve*

Zone or Reserve Sub-zone is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage.

(c)   The Office of the Interconnection shall issue day-ahead alerts to PJM Members of the possible need to use emergency procedures during the following Operating Day. Such emergency procedures may be required to alleviate real-time emergency conditions such as a transmission emergency or potential reserve shortage. The alerts issued by the Office of the Interconnection may include, but are not limited to, the Maximum Generation Emergency Alert, Primary Reserve Alert and/or Voltage Reduction Alert.   These alerts shall be issued to keep all affected system personnel informed of the forecasted status of the PJM bulk power system. The Office of the Interconnection shall notify PJM Members of all alerts and the cancellation thereof via the methods described in the PJM Manuals. The alerts shall be issued as soon as practicable to allow PJM Members sufficient time to prepare for such operating conditions. The day-ahead alerts issued by the Office of the Interconnection are for informational purposes only and by themselves will not impact price calculation during the Operating Day.

(d)   The Office of the Interconnection shall issue a warning of impending operating reserve shortage and other emergency conditions in real-time to inform members of actual capacity shortages or contingencies that may jeopardize the reliable operation of the PJM bulk power system. Such warnings will generally precede any associated action taken to address the shortage conditions.   The Office of the Interconnection shall notify PJM Members of the issuance and cancellation of emergency procedures via the methods described in the PJM Manuals. The warnings that the Office of the Interconnection may issue include, but are not limited to, the Primary Reserve Warning, Voltage Reduction Warning, and Manual Load Dump Warning.

The purpose of the Primary Reserve Warning is to warn members that the available Primary Reserve may be less than the Minimum Primary Reserve Requirement. If the Primary Reserve shortage condition was determined as described above, the applicable Reserve Penalty Factor is incorporated into the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price and Locational Marginal Price as applicable.

The purpose of the Voltage Reduction Warning is to warn PJM Members that the available Synchronized Reserve may be less than the Minimum Synchronized Reserve Requirement and that a voltage reduction may be required. Following the Voltage Reduction Warning, the Office of the Interconnection may issue a Voltage Reduction Action during which it directs PJM Members to initiate a voltage reduction. If the Office of the Interconnection issues a Voltage Reduction Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational

Marginal Price calculation, as applicable, until the Voltage Reduction Action has been terminated.

The purpose of the Manual Load Dump Warning is to warn members that dumping load may be necessary to maintain reliability. Following the Manual Load Dump Warning, the Office of the Interconnection may commence a Manual Load Dump Action during which it directs PJM Members to initiate a manual load dump pursuant to the procedures described in the PJM Manuals. If the Office of the Interconnection issues a Manual Load Dump Action for the Reserve Zone or Reserve Sub-Zone the Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement are incorporated in the calculation of the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price as applicable. The Reserve Penalty Factors for the Minimum 30-minute Reserve Requirement, the Minimum Primary Reserve Requirement and the Minimum Synchronized Reserve Requirement will continue to be used in the Synchronized Reserve Market Clearing Price, Non-Synchronized Reserve Market Clearing Price, Secondary Reserve Market Clearing Price, and Locational Marginal Price calculation, as applicable, until the Manual Load Dump Action has been terminated.

Shortage pricing will be terminated in a Reserve Zone or Reserve Sub-Zone when demand and reserve requirements can be fully satisfied with generation and Economic Load Response Participant resources and any Voltage Reduction Action and/or Manual Load Dump Action taken for that Reserve Zone or Reserve Sub-Zone has also been terminated.

Attachment C

Affidavit of Rebecca Carroll
on Behalf of PJM Interconnection, L.L.C.

PJM Interconnection, L.L.C.	)	Docket No. ER20-2573-000

AFFIDAVIT OF REBECCA CARROLL
ON BEHALF OF PJM INTERCONNECTION, L.L.C

1.   My name is Rebecca Carroll. My business address is 2750 Monroe Blvd., Audubon, Pennsylvania, 19403. I am Director, Dispatch, of PJM Interconnection, L.L.C. ("PJM"). I am submitting this affidavit on behalf of PJM to provide additional detail regarding the "short-term" dispatch and pricing alignment reforms that are the subject of this Federal Power Act ("FPA") Section 205 proceeding. In addition, in this affidavit I also provide factual background and detail regarding the intermediate-term and long-term reforms. While the intermediate-term and long-term reforms are not the subject of this specific FPA Section 205 filing, additional explanation is useful in better understanding the broader efforts to reform dispatch and pricing practices in PJM.

I.   QUALIFICATIONS

2.   I have worked for PJM since 1999 in both market and system operation roles. As Director, Dispatch, I am currently responsible for the oversight and operation of the Valley Forge and Milford Control Centers and PJM dispatchers. This function includes ensuring the reliable operation of the power grid, in accordance with all North American Electric Reliability Corporation ("NERC") mandatory reliability standards pertaining to several functions including Reliability Coordinator, Balancing Authority, and Transmission Operator. In addition, I am responsible for ensuring the efficient economic dispatch of the system under the existing PJM market rules and neighboring Joint Operating Agreements. Previously, as an engineer in the Market Operations Department, I supported the day-to-day activities required to clear PJM's energy and ancillary services markets and the design and implementation of the associated market rules and tools. I was later promoted to Manager of the Real-time Market Operations group where I oversaw the design and daily operation of the energy and ancillary services markets and congestion management processes.

3.   I hold a Bachelor of Science degree in Electrical Engineering from Widener University.

II.   DISPATCH AND PRICING ALIGNMENT (THE "SHORT-TERM REFORMS")

4.   As the Balancing Authority, PJM must operate such that the Control Performance Standard 1 ("CPS1"),[1] Reporting Area Control Error ("RACE"), and Balancing Authority ACE Limit ("BAAL") are all controlled and reported as required under NERC reliability standard BAL-001-2. PJM's markets are designed to provide financial incentives that reinforce reliable grid operations consistent with NERC reliability standards. The Real-time Energy Market achieves this goal by tightly coupling resource dispatch instructions to financial incentives in the form of real-time Locational Marginal Prices ("LMPs"). The real-time LMPs are calculated for every five-minute settlement interval and are based on actual system operating conditions, as described by the Real-Time Security Constrained Economic Dispatch ("RT SCED") dispatch solution.

A.   Real-time Security Constrained Economic Dispatch

5.   PJM's RT SCED tool is designed to co-optimize the energy and reserves for online resources to meet demand while respecting transmission constraints. The tool determines the associated resource basepoints for a ten-minute look-ahead period. An RT SCED solution is executed automatically, or manually by the PJM dispatcher on an ad hoc basis. To calculate the solution, data from multiple sources is utilized, including, but not limited to, resource capability and ramp rate, resource offers, forecasted load, scheduled and current interchange, as well as various other input parameters. The RT SCED solution uses a snapshot of all on-line resources and determines the future desired output for the look-ahead period based on the forecasted load and interchange to achieve a dispatch solution that will adequately control for the forecasted conditions. The approved RT SCED solution then becomes the basis for the price signals calculated by the Locational Pricing Calculator ("LPC").

B.   Locational Pricing Calculator

6.   LPC's function is to calculate the Real-time LMP values and Ancillary Service clearing prices on a five-minute interval. LPC calculates LMPs at all injections, withdrawals, EHV locations (nominal voltage of 500 KV and above), interfaces, and various aggregations. LPC utilizes input data from the approved RT SCED solution used to dispatch the system when the LPC case was executed, regardless of the look-ahead period of the RT SCED solution.

C.   Dispatch and Market Settlement Interval Alignment

7.   The lack of consideration for the look-ahead period of the RT SCED solution in the LPC execution creates a disconnect between the dispatch instruction interval and the market settlement interval where the LMPs are applied. This misalignment may weaken the financial incentives created by PJM's Real-time Energy Market for resources to follow their dispatch instructions. Altering LPC to use the approved RT SCED case for the same

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target time, as proposed in this proceeding, will align dispatch and pricing intervals, and ensure the prices reflect the costs of marginal resources and dispatch instructions.

III. RT SCED CASE EXECUTION FREQUENCY (THE "INTERMEDIATE-TERM REFORMS")

8. As mentioned above, an RT SCED solution is executed automatically or manually by the PJM dispatcher, whereas LPC is executed automatically every five minutes. When the RT SCED auto-execution is set at something other than five minutes, only a subset of the approved RT SCED cases will be used by LPC to calculate LMPs and subsequently used downstream in settlements. Generally, PJM dispatchers approve more than one RT SCED case per five-minute interval. One contributing factor is that the auto-execution time has historically been set at *less than* five minutes. However, on June 22, 2020, PJM changed the auto-execution of RT SCED cases to five minutes.[2] By changing the auto-execution time to five minutes, the dispatch instructions become more tightly coupled with the LMPs calculated, thereby ensuring that more RT SCED cases will be priced by LPC and used in settlements.

9. Table 1 below summarizes the percentage of approved RT SCED cases priced by LPC and used in settlements for the first seven months of 2020. During the first six months of the year when the auto-execution in RT SCED was set at a value *less than* five minutes, an average of 76% of the RT SCED cases were priced by LPC. However, once the auto-execution time was changed to five minutes, an average of 90% of the RT SCED cases were priced by LPC.

Table 1

MONTH	Approved SCED Cases	SCED Cases Priced by LPC	% of Approved Cases Priced
January	11860	7716	65%
February	10149	7125	70%
March	9914	7882	80%
April	8888	7238	81%
May	9416	7698	82%
June 1-22	6829	5659	83%
TOTAL 1/1-6/22	57056	43318	76%

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[2] RT SCED auto-execution was changed from three minutes to four minutes on February 24, 2020. Following a trial run of auto-execute at five minutes from May 21 to May 23, 2020, the auto-execution was permanently changed to five minutes on June 22, 2020.

Day	Approved SCED Cases	SCED Cases Priced by LPC	% of Approved Cases Priced
23-Jun	287	260	91%
24-Jun	282	265	94%
25-Jun	290	269	93%
26-Jun	312	263	84%
27-Jun	315	257	82%
28-Jun	287	262	91%
29-Jun	284	257	90%
WEEK 6/23-6/29	2057	1833	89%
30-Jun	279	260	93%
1-Jul	271	253	93%
2-Jul	284	269	95%
3-Jul	298	271	91%
4-Jul	291	266	91%
5-Jul	288	268	93%
6-Jul	296	259	88%
WEEK 6/30-7/6	2007	1846	92%
7-Jul	319	257	81%
8-Jul	276	254	92%
9-Jul	275	249	91%
10-Jul	299	261	87%
11-Jul	289	270	93%
12-Jul	295	267	91%
13-Jul	309	267	86%
WEEK 7/7-7/13	2062	1825	89%
TOTAL 6/23-7/13	6126	5504	90%

10.   In order to comply with BAL-001-2, it will continue to be necessary for PJM dispatchers to be able to deviate from a five-minute RT SCED execution and approval when the auto-executed RT SCED case does not accurately reflect the dynamically changing system conditions. System volatility caused by unexpected events (internal or external to PJM) requires dispatchers to have the ability and flexibility to deviate from a mandated case execution and approval frequency. Unforeseen weather patterns that can affect system load, deviations in units following their dispatch basepoint, and constraint volatility, are just some of the constantly changing variables that may create the need to re-dispatch. In these situations, PJM dispatchers may need to refresh the RT SCED case inputs and manually execute and approve RT SCED cases to obtain a solution that more closely aligns with system conditions to ensure reliability of the Bulk-Power System. When system conditions allow, PJM dispatchers will minimize this deviation and allow RT SCED cases to be auto-executed on a five-minute basis.

IV.   EVALUATION OF "LONG-TERM" REFORMS

11.   In addition to the dispatch and pricing alignment changes mentioned above, discussions at the special sessions of the PJM Market Implementation Committee on five-minute dispatch and pricing considered altering the case approval process and resource ramping methodology in RT SCED—referred to as the "long-term" reforms. These changes are complex and require additional analysis to better understand what potential benefits and/or disadvantages they introduce.

12.   PJM has utilized a security constrained economic dispatch algorithm as the basis for the Real-time Energy Market to reliably operate the system for over two decades. When modifications to the algorithm are introduced, they go through significant vetting so both PJM and stakeholders understand the potential impacts to system control as well as the market impacts. Prior to implementing any change to real-time operating tools, PJM dispatchers are fully trained in a simulator environment. This allows dispatchers to understand the impacts to their day-to-day job functions and obtain operating experience in the simulator.   When possible, PJM may also operate a parallel beta version of the RT SCED application with the software modifications for a period of time to gain a better understanding of both the reliability and market impacts of the changes. This analysis is key to determining whether a change is beneficial and what its impact will be to market participants. This level of vetting cannot be done until software changes have been developed, and therefore it has not been conducted thus far with respect to the proposed RT SCED auto-approval process and resource ramping reforms that comprise the long-term reforms.

A.   Real-time Security Constrained Economic Dispatch Case Auto-Approval

13.   PJM dispatchers consider several data points when approving new dispatch instructions, including how well resources are following their dispatch instructions, how closely load is tracking to the forecast, and transmission constraint control. These variables change dynamically and PJM is obligated to respond accordingly and re-dispatch when necessary.

14.   As stated in NERC reliability standard BAL-002-3, PJM must be able to respond to the loss of the largest single contingency in the PJM system. This recovery must take place within fifteen minutes. If an unplanned generation loss occurs, PJM dispatchers need to retain the ability to re-dispatch energy and reserves by executing and approving new RT SCED solutions whenever necessary to ensure compliance with this reliability standard.

15.   PJM represents approximately one-third of the overall load in the Eastern Interconnection. As such, NERC reliability standard BAL-003-1.1 requires PJM to maintain a frequency bias factor of 1,382.2MW/0.1Hz. This high bias can significantly affect our Area Control Error ("ACE") during frequency excursions due to events external to the PJM Balancing Authority such as external unit losses, load losses, transmission equipment failures, or requests for shared reserves to provide recovery assistance to the external area. These types

of unforeseen events require immediate response and immediate updated dispatch instructions from RT SCED to help restore the frequency in the Eastern Interconnection.

16.   PJM may also need to re-dispatch and approve a new RT SCED solution to prevent or manage potential or actual System Operating Limit ("SOL") and Interconnection Reliability Operating Limit ("IROL") violations in order to maintain reliability. As a sink Balancing Authority, NERC reliability standards IRO-006-5 and IRO-006-EAST-2 oblige PJM to curtail contracts or respond to generation relief requests, sometimes on very short notice. Additionally, PJM's Joint Operating Agreements ("JOA") with MISO and NYSIO require PJM to re-dispatch for coordinated flowgates. Delaying these actions based on a strict RT SCED case approval timeline would not be appropriate as any delay could further degrade system conditions.

17.   Requiring PJM dispatchers to automatically approve an RT SCED case every five minutes without any flexibility could have negative operational consequences. In 2016, a Balancing Authority experienced market application failures[3] that issued invalid dispatch instructions to market participants. Dispatchers were unable to manually override the automated dispatch instructions to regain control of the system. The result was a large negative ACE of -3227 MW and a system frequency of 59.83 Hz. This event teaches us two things: (a) the higher the level of automation, the greater the risk for loss of situational awareness by dispatchers; and (b) a well-designed software system should allow a dispatcher to manually intervene when something goes wrong. For these reasons, PJM dispatchers need to retain the ability to approve RT SCED cases when necessary, while continuing to strive toward the objective of approving cases every five minutes if system conditions allow.

B.   *Resource Ramping Methodology*

18.   RT SCED initiates with a snapshot of the real-time system using the PJM Energy Management System ("EMS") State Estimator case. This case includes the real-time load, generation, system topology, and interchange. Based on the load forecast, RT SCED will re-dispatch resources using their submitted parameters to meet the forecasted demand. The state estimator generation MW is used as the initial or starting point MW in the RT SCED optimization because it represents where the generator is actually operating.

19.   Utilizing the previous RT SCED dispatch basepoint as the initial MW instead of the State Estimator MW assumes generators operate exactly as their bid-in parameters indicate. However, while this is a valid assumption, it is not necessarily a precise assumption. Generators are physical machines that cannot and typically do not operate perfectly to their submitted parameters. Generators experience operating realities that require them to deviate from these parameters such as mill points, loading duct firing, feed water pump

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[3] *See* NERC Lesson Learned - Dispatch Reduction in Generation Output Causes Frequency Deviation, available here:
https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20170401_Dispatched_Reduction_in_Generation_Output_Causes_Frequency_Deviation.pdf

issues, increased river water temperatures, ambient air temperatures, or ice on wind turbine blades. More examination is needed to determine when or if the previous RT SCED dispatch basepoint is accurate enough to be utilized as the initial MW in the RT SCED solution. Implementing this foundational change to the RT SCED optimization could create issues with PJM meeting the operating and reporting requirements in NERC reliability standard BAL-001-2. BAL-001-2 is designed to control the interconnection frequency within defined limits, establishes performance criteria for the PJM Balancing Authority to evaluate the area's frequency control, and is a function of ACE and how well generators are following PJM's dispatch signals. PJM could have challenges with generators adhering precisely to their control signals, which could lead to violations of R1 and R2 of BAL-001-2 by PJM not meeting CPS1 and BAAL. Generators do not follow their control signal precisely and system operators need to have the ability to take actions to maintain the ACE and system frequency to respond to volatility and unplanned events. By using State Estimator MW, RT SCED is dispatching units based off of where they are presently operating, not where they are anticipated to be.

20.   This concludes my affidavit.[4]

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[4] Pursuant to the Federal Energy Regulatory Commission's May 8, 2020 Supplemental Notice Waiving Regulations in Docket No. AD20-11-000 (the "May 8, 2020 Notice"), PJM has omitted a notarized verification with this Affidavit. *See* May 8, 2020 Notice at 1 ("Given the ongoing emergency conditions caused by COVID-19, there is good cause to waive through September 1, 2020, the Commission's regulations that require that filings with the Commission be notarized or supported by sworn declarations.").