UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

PROTEST OF THE INDEPENDENT MARKET MONITOR FOR PJM

Pursuant to Rule 211 of the Commission's Rules and Regulations,[1] Monitoring Analytics, LLC, acting in its capacity as the Independent Market Monitor ("Market Monitor") for PJM Interconnection, L.L.C. ("PJM"),[2] submits these comments responding to the filing submitted by PJM on July 31, 2020 ("July 31st Filing") in response to the Commission's January 23, 2020, order in Docket No. ER19-2722 holding PJM's fast start compliance filing in abeyance ("Abeyance Order").[3] The July 31st Filing does not resolve the misalignment issues with dispatch and settlements in PJM's Real-Time Energy Market, and fast start pricing will not result in the intended market outcomes under the changes proposed by the July 31st Filing. The July 31st Filing should be rejected. The Abeyance Order in Docket No. ER19-2722 should remain effective unless and until PJM submits a filing that resolves the identified misalignment issues.[4]

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1 18 CFR § 385.211 (2019).

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

3 PJM Filing, Docket No. ER20-2573 (July 31, 2020) ("July 31st Filing").

4 On July 21, 2020, the Market Monitor submitted a Motion for Extension of Abeyance in Docket No. ER19-2722-000 (and in this Docket No. ER20-2573), in order to facilitate the coordinated resolution of the closely related issues raised in these dockets.

The July 31st Filing does not meet the standards in the Abeyance Order. The Abeyance Order (at P 31) states:

> 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. Moreover, implementing fast-start pricing as directed in the Order on Paper Hearing could exacerbate the pricing and dispatch misalignment issue because the lost opportunity cost payments directed in the Order on Paper Hearing may be calculated based on inaccurate prices and therefore, may not correctly compensate opportunity costs. In addition, implementing fast-start pricing could cause lost opportunity cost payments to be ineffective because they may not provide correct incentives to follow dispatch.

Contrary to the directive in the Abeyance Order, the July 31st Filing does not resolve the pricing and dispatch misalignment problem. Under the July 31st Filing, prices will not reflect the marginal cost of serving load. Under the July 31st Filing, lost opportunity costs will be incorrectly compensated.

The July 31st Filing proposes revisions ("short term proposal") to the PJM market rules claims to provide "greater accuracy in the pricing and dispatch of resources in PJM's footprint" and to contribute to better price formation consistent with Commission's policy objectives, citing Order No. 825.[5] The short term proposal changes real-time energy market pricing. It includes select aspects of a comprehensive plan developed by PJM and the Market Monitor to align five minute dispatch and pricing in the real-time energy market, but the short term proposal does not stand on its own.[6] [7] The intermediate and long term

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[5] July 31st Filing at 1–2, citing *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").

[6] *See* PJM "Status Update 5 Minute Dispatch and Pricing," presented at the March 31, 2020 special session of the Markets Implementation Committee, which can be accessed at <https://www.pjm.com/-

changes are required. On its own, the short term proposal creates new problems in the misalignment of five minute dispatch and pricing. Changes to the dispatch process (identified by PJM as long term changes) must be implemented along with the short and intermediate term changes to correct compensation and incentives in the five minute energy market.

The July 31st Filing is inconsistent with the intent of Commission Order No. 825 because it creates a price signal that does not correspond to the effective dispatch signal during the five minute real-time market interval to which the prices apply for settlements. Under the short term proposal, PJM would settle each five minute interval using prices based on the dispatch instructions that were effective for the preceding five minute interval, which are no longer effective during the interval being priced and settled. In other words, prices and settlements would lag dispatch instructions by approximately five minutes. The outcome is inefficient and inconsistent with the competitive market goal of pricing to compensate resources for following dispatch. The outcome is not just and reasonable. The July 31st Filing should be rejected.

The status quo is not correct either. PJM currently applies prices based on the latest dispatch signal, but it uses a 10 minute ramp time to solve for prices and dispatch so that resources do not have time to achieve the target dispatch. The status quo also settles reserves and five minute uplift payments using MW and prices from mismatched dispatch solutions. To correct the misaligned dispatch and pricing, PJM must reduce the real-time security constrained economic dispatch software ("RT SCED") ramp time from ten minutes to five minutes to achieve an actual five minute dispatch that matches the five minute pricing and settlements. The comprehensive solution proposed by the Market Monitor,

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/media/committees-groups/committees/mic/2020/20200331-special-five/20200331-item-03-timeline.ashx>. PJM later withdrew their support for the comprehensive plan.

7 *See* PJM, "PJM/IMM Joint Package Highlights," presented at the March 31, 2020 special session of the Markets Implementation Committee, which can be accessed at <*https://www.pjm.com/-/media/committees-groups/committees/mic/2020/20200331-special-five/20200331-item-04a-pjm-imm-joint-package-highlights.ashx*>.

including the reduced ramp time, along with the short term changes proposed in the July 31st Filing, will create a true five minute market, as required by Order No. 825.

It is essential that PJM have a true five minute market where dispatch instructions, price signals and settlements are aligned in order to ensure that proposed price formation reforms such as fast start pricing and reserve market reforms work as intended.[8] It does not make sense for PJM to hastily implement a partial solution that creates new dispatch and pricing issues for the sake of an earlier, but incorrect, fast start pricing implementation. It is not reasonable to impose the considerable costs on customers associated with the fast start pricing and reserve market reforms until there is a comprehensive solution to the misalignment of dispatch and pricing. Failure to do so will impose additional and unnecessary costs on customers in addition to the uncertainty of unintended consequences.

I. BACKGROUND

A. Dispatch, Pricing and Settlement Timeline and Terminology

In order to fully understand the characteristics and flaws of the status quo and of PJM's short term proposal, it is necessary to define the terms used by PJM and the Market Monitor and to understand the timeline of RT SCED, the real-time pricing software ("LPC") and settlements.

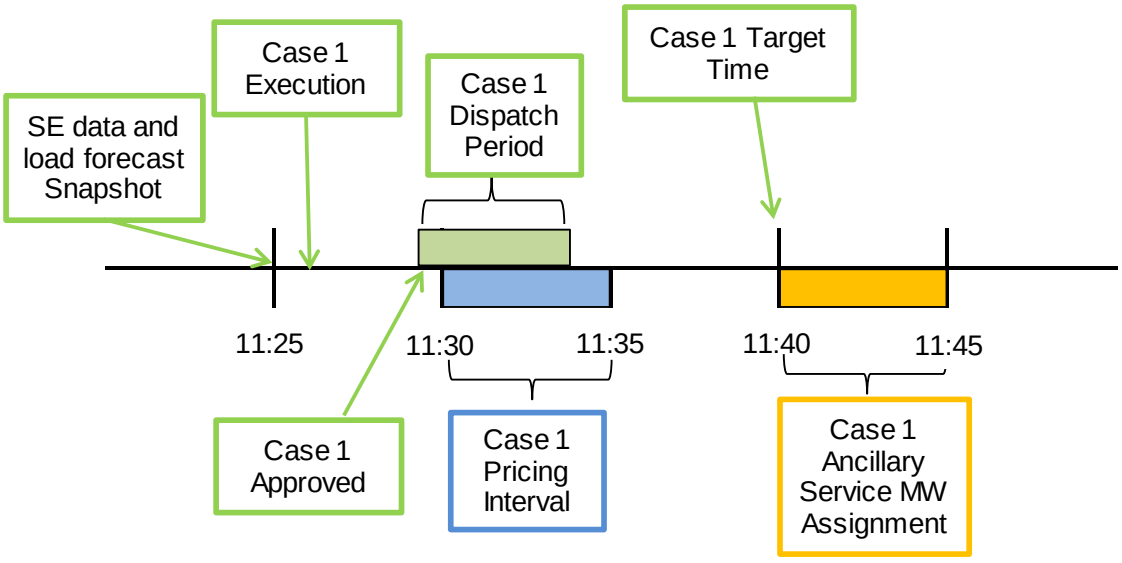
RT SCED is the security constrained economic dispatch tool that runs in real time. RT SCED dispatches online resources to meet demand (energy and reserve requirements) subject to generator and transmission constraints. Beginning June 22, 2020, RT SCED executes (begins to solve) at an automated frequency of one case every five minutes. From February 24, 2020 through June 22, 2020, RT SCED executed at an automated frequency of one case every four minutes. Prior to February 24, 2020, RT SCED executed at an automated frequency of one case every three minutes. PJM dispatchers also execute additional RT SCED cases in between the automatically executed cases. The time when each case begins to

[8] *See* Docket Nos. ER19-2722, ER19-1486.

solve is called the case's execution time. RT SCED cases generally produce solutions in less than two minutes after execution.

The demand used in RT SCED cases is a forecast of load by PJM zone for each five minute mark of the hour (e.g., 11:00, 11:05, 11:10, 11:15 and so on). Load is forecast prior to RT SCED execution. The load that is forecasted is an instantaneous MW value for the forecast time, and not the energy (MWh) consumed over the five minute period. These five minute marks are known as target times. When an RT SCED case begins to solve, the target time it solves for is at least 10 minutes after the execution time. Currently, the target time is 14 minutes after the execution time for an automatically executed case.[9] Figure 1 shows the timeline of an RT SCED case, Case 1. In this example, Case 1 is executed at 11:26 and solves for optimal dispatch to meet load forecast for 11:40, the target time. PJM's load forecast model produces a forecast every five minutes, so the forecast used in Case 1 is the forecast for 11:40 that was calculated at 11:25.

Figure 1 Status quo timeline of dispatch, pricing and settlement



RT SCED also uses state estimator (SE) data from the Energy Management System (EMS), which is captured prior to execution, as one of the inputs which provides a snapshot

[9] When PJM operators manually execute an RT SCED case, the target time may differ from 14 minutes.

of the state of the PJM system, including resource MW and flows on transmission facilities. In the example shown in Figure 1, Case 1 uses an SE snapshot captured at 11:25 as an input.

The time over which resources are ramped in RT SCED from their initial MW in the SE data, is called the ramp time. The ramp time in RT SCED is currently fixed at 10 minutes. When Case 1 executes, it is solving for the incremental load fifteen minutes in the future (load at 11:40 that was forecast at 11:25), while the modeled ramp time for resources in RT SCED to achieve optimal dispatch to meet this incremental load is 10 minutes.

Each RT SCED case solves three scenarios with different levels of load, and produces three solutions.[10] PJM operators manually select and approve an RT SCED solution from among all the available solutions, and when a solution is approved, PJM sends dispatch signals to resources. PJM operators approve RT SCED solutions (and consequently send dispatch signals) at a varying frequency. In the example, one of the solutions from Case 1 is approved at 11:29, which immediately sends dispatch signals to resources. There is no time target communicated to resources associated with the dispatch signal. Each dispatch signal stands as the target MW for resources to reach until PJM sends another dispatch signal that provides a new target. PJM usually provides a new signal with a revised target by approving a new solution in less than five minutes after a prior signal. PJM rarely allows resources to ramp for the full 10 minutes that is the basis of the optimal dispatch solution in RT SCED. This is an important inconsistency because the marginal unit determination (and the associated marginal cost used to calculate LMPs and reserve market clearing prices (MCPs)) is made using a 10 minute ramp to meet the load forecast for the target time. This means that prices are, at times, determined by points on resource offer curves that are not achievable within the dispatch period.

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[10] PJM operators use an input called the load bias, which adjusts the total RTO load forecast used in RT SCED. Each RT SCED case solves with three different levels of load bias, resulting in three different levels of demand, and consequently three different levels of supply to meet the demand, for the target time.

The locational pricing calculator (LPC) is a linear optimization program identical to the RT SCED model. LPC uses an approved RT SCED case as a reference case, and calculates LMPs and reserve market clearing prices (MCPs) for a target time, but applies these prices to five minute time periods called pricing intervals. LPC currently executes at a fixed 5 minute frequency, 90 seconds into each five minute pricing interval, and uses the latest approved RT SCED case available as a reference case, regardless of its target time. In the scenario shown in Figure 1, LPC executes at 11:31:30 (90 seconds into the 11:30 – 11:35 pricing interval), and uses the Case 1 solution approved at 11:29 as the reference case, since it is the latest available approved RT SCED case.[11] [12] LPC solves and prices are published at approximately 11:33, three minutes into the pricing interval. These prices are used to pay for (settle) energy generated in the 11:30 – 11:35 pricing interval. These prices result from the Case 1 solution that calculates resource dispatch MW, using a 10 minute ramp time, to meet load at 11:40. However, resources are settled using these prices for the energy generated between 11:30 and 11:35. While LPC uses the Case 1 solution with a 10 minute ramp time to calculate the marginal cost associated with the target dispatch to calculate LMPs and reserve MCPs, resources are not given the opportunity of a full 10 minutes to attain the target because the dispatch signal is overwritten by a new approved RT SCED dispatch solution in less than five minutes.

Resources are settled for energy based on the metered actual MWh (or estimated interpolated MWh) during the 11:30 to 11:35 interval using the LMPs assigned to the same

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[11] If another RT SCED solution were approved, at 11:30, this new solution is used by LPC. PJM dispatchers approve RT SCED cases with variable frequency, as needed. Some of the approved RT SCED cases used to dispatch resources are not used in LPC to calculate prices because they are overwritten by a new solution prior to the LPC execution.

[12] Although PJM uses the word "reference case", which seems to suggest that RT SCED solution is used as a starting point to obtain a new LPC solution, in practice, RT SCED and LPC are identical in terms of the optimization formulation. RT SCED and LPC produce identical prices and resource dispatch MW when same inputs are used. LPC calculates prices for the entire set of pricing nodes in PJM, and PJM can recalculate prices by resolving LPC with updated inputs if errors are identified.

interval, regardless of which dispatch instructions they were following during that interval.[13]

PJM's current ancillary services settlement is even further disconnected from the energy settlement. The ancillary service cleared MW from the approved Case 1 solution that solved for target time 11:40 are assigned to the 11:40 to 11:45 settlement interval. At 11:40, it is likely that the dispatch instructions have been overwritten with multiple new approved RT SCED solutions, and the units that cleared ancillary services in the approved Case 1 solution are not capable of providing the ancillary service MW that they are being settled for. The reserve MCPs used to compensate the reserve assignments from 11:40 to 11:45 will not be from Case 1 but from a different RT SCED case (the latest RT SCED case used by LPC during that pricing interval, usually based on the 11:50 target time).

Table 1 shows the definitions of the terms used, the status quo for each term and PJM's short term proposal for each term. The short term proposal was designed to align the pricing interval and the settlement interval only. PJM's intermediate term changes modified the automatic execution of RT SCED from three to five minutes. The long term changes would complete the alignment by reducing the ramp time to align the dispatch period with the pricing interval and settlement interval. Only the full set of changes will align dispatch and settlements at five minutes.

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[13] When the revenue meter data for generation is submitted to PJM as an hourly MWh value, PJM uses a scaling calculation to allocate the hourly MWh to each five minute settlement interval in the hour. PJM proposed this calculation as part of its compliance with Order 825. *See* PJM, "Order No. 825 Compliance Filing," Docket No. ER17-775 (January 11, 2017), *revised*, Docket No. ER17-775-003 (March 23, 2018).

Table 1 Definitions

Term	Definition	Status Quo	Short Term Proposal
Settlement Interval	Period of time for which metered energy is paid, cleared ancillary services are paid, and five minute uplift payments are determined.	Duration: Five minutes. Five minute period that starts at the RT SCED target time is used for reserves and uplift MW.	Duration: Five minutes. Five minute period that ends at the RT SCED target time to be used for reserves and uplift MW.
Pricing Interval	Period of time to which prices are applied.	Duration: Five minutes. Price Assignment: Five minute period when LPC was executed. Regardless of the RT SCED target time.	Duration: Five minutes. Price Assignment: Five minute period that ends at the RT SCED target time.
Dispatch Frequency	The frequency with which PJM operators send dispatch signals to resources.	Variable, based on operator discretion.	Variable, based on operator discretion.
Dispatch Period	Period of time during which the dispatch signal is effective.	Duration: Variable, based on operator discretion.	Duration: Variable, based on operator discretion.
Target Time	Instant of time for which RT SCED solves the security constraint economic dispatch problem.	Between 10 to 14 minutes into the future.	Between 10 to 14 minutes into the future.
Ramp Time	Amount of time used by RT SCED to ramp resources.	Ten minutes.	Ten minutes.

In the example shown in Figure 1, under status quo, the RT SCED target time is 11:40, the ancillary services MW from RT SCED are assigned to the 11:40 to 11:45 settlement interval, but the LMPs and ancillary service MCPs are assigned to the 11:30 to 11:35 pricing interval. These LMPs are used to pay resources for the energy actually produced during the 11:30 to 11:35 settlement interval. The dispatch period, when the instructions are effective, begins 11:29, when the solution was approved, until a new solution is approved, generally within less than five minutes. The ancillary service MW that cleared for the interval from 11:40 to 11:45 (based on the RT SCED with target time of 11:40) are settled at MCPs that are based on a different approved RT SCED case that is approved prior to 11:41:30, when LPC calculates prices for the 11:40 to 11:45 interval.

B. PJM's Short Term Proposal

The July 31st filing includes two main changes. First, PJM proposes to change the LMPs and ancillary services clearing price assignments that are based on the Case 1 solution from 11:30 to 11:35 pricing interval under status quo, to the 11:35 to 11:40 pricing interval. In other words, the RT SCED target time (11:40), and the LPC pricing interval end time (11:40) will match, as long as an approved RT SCED solution exists for each five minute target time.[14] PJM also proposes to change the ancillary services MW assignment

[14] If there is no approved RT SCED solution for a target time, the last approved RT SCED solution will be used in LPC. Under this scenario, the RT SCED target time and the LPC pricing interval end time will not match.

from the 11:40 to 11:45 interval under status quo, to the 11:35 to 11:40 settlement interval. Second, PJM proposes to use generator hourly offers, and hourly inflexible reserve assignments from the Ancillary Service Optimizer (ASO) that are effective for the hour with the RT SCED target time.[15] For example, currently, an RT SCED case with a target time of 12:00 uses the generator offers and ASO assignments for the hour from 12:00 to 13:00. Under the proposed short term changes, the RT SCED case with target time of 12:00 will use the offers and ASO assignments for the hour from 11:00 to 12:00, and the RT SCED case with target time of 12:05 will use the hourly offers and ASO assignments for the hour from 12:00 to 13:00. This ensures that RT SCED dispatches resources during an hour consistent with the generator offers that are applicable for the hour. PJM did not submit tariff updates for this second set of changes. PJM should be required to submit corresponding tariff modifications.

PJM also began implementing certain changes to the execution frequency for RT SCED. These changes were referred to as the intermediate term changes in the stakeholder process. On February 24, 2020, PJM updated the automatic execution frequency of RT SCED from once every three minutes to once every four minutes, with dispatchers having the ability to execute additional cases at any time. PJM changed the RT SCED execution frequency to once every five minutes on July 22, 2020, with the goal of approving one RT SCED solution every five minutes.[16] But PJM provided no timeline to modify approval frequency. Figure 2 and Figure 3 show the sequence of dispatch, pricing and settlement under PJM's short term proposal, assuming the intermediate term changes have also been implemented. The short term proposal will result in energy produced during the 11:35 to 11:40 settlement interval being paid the LMPs associated with the Case 1 solution that solved for the 11:40 target time, while resources are expected to follow the signal from Case 2 solution that solved for the 11:45 target time. This creates a systematic inconsistency

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15 July 31st Filing at 5.

16 *See* "PJM Package Highlights: 5 Minute Dispatch and Pricing," presented at the PJM Members Committee (July 23, 2020) at 6.

between the dispatch instructions effective during any five minute period, and the LMPs and MCPs used to settle for energy and reserves during that five minute period.

Figure 2 PJM short term proposal, step 1

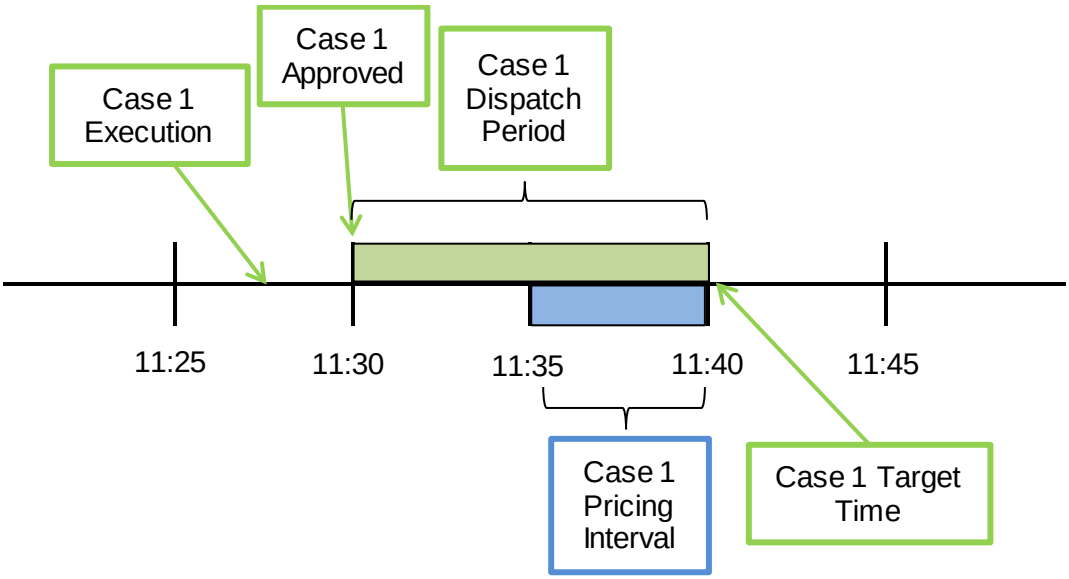
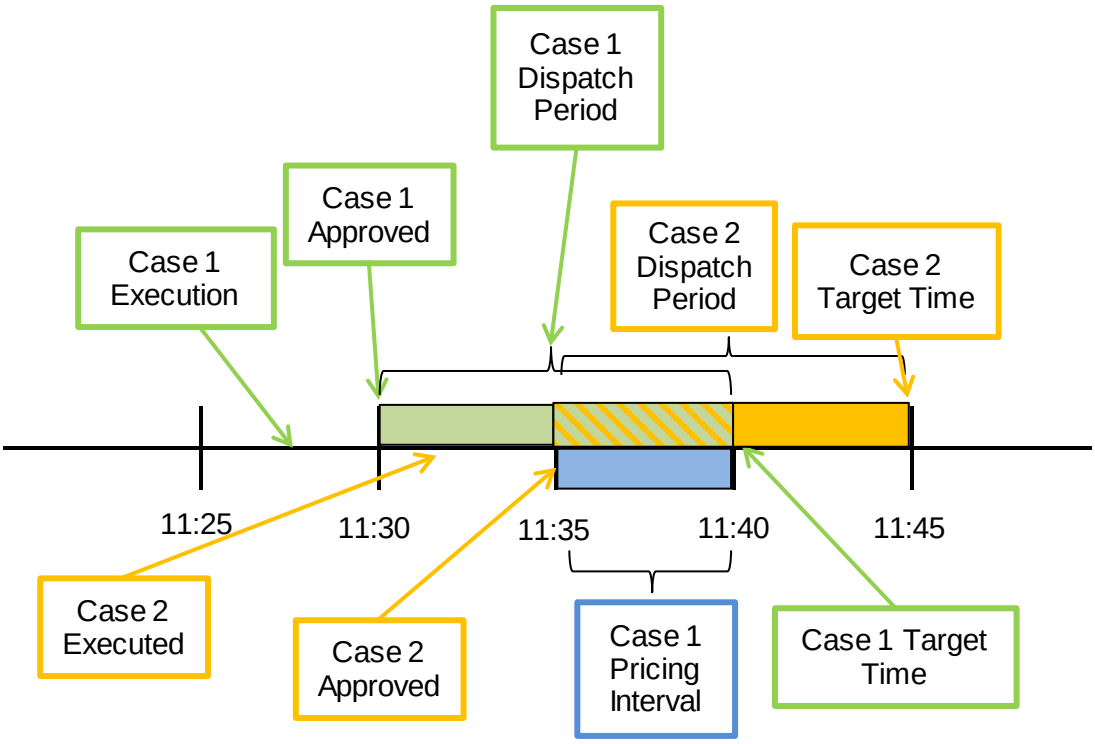


Figure 3 PJM short term proposal, step 2



C. The Market Monitor's Proposal

During the stakeholder process, the Market Monitor proposed its changes that involve a comprehensive set of updates to the RT SCED model, RT SCED execution, solution approval and use of the approved solution in LPC. This includes PJM's short term proposal, the intermediate term changes and changes to the RT SCED model with the goal of a true five minute market.

As shown in Table 2, under the Market Monitor's proposal, the ramp time in RT SCED is reduced to five minutes from the current 10 minutes to match with the five minute pricing and settlement intervals. This will also result in RT SCED solving for a target time that is closer to the time of execution and using a more up to date load forecast from ten minutes prior to the target time.

Table 2 Definitions Under Market Monitor's Proposal

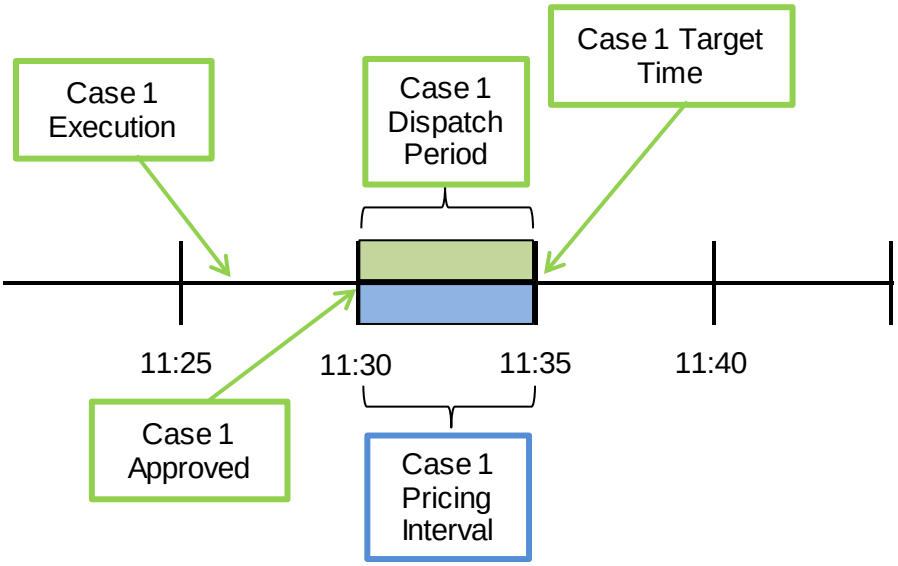
Term	Definition	Status Quo	Market Monitor Proposal
Settlement Interval	Period of time for which metered energy is paid, cleared ancillary services are paid, and five minute uplift payments are determined.	Duration: Five minutes. Five minute period that starts at the RT SCED target time is used for reserves and uplift MW.	Duration: Five minutes. Five minute period that ends at the RT SCED target time to be used for reserves and uplift MW.
Pricing Interval	Period of time to which prices are applied.	Duration: Five minutes. Price Assignment: Five minute period when LPC was executed. Regardless of the RT SCED target time.	Duration: Five minutes. Price Assignment: Five minute period that ends at the RT SCED target time.
Dispatch Frequency	The frequency with which PJM operators send dispatch signals to resources.	Variable, based on operator discretion.	Routinely every five minutes with exceptions for relaibility issues.
Dispatch Period	Period of time during which the dispatch signal is effective.	Duration: Variable, based on operator discretion.	Five minute period that ends at the RT SCED target time.
Target Time	Instant of time for which RT SCED solves the security constraint economic dispatch problem.	Between 10 to 14 minutes into the future.	Between 8 to 10 minutes into the future.
Ramp Time	Amount of time used by RT SCED to ramp resources.	Ten minutes.	Five minutes.

In order to account for the change in system conditions during the time it takes to solve RT SCED, to review the solutions and approve a solution, the Market Monitor also proposed to use the previous approved RT SCED solution as a starting point for each RT SCED case. This includes using the previous dispatch target MW as the initial resource MW from which resources will be ramped. This will improve the accuracy of the initial resource status compared to the current practice of using the state estimator ("SE") MW because it is likely that units have moved on during the three to five minutes it takes from the time when the SE snapshot was captured to the time when a solution is approved. This time includes the time to solve an RT SCED case, to review the solutions, and select a solution to approve by PJM operators. Instead of using stale SE MW as the initial resource MW, the Market Monitor proposed using an estimated resource initial MW that takes the previous

dispatch target for each resource, and adjusts it for resources that are not following dispatch. This adjustment aims to capture a more accurate initial MW for resources that are determined to not be following dispatch using a calculated metric. This proposed change to the initial resource MW is consistent with the method used by Midcontinent ISO (MISO) as described in MISO's business practice manuals.[17]

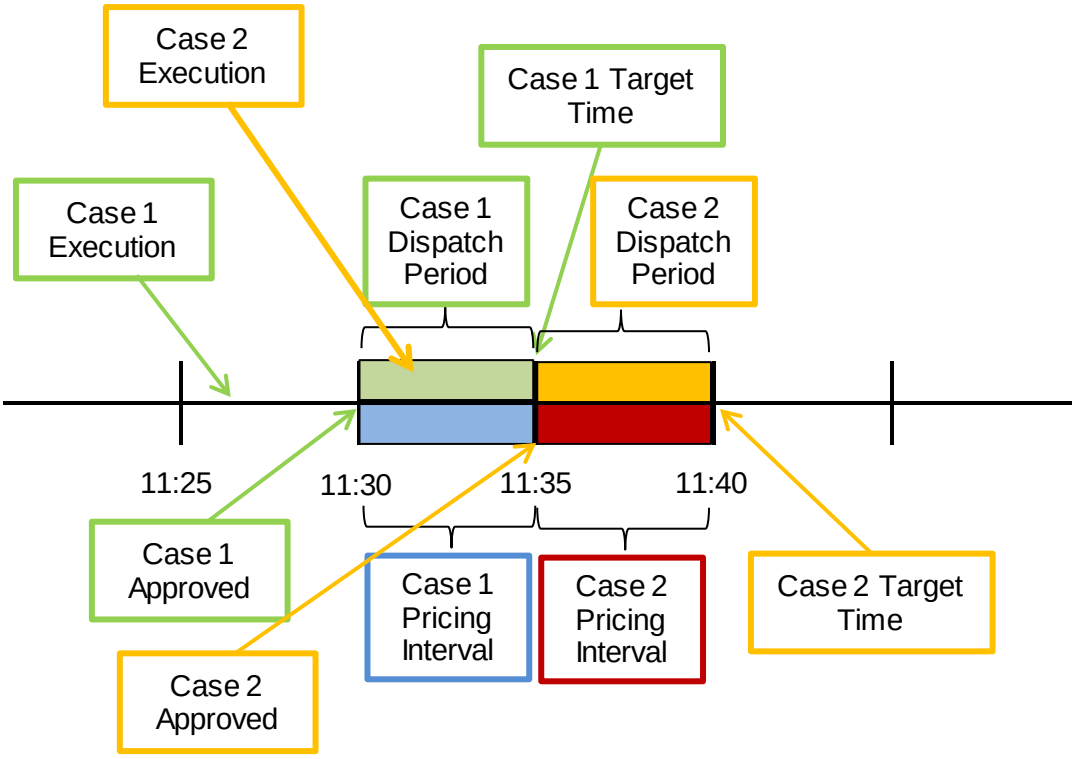
The Market Monitor also proposed to have at least one, but only one RT SCED solution approved for each five minute target time, to be approved five minutes prior to the target time, with exceptions for operators to deviate from this for reliability reasons. The five minute approval frequency and timing ensures that dispatch signals to resources match with the modeled dispatch solution in RT SCED. Figure 4 and Figure 5 illustrate the five minute dispatch and pricing process under the Market Monitor's proposal.

Figure 4 Market Monitor's Proposal, step 1



[17] *See* MISO, "Real-Time Energy and Operating Reserve Market Software Formulations and Business Logic," Attachment D to Energy and Operating Reserve Markets Business Practice Manual, Rev. 20, (September 23, 2019) at 3.7 Initial Energy Output.

Figure 5 Market Monitor's Proposal, step 2



Under the Market Monitor's proposal, the dispatch period for RT SCED, pricing interval in LPC and the settlement interval for energy and reserves are the same. LPC executes after an RT SCED case is approved, and calculates prices using the approved RT SCED solution that applies to the same five minute period as the dispatch period in the reference RT SCED solution. Using the example shown in Figure 4, the Case 1 RT SCED solution target time is 11:35, the ramp time is 5 minutes, the dispatch period, the pricing interval, the energy and ancillary service settlement intervals are all the same, from 11:30 to 11:35. The following RT SCED solution, from Case 2, as shown in Figure 5, is approved at or close to 11:35 for target time 11:40. The dispatch period, the pricing interval and the settlement interval for energy and reserves for Case 2 is from 11:35 to 11:40. This ensures that prices are consistent with the dispatch instructions for each five minute period, and ensures that resources are compensated accurately for the energy and reserves provided. These changes are necessary to correct market incentives and settlement accuracy for revenues based directly on LMPs and reserve MCPs, and for uplift calculations including lost opportunity cost and make whole payments.

II. COMMENTS

A. PJM's Dispatch Period and Settlement Intervals are Not Aligned and Will Continue to be Misaligned Under PJM's Short Term Proposal.

Order No. 825 states (at P 19) that alignment of settlement and dispatch intervals "should improve incentives for resources to respond quickly to dispatch instructions" and (at P 20) that "resources dispatched economically during high-priced periods would receive those higher prices." The goals of Order No. 825 are not achieved under the July 31st Filing. The July 31st Filing creates a systematic delay between the dispatch signal and pricing that undermines the incentive to follow dispatch.

When a single RT SCED case with shortage pricing is approved under the process proposed in the July 31st Filing, the dispatch instructions would reflect the shortage immediately, but resources would be paid for the shortage dispatch period based on a previous lower priced RT SCED case. Resources dispatched due to high marginal cost conditions would not receive the associated higher prices. The same mismatch occurs for any price fluctuations due to changes in load or transmission constraints, not just shortages.

1. Reliability and Pricing Disconnect

One of the goals of Order No. 825 is to support incentives to maintain reliability.[18] As a Balancing Authority, PJM must operate its system consistent with the NERC reliability standards. The July 31st Filing states that PJM achieves "this goal by tightly coupling resource dispatch instructions to financial incentives in the form of real-time Locational Marginal Prices."[19] The goal is stated correctly, but the end is not achieved. The dispatch instructions provided by PJM dispatchers are not routinely consistent with the settled prices simply because PJM does not use all approved RT SCED cases for pricing and

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[18] *See* Order No. 825 at PP 5–6.

[19] *See* July 31st Filing, Attachment C: Affidavit of Rebecca Carroll on Behalf of PJM Interconnection, L.L.C. ("Carroll Affidavit"), at 4.

because, under the July 31st Filing, the pricing interval would occur during a time when resources are receiving a different dispatch signal.

PJM states (at 9):

> 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.

The July 31st Filing's statements about the incentives to follow dispatch are inaccurate and misleading. The July 31st Filing does not describe the complete dispatch process. Since PJM uses a ten minute ramp time, LMPs are based on resources achieving the target in 10 minutes. But PJM's process of approving a new dispatch case every five minutes (in many instances less than 5 minutes) makes the LMP calculation inaccurate, because resources are sent a new dispatch signal five minutes into the 10 minute ramp time and expected to follow this new signal while they are compensated using LMPs based on the 10 minute ramp time. This mistake repeats with every dispatch signal under PJM's short term proposal, which, when dispatch signals change, makes every LMP calculation inaccurate and inconsistent with the dispatch signals that resources are asked to follow. A profit maximizing generator in the real-time energy market, capable of following price signals, will ignore PJM's dispatch instructions and simply follow the LMP, or follow PJM's dispatch instructions with a five minute delay, when the LMP from the dispatch instruction is used in settlements.

2. PJM's Dispatch Period and Settlement Interval Misalignment Hinders Flexibility.

Another goal of Order No. 825 is to reward resource flexibility.[20] Taking full advantage of the flexible resources in PJM's fleet requires an accurate dispatch signal. Sending overlapping signals is detrimental to flexible resources. The faster the resource, the worse it will be. Figure 6 shows a fast ramping combined cycle (CC) unit, capable of ramping 20 MW per minute, that is provided a dispatch signal from PJM to increase output by 20 MW from 500 MW to 520 MW. It takes the unit one minute to achieve that dispatch instruction. Five minutes later, PJM sends another signal that dispatches the unit back to 500 MW. The unit follows. During the first five minute interval, the unit produces 516 MW on average (one minute at 500 MW and four minutes at 520 MW). During the first interval, the LMP consistent with the current dispatch is $200, but the actual LMP is $20, consistent with a prior dispatch. During the second five minute interval, the unit produces 504 MW (one minute at 520 MW and four minutes at 500 MW). During the second interval, the LMP consistent with the current dispatch is $20, but the actual LMP is $200, consistent with the prior dispatch. Under the short term proposal, the unit will be paid the higher $200 per MWh LMP from the dispatch signal that instructed the unit to ramp up for the lower amount of energy (504 MW) it produced when it was ramping down. The unit will not be correctly compensated for the service provided. The price paid will be inconsistent with the dispatch. In contrast, a slower moving unit of the same size with a 4 MW per minute ramp rate will receive a greater payment. Both units reach the desired target at the five minute mark but the one that reaches the target faster receives less compensation. The slower unit will be paid more because its slower ramp meant that it produced fewer MWh compared to the fast ramping unit when the price was low and it was ramping up and more MWh compared to the fast ramping unit when the price was high and it was ramping down.

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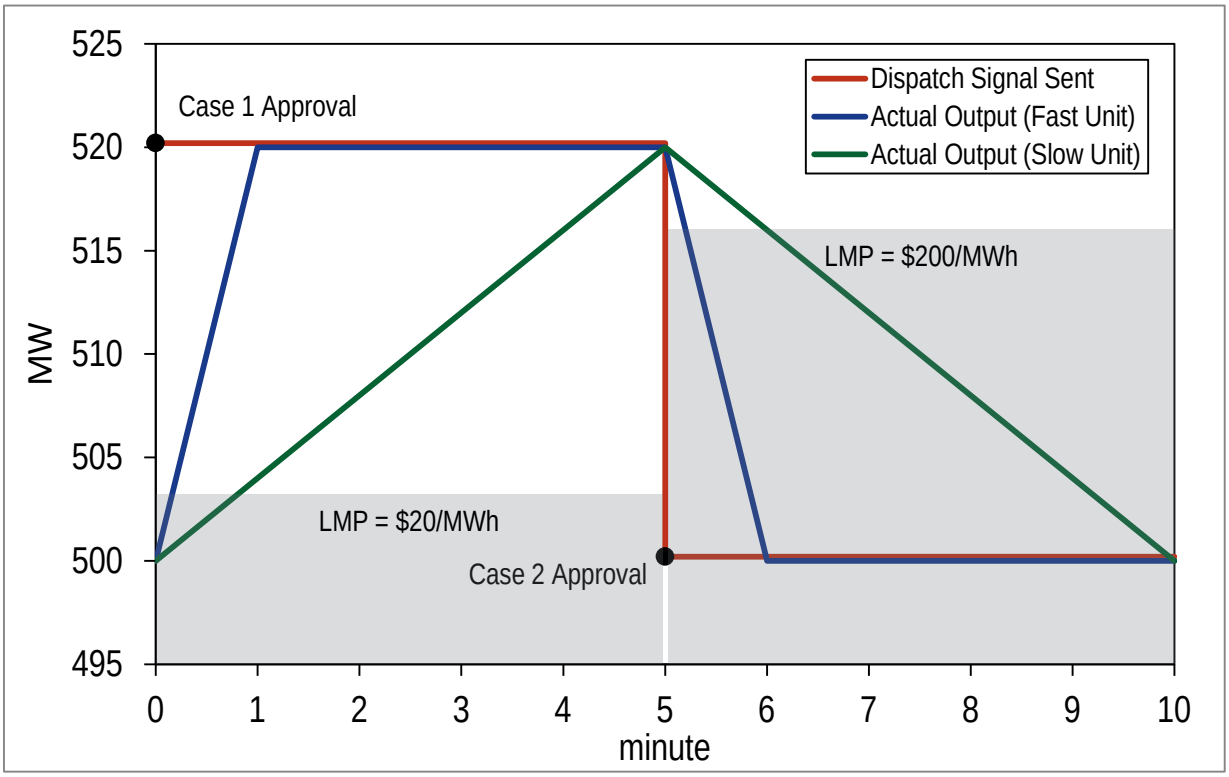
[20] *See* Order No. 825 at PP 6–7.

Figure 6 Overlapping signals impact on a flexible unit.



This example shows conventional resources. The inconsistency between dispatch and payment are more significant for more flexible resources including batteries.

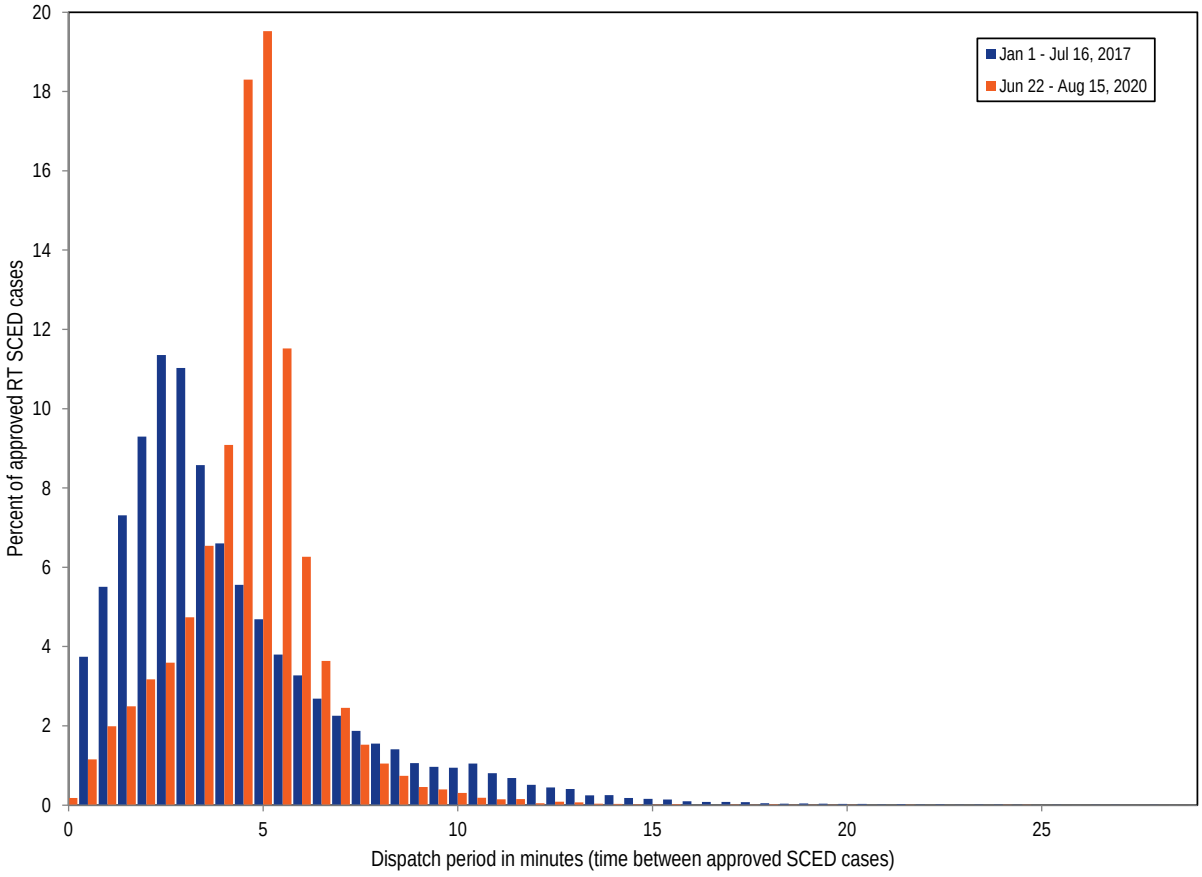
3. A Variable Dispatch Period is Not Consistent with Order No. 825

The issues with PJM's misaligned dispatch and pricing intervals should have been identified in PJM's Order No. 825 compliance filing. In that filing PJM incorrectly stated that "[t]oday in PJM, all resources are dispatched in 5-minute intervals."[21] This was not the case, and it is still not the case. The length of time between dispatch signals continues to vary widely and is not set at five minutes. At the time of the compliance filing, PJM ran an automated dispatch (RT SCED) calculation every three minutes with a 15 minute resource ramp time, and RT SCED solutions were used to send dispatch signals at a frequency

[21] Order No. 825 Compliance Filing at 3.

varying from a few seconds to over 15 minutes and averaging four and a half minutes.[22] The real-time dispatch of resources was not in five minute intervals. The length of the dispatch period continues to vary significantly, even after PJM reduced the frequency of RT SCED automatic execution to once every five minutes on June 22, 2020. Figure 7 shows the distribution of the actual dispatch periods (the time between approved solutions) from January 1, 2017, through July 16, 2017 and from June 22, 2020 through August 15, 2020. The actual dispatch signal is from an approved solution rather than an executed case. PJM dispatchers continue to have the discretion to approve cases without a specific time requirement.

Figure 7 Distribution of the dispatch period, January 1, 2017 through July 16, 2017 and June 22, 2020 through August 15, 2020



[22] Average frequency of RT SCED solution approval calculated for period from January 1, 2017 through July 16, 2017. On July 17, 2017, PJM shortened the time from execution of RT SCED to its target time from a minimum of 15 minutes to a minimum of 10 minutes.

B. Dispatch Periods and Shortage Pricing

The July 31st Filing does not address unpriced shortages because it does not align dispatch and settlement intervals. Order No. 825 required PJM to implement shortage pricing for any five minute interval with a shortage indicated by the RT SCED.[23] Given that each RT SCED case produces three solutions, and RT SCED may be executed more than once every five minutes, there are, by definition, more RT SCED solutions than there are five minute intervals for any period. Since PJM operators approve RT SCED solutions at their discretion, there is no defined process to ensure that an RT SCED solution that accurately indicates a shortage of reserves is reflected in pricing.

The Market Monitor analyzed the target times for which one or more RT SCED case solutions indicated a shortage of one or more reserve products. Under PJM market rules, reserves are considered short if the quantity (MW) of reserves dispatched by RT SCED for a target time was less than the extended reserve requirement.[24] Table 3 shows, for each month of 2019 and the first six months of 2020, the total number of target times, the number of target times for which at least one RT SCED solution showed a shortage of reserves, the number of target times for which more than one RT SCED solution showed a shortage of reserves, and the number of five minute pricing intervals for which the prices, set in the LPC solution, reflected a shortage of reserves. Table 3 shows that 874 target times, or 1.7 percent of all five minute target times in the first six months of 2020, had at least one RT SCED solution showing a shortage of reserves, and 364 target times, or 0.7 percent of all five minute target times in the first six months of 2020, had more than one RT SCED solution showing a shortage of reserves. But only two five minute pricing intervals, or 0.004 percent of all pricing intervals, included shortage pricing in the first six months of 2020. In 2019, 3,046 target times, or 2.9 percent of all target times had at least one RT SCED solution

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2323 Order No. 825 Compliance Filing at 24.

24 The extended reserve requirement is the minimum reserve requirement for each of the reserve products plus 190 MW.

showing a shortage of reserves and 1,405 target times, or 1.3 percent of all target times had more than one RT SCED solution showing a shortage of reserves. But only 33 five minute pricing intervals, or 0.03 percent of pricing intervals included shortage pricing in 2019.

Table 3 Five minute target times and pricing intervals with shortage: January 1, 2019 through June, 2020

Year, Month	Number of Five Minute Target Times	Number of Target Times With At Least One RT SCED Solution With Reserve Shortage	Percent Target Times With At Least One RT SCED Solution With Reserve Shortage	Number of Target Times With Multiple RT SCED Solutions With Reserve Shortage	Percent Target Times With Multiple RT SCED Solutions With Reserve Shortage	Number of Pricing Intervals With Five Minute Shortage Prices in LPC	Percent Pricing Intervals With Five Minute Shortage Prices in LPC
2019 Jan	8,928	87	1.0%	34	0.4%	3	0.0%
2019 Feb	8,064	184	2.3%	79	1.0%	0	0.0%
2019 Mar	8,916	347	3.9%	173	1.9%	10	0.1%
2019 Apr	8,640	424	4.9%	217	2.5%	7	0.1%
2019 May	8,928	203	2.3%	94	1.1%	0	0.0%
2019 Jun	8,640	233	2.7%	93	1.1%	0	0.0%
2019 Jul	8,928	312	3.5%	134	1.5%	3	0.0%
2019 Aug	8,928	218	2.4%	85	1.0%	0	0.0%
2019 Sept	8,640	288	3.3%	131	1.5%	4	0.0%
2019 Oct	8,928	284	3.2%	139	1.6%	3	0.0%
2019 Nov	8,652	283	3.3%	125	1.4%	1	0.0%
2019 Dec	8,928	183	2.0%	101	1.1%	2	0.0%
2019 Total	105,120	3,046	2.9%	1,405	1.3%	33	0.0%
2020 Jan	8,928	172	1.9%	89	1.0%	0	0.0%
2020 Feb	8,352	94	1.1%	44	0.5%	0	0.0%
2020 Mar	8,916	173	1.9%	66	0.7%	0	0.0%
2020 Apr	8,640	208	2.4%	99	1.1%	2	0.0%
2020 May	8,928	113	1.3%	36	0.4%	0	0.0%
2020 Jun	8,640	114	1.3%	30	0.3%	0	0.0%
2020 Jan - Jun	52,404	874	1.7%	364	0.7%	2	0.0%

The PJM Real-Time Energy Market produces an efficient outcome only when prices are allowed to reflect the fundamental supply and demand conditions in the market in real time. While it is appropriate for operators to ensure that cases use data that reflect the actual state of the system, it is essential that operator discretion not extend beyond what is necessary and that operator discretion not prevent shortage pricing when there are shortage conditions. This is a critical issue because PJM settles all real-time energy transactions on a five minute basis using the prices calculated by LPC. The data suggests that PJM does not always implement shortage pricing when RT SCED indicates a shortage of reserves.

For example, on October 1, 2019, the LMPs in PJM during the period between 1400 EPT and 1800 EPT were significantly higher relative to the rest of the day. The higher than forecast load, in combination with inadequate generator response, the declaration of a

spinning event, violation of transmission constraints, and reserve shortages contributed to the higher LMPs observed on October 1, 2019.[25] There was a period of 25 minutes on October 1, 2019, when there were no approved RT SCED cases. This occurred at the peak load time of day. PJM approved an RT SCED solution at 1648 EPT and the next approved RT SCED solution was at 1714 EPT. During this period, PJM solved nine RT SCED cases, each producing three RT SCED solutions, for a total of 27 RT SCED solutions. The three solutions from each RT SCED case are assigned a low, mid or high load bias. Table 4 shows, for the nine solved RT SCED cases, the shortage status for each of the three solutions. Out of the nine solved RT SCED cases, three cases had no solutions with reserve shortages, six cases had reserve shortages for one or more load bias cases, five had reserve shortages for two or more load bias cases and three had reserve shortages for all three load bias cases. PJM did not approve any of these RT SCED solutions.

Table 4 RT SCED solutions not approved from 1648 through 1714 EPT: Oct 1, 2019

		Load Bias Solution		
SCED Case ID	SCED Target Time	Low	Mid	High
1	01-Oct 17:00			
2	01-Oct 17:05			
3	01-Oct 17:05			
4	01-Oct 17:10	Shortage	Shortage	Shortage
5	01-Oct 17:10	Shortage	Shortage	Shortage
6	01-Oct 17:15	Shortage	Shortage	Shortage
7	01-Oct 17:15		Shortage	Shortage
8	01-Oct 17:20		Shortage	Shortage
9	01-Oct 17:20			Shortage

PJM should have a defined, transparent, rule based approach to approving RT SCED solutions so that reserve shortages signaled by the RT SCED tool are reflected in LPC and therefore in prices to ensure compliance with Order No. 825. This requires that PJM

[25] For a detailed analysis of the events on October 1, 2019, please refer to the *2019 State of the Market Report for PJM*, Vol. 2, Section 3: Energy Market, at Analysis of October 1 Events.

approve RT SCED cases at a five minute dispatch frequency, creating a five minute dispatch period consistent with the objective of aligning dispatch with pricing and settlements.

C. Overlapping Dispatch Periods

In addition to the market issues with incentives to follow dispatch and correct compensation, the July 31st Filing highlights problems with having RT SCED set to a ten minute ramp time and five minute execution frequency. PJM market operators should have the most accurate processes and tools available to support the reliable dispatch of resources to meet load. The real-time dispatch process does not provide accurate results, because it can be easily demonstrated that use of RT SCED with a ten minute ramp time executed on a three to five minute basis would result in power imbalance if all else were held constant.

RT SCED calculates dispatch MW for every online flexible resource in PJM. RT SCED dispatches online resources up or down based on the economic dispatch solution. The economic dispatch takes into account resources' operating parameters such as economic minimum, economic maximum and ramp rates and resources' energy offers. When resources follow dispatch, they increase or decrease output based on their ramp rates.

The parameters used by PJM in RT SCED, specifically, a ten minute dispatch executed on a five minute frequency tend toward overgeneration when load increases and toward undergeneration when load decreases, because PJM sends a new dispatch signal before the unit completes the ramp up or ramp down to the previous dispatch target. When resources do not complete the previous ramp time, resources may not reach the dispatch point where power balance is achieved. When the dispatch period is shorter than the ramp time, dispatch moves faster than load.

Table 5 shows an example of the RT SCED execution sequence following a 10 minute ramp time executed on a five minute frequency, the timing under both the status quo and the changes proposed by PJM. The example assumes a resource that can follow load with a five MW per minute ramp rate. The SE generation MW is the state estimator output of the resource, which follows its dispatch signal perfectly. The dispatch signal MW equals the load forecast 10 minutes in the future.

Table 5 RT SCED Example Execution Sequence

Event	Time	Load Forecast (MW)	SE Generation MW	Dispatch Signal MW
	0:00		80	
SCED1 execution for target time 0:15	0:01		80	
	0:02		80	
	0:03		80	
	0:04		80	
SCED1 approval for target time 0:15	0:05		80	120
SCED2 execution for target time 0:20	0:06		85	
	0:07		90	
	0:08		95	
	0:09		100	
SCED2 approval for target time 0:20	0:10	100	105	135
SCED3 execution for target time 0:25	0:11		110	
	0:12		115	
	0:13		120	
	0:14		125	
SCED3 approval for target time 0:25	0:15	120	130	160
SCED4 execution for target time 0:30	0:16		135	
	0:17		140	
	0:18		145	
	0:19		150	
SCED4 approval for target time 0:30	0:20	135	155	185
	0:21		160	
	0:22		165	
	0:23		170	
	0:24		175	
	0:25	160	180	185
	0:26			
	0:27			
	0:28			
	0:29			
	0:30	185		

The example starts with SCED case 1 (SCED1), executed at 0:01, solved and approved at 0:05. This case results in a dispatch to meet the forecasted load of 120 MW at 0:15. The resource is instructed to ramp up to 120 MW, 40 MW more than the MW level when SCED1 was executed (80 MW). The resource can ramp up to 120 MW in eight minutes.

At 0:06, another SCED case is executed (SCED2). This case results in a dispatch to meet the forecasted load of 135 MW at 0:20. SCED2 is approved at 0:10. The resource is instructed to ramp up to 135 MW, 20 MW more than the MW level when SCED2 was executed (85 MW). The resource can achieve 135 MW in four minutes.

At 0:11, another SCED case is executed (SCED3). This case results in a dispatch to meet the forecasted load of 160 MW at 0:25. SCED3 is approved at 0:15. The resource is instructed to ramp up to 160 MW, 50 MW more than the MW level when SCED3 was executed (110 MW). The resource can achieve 160 MW in 10 minutes from the SCED3 execution.

At 0:15, load reaches 120 MW but the resource is producing 130 MW, overproducing by 10 MW. That is because at 0:10 the resource dispatch signal of 120 MW is overwritten by a new one (135 MW) sent at 0:10.

At 0:16, another SCED case is executed (SCED4). This case results in a dispatch to meet the forecasted load of 185 MW at 0:30. SCED4 is approved at 0:20. The resource is instructed to ramp up to 185 MW, 50 MW more than the MW level when SCED4 was executed (135 MW). The resource can achieve 185 MW in 10 minutes from the SCED4 execution.

At 0:20, load reaches 135 MW but the resource is producing 155 MW, overproducing by 20 MW. That is because at 0:15 the resource dispatch signal of 135 MW is overwritten by a new one (160 MW) sent at 0:15.

RT SCED solves for a target time 10 to 14 minutes ahead. Therefore it does not take into account the system conditions five minutes ahead. It does not try to meet power balance five minutes ahead. PJM operators manage the system reliably. For the most part, they use RT SCED to provide dispatch signals to generators of how much power to produce while maintaining power balance. PJM operators adjust the RT SCED case approval frequency, load bias, transmission line limits and penalty factors to provide dispatch signals to generators that are consistent with maintaining a reliable system.

The example shows that using parameters in RT SCED, specifically, a 10 minute dispatch executed on a three to five minutes frequency tends toward power imbalance, both in aggregate and at a local level. RT SCED includes tools available to PJM operators such as load bias, the ability to not approve RT SCED cases, transmission limit control (transmission limits bias), and transmission constraint penalty factors that are used to maintain reliability when the unbiased RT SCED solution does not.

Manual actions taken by PJM operators such as load bias or not approving RT SCED cases, and transmission limits bias have a direct impact on pricing. If these actions are taken because of inconsistencies created by having RT SCED set to a 10 minute ramp rate and a five minute dispatch period, and not to correct an inaccurate load forecast or unit nonperformance, then the resulting prices are inaccurate.

D. Dispatch, Pricing, and Settlement Alignment is Required for Effective Market Design.

The July 31st Filing includes only PJM's short term solution to the misalignment of dispatch and settlements in PJM's real-time energy market. PJM has actually implemented a part of its intermediate solution, to automatically execute RT SCED every five minutes, but PJM has not included its intermediate solution in the PJM Market Rules. PJM has made no commitment to long term proposals to reduce the RT SCED dispatch interval (ramp time) to five minutes or to implement a process to approve RT SCED cases on a five minute basis. Without the short, intermediate, and long term changes, the dispatch and settlements of PJM's energy market are not aligned and the goals of Order No. 825 are not realized. Without a comprehensive solution to the misalignment of dispatch and pricing in the PJM Market Rules, any market design changes will fall short of the intended outcomes. This includes fast start pricing and the extended ORDC.

The July 31st Filing does not stand on its own. Without the intermediate and long term changes, it produces inefficient market outcomes, inconsistent with Order No. 825. The July 31st Filing should be rejected.

1. Fast Start Pricing with Short Term Changes

The July 31st Filing will not result in the market outcomes intended by fast start pricing. A simple example illustrates how the misaligned dispatch and pricing intervals under the short term proposal result in incorrect pricing and a dispatch differential lost opportunity cost (LOC) calculation that does not achieve the correct compensation. The dispatch differential LOC is meant to ensure that resources that follow dispatch instructions

from the dispatch run (RT SCED) do not forgo an opportunity to make more revenues following the fast start price signal from the pricing run (calculated by LPC).[26] Under fast start pricing, fast start units can set price based on PJM assuming that the actual operating limits do not apply (euphemistically referred to as relaxing the operating limits or integer relaxation) in the LPC. PJM asserted that the dispatch differential LOC is needed to ensure that fast start pricing does not result in reliability issues from flexible resources chasing prices instead of following PJM's dispatch signal.[27]

The example scenario is based on Figure 2 and Figure 3. Consider two units, one flexible unit that is not fast start ("flexible unit"), and another block loaded fast start unit ("fast start unit"). The offers and parameters for the two units are shown in Table 6. Under PJM's proposed fast start pricing mechanism, the RT SCED ("dispatch run") and LPC ("pricing run") solutions will differ in the way that fast start resources are treated. The pricing run will incorporate the composite energy offer for fast start resources that includes their incremental cost, start cost and no load cost. The pricing run will also ignore (relax) the economic minimum MW value of fast start resources to zero MW so that their output in the pricing run can vary between 0 MW and their economic maximum MW. In this example, the fast start unit is offered block loaded, with its economic maximum MW and economic minimum MW equal to 42 MW.

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[26] *See* PJM, "Initial Brief of PJM Interconnection LLC," Docket No. EL18-34, (February 12, 2018) at 16 – 18, and "Compliance Filing Concerning the Pricing of Fast-Start Resources," Docket No. ER19-2722 (August 30, 2019) at 21–23.

[27] *See* PJM, "Initial Brief of PJM Interconnection LLC," Docket No. EL18-34, (February 12, 2018) at 17.

Table 6 Flexible and fast start unit offers and parameters

Flexible (Non-fast start) Unit Offer	
Noload Cost ($/hour)	$800

MW	Price ($/MWh)	Area Under the Incremental Curve ($/hour)	Cost ($/hour)
60	$20	$1,200	$2,000
100	$40	$2,400	$3,200
120	$50	$3,300	$4,100
Economic Max MW		100 MW	
Economic Min MW		40 MW	

Fast Start Unit Offer	
Noload Cost ($/hour)	$588
Start Cost ($)	$42
Min Run Time (hours)	1

MW	Price ($/MWh)	Amortized Start Cost	Amortized Noload Cost	Composite Energy Offer
42	$33	$1	$14	$48
Economic Max MW		42 MW		
Economic Min MW		42 MW		

Under PJM's proposed short term changes, the Case 1 solution that solved for target time 11:35 is approved at 11:25, and dispatch instructions are effective between 11:25 and 11:30, but the prices based on Case 1 apply to the five minute interval from 11:30 – 11:35. At 11:30, a solution from RT SCED Case 2 is approved that overwrites the dispatch instructions from Case 1. From 11:30 – 11:35 the resources are following dispatch signals from the Case 2 dispatch run, while the LMPs used for energy and for uplift calculations are from the Case 1 pricing run.

Table 7 shows the results from the dispatch run and pricing run for Case 1 with fast start pricing. In the dispatch run, the economic minimum and economic maximum MW limits of the units are enforced because they represent the actual capabilities of the units. So the fast start unit is block loaded at 42 MW, and the flexible unit is dispatched to 60 MW, to meet the 102 MW load. In the pricing run, the economic minimum MW of the fast start resource is relaxed to 0 MW, and the composite energy offer of $48 per MWh is used. This results in flexible unit output of 100 MW (its economic maximum) because the flexible unit is more economic ($40 per MWh) compared to the fast start unit ($48 per MWh). The fast start unit output is 2 MW. The fast start unit is the marginal unit, and sets LMP at $48 per MWh. The LMPs used for settlements come from the pricing run.

Table 7 Case 1 dispatch run and pricing run results with fast start pricing under PJM's short term proposal

Case 1 - Target 11:35		
Approved 11:25		
Price applied to interval 11:30 - 11:35		
Load (MW)	102	102
Flexible non FS unit	**Dispatch Run**	**Pricing Run**
Dispatch MW at target	60	100
LMP	$20	$48
Block loaded FS Unit		
Dispatch (Target) MW	42	2
LMP	$20	$48

At 11:30, when the Case 2 solution is approved, if the load forecast for 11:40, Case 2's target time, is 5 MW more than the load forecast for 11:35, then the flexible unit is dispatched to 65 MW to meet the incremental load. The flexible unit's actual output from 11:30 to 11:35 reflects this dispatch instruction from the Case 2 solution.

Table 8 shows the settlements calculation for the five minute interval from 11:30 to 11:35 under PJM's short term proposal using the dispatch differential LOC calculation proposed by PJM.[28] [29] Table 8 shows that the flexible unit would earn a profit of $124 for the 11:30 to 11:35 interval by following PJM dispatch instructions, including PJM's dispatch differential LOC, and would have earned a profit of $133 for that interval by instead responding to the LMP. In other words, the unit is not indifferent between following the dispatch instructions and the price signal. This occurs because PJM's dispatch differential LOC calculation uses a combination of the actual and dispatched MW value, which would be systematically different for each five minute period under the short term proposal.

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28 *See* PJM, "Fast Start Pricing – Settlement Update," presented at the Market Implementation Committee, (August 7, 2019) at 7 – 10, which can be accessed at <*https://www.pjm.com/-/media/committees-groups/committees/mic/20190807/20190807-item-11a-fast-start-pricing-settlements.ashx*>.

29 The division by 12 is done to convert the MW power value into a MWh energy value that is settled for the five minute interval.

Table 8 Flexible unit settlements under PJM's short term proposal

Flexible Unit Settlements (11:30 - 11:35)	Dispatch Run	Pricing Run	Formulae
Unit dispatch MW (from Case 1)	60	100	
Unit actual MW (from Case 2)	65		
LMP Revenue at dispatch MW	$240	$400	Dispatch or Pricing MW*LMP /12
LMP Revenue at actual MW	$260		Actual MW*LMP /12
Cost of actual MW (at 65 MW)	$176		Cost at 65 MW /12
Cost of dispatch MW (at 60 MW)	$167		Cost at 60 MW /12
Dispatch Run Revenue above cost	$93		max($240, $260) - min($167, $176)
Pricing Run Cost (at 100 MW)		$267	Cost at 100 MW /12
Pricing Run Revenue above cost		$133	$400 - $267
Dispatch Differential LOC	$40		max($133 - $93 ,0)
Profit with LOC	$124	$133	($260 - $176 +$40), ($400 - $267)

In the order on fast start pricing, the Commission explicitly highlighted (at P. 138) the issue of price chasing and over generation:[30]

> In the December 2017 Order, the Commission recognized that fast-start pricing may create an incentive to deviate from PJM's dispatch instructions in order to take advantage of higher prices that result from fast-start pricing. This problem is particularly acute for resources that incur lost opportunity costs as a result of being dispatched down to accommodate fast-start resources.

PJM's short term proposal results in precisely the incentive to deviate from dispatch instructions that the Commission recognized as a problem.

Table 9 shows the dispatch and pricing run results under the Market Monitor's proposal. The Case 1 solution for target time 11:35 is approved at 11:30, ensuring that the dispatch period matches the ramp time of five minutes. The LMP and MW output results are identical to the results shown in Table 7. The flexible unit receives the dispatch instruction to ramp to 60 MW between 11:30 and 11:35, so the actual MW for the flexible unit is the same as the dispatch MW from the dispatch run under the Market Monitor's proposal.

[30] 167 FERC ¶ 61,058 (2019).

Table 9 Case 1 dispatch run and pricing run results with fast start pricing under the Market Monitor's proposal

Case 1 - Target 11:35		
Approved 11:30		
Price applied to interval 11:30 - 11:35		
Load (MW)	102	102
Flexible non FS unit	**Dispatch Run**	**Pricing Run**
Dispatch MW at target	60	100
LMP	$20	$48
Block loaded FS Unit		
Dispatch (Target) MW	42	2
LMP	$20	$48

Table 10 shows the flexible unit settlements under the Market Monitor's proposal. If the flexible unit follows PJM's dispatch instructions, the settlement calculations simplify because there is no difference between the dispatch run output and the actual unit output. Under the Market Monitor's proposal, the flexible unit will be paid a dispatch differential LOC of $60, which results in a total profit for the five minute interval of $133, which is identical to the profit it would receive from following the price signal instead. In other words, the flexible unit is indifferent between following the dispatch instructions and the price signal. The dispatch differential LOC works as intended and ensures that the flexible unit has the incentive to follow dispatch instructions.

Table 10 Flexible unit settlements under the Market Monitor's proposal

Flexible unit settlements	Dispatch Run	Pricing Run	Formulae
Unit dispatch MW (from Case 1)	60	100	
Unit actual MW (from Case 1)	60		
LMP Revenue	$240	$400	Dispatch or Pricing MW*LMP /12
Cost (Area under curve + noload)	$167	$267	Cost at 60 MW or 100 MW /12
Revenue above cost	$73	$133	($240 - $167), ($400 - $267)
Dispatch Differential LOC	$60		($133 - $73)
Profit with LOC	$133	$133	($240 - $167+ $60), ($400 - $267)

2. Extended ORDC with Short Term Changes

The July 31st Filing would also undermine the intended results of the changes to PJM's reserve and energy markets under Docket No. ER19-1486.

PJM's proposed extended operating reserve demand curves (ORDC) begin with the price of $2,000 per MWh for the minimum reserve requirement (MRR) quantity, and gradually decrease for quantities beyond the minimum reserve requirement.[31] PJM also added a secondary 30 minute reserve product, in addition to the primary and synchronized reserves. With the proposed ORDCs, if an approved RT SCED solution indicates a shortage of reserves, the LMPs would include penalty factors of at least $2,000 per MWh for a single reserve product, and the dispatch instructions corresponding to this solution would ramp resources higher. But under PJM's short term proposal, the LMPs corresponding to this shortage solution would not be applied to the dispatch period when the resources are following the shortage instructions. If resources respond to the dispatch instructions from the shortage solution, and the subsequent RT SCED case does not indicate a reserve shortage, the prices paid for following the shortage instructions will not reflect shortage conditions. The result of the dispatch and settlement misalignment under the PJM short term proposal would be incorrect compensation for the resources that provided reserves and energy during the shortage. While this result will occur without the ORDC, the impact of the dispatch settlement misalignment under PJM's proposed extended ORDC would be more significant as a result of the increased reserve penalty factors and the ORDC prices for reserves beyond the MRR.

PJM also proposed five minute lost opportunity cost credits for reserve deviations between the day-ahead and real-time markets.[32] The discrepancy in the reserves cleared for a five minute period, and the reserves actually provided during that five minute period due to an updated dispatch instruction, under the short term proposal, will lead to incorrect five minute reserve LOC calculations, particularly during the five minute intervals that begin and end at the top of the hour.

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31 *See* "Enhanced Price Formation in Reserve Markets of PJM Interconnection, L.L.C.," transmittal letter ("ORDC Transmittal Letter"), Docket No. ER19-1486 (March 29, 2019) at 64–68.

32 *Id.* at 107–108.

PJM also proposed a rule to ensure that no MW are double counted as providing reserves and energy. To implement this, PJM proposed to cap the amount of reserves a resource can be credited for in a given five minute settlement interval at the difference between the resource's maximum available reserve capability and the resource's energy production for that interval.[33] With PJM's short term proposal, even if a resource diligently follows PJM's dispatch instructions, the energy provided in a settlement interval will not correspond to the reserves cleared for that interval. This is because PJM's dispatch instructions are overwritten approximately five minutes into the 10 minute ramp time, and the resource's energy production reflects the new approved dispatch solution. The systematic mismatch between the dispatch and settlement interval under PJM's short term proposal may incorrectly penalize resources following PJM's dispatch signals by summing the incorrect energy and reserve MW to check against the resource's capability.

E. LMP Posting

The July 31st filing proposes to add a significant delay in the use of an approved RT SCED solution in LPC compared to the status quo.[34] For example, resources will receive a dispatch signal close to 11:50 for target time 12:00. Under the status quo, LPC will be solved at 11:51:30 and prices will be posted as soon as the LPC case is solved. Under the short term proposal, LPC will be solved five minutes later at 11:56:30 and prices will be posted as soon as LPC case is solved. The delay between the time in which resources are provided the dispatch signal and the time prices are posted will increase by at least five minutes if PJM's short term proposal is implemented, but there is no software or other technical reason for that increase.

PJM will be delaying posting price information. Dispatch signals provide a strong indication to resources of the LMP. The July 31st filing will create a disparity between the information provided to resources and other market participants. If a market seller observes

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33 *Id.*

34 *See* July 31st Filing at 6.

that its resource receives a dispatch signal that implies a large price change, the market seller will have information about prices that it can act on to its advantage when that information is not available to the rest of the market for several minutes.

F. An Accurate RT SCED Model Helps Reliable Operations, and Reduces Need for Manual Interventions.

The Market Monitor disagrees with PJM's characterization of the necessary long term changes. The automated approval of RT SCED solutions is not required. PJM can continue with manual operator approval upon operator review of the solutions, with the goal of having a uniform five minute dispatch frequency.[35] Some of the asserted reliability issues raised by PJM with automating SCED approval can be addressed by keeping the control over approving cases with PJM operators.[36] Characterizing these changes as long term is misleading. The long term changes can and should be clearly defined and implemented in a timely manner, recognizing that appropriate testing should be done but also recognizing that there is no reason to delay these necessary changes into the undefined long term. These changes are an essential part of solving the mismatch between dispatch and pricing.

The key step in the required long term changes is to reduce the ramp time to five minutes. As the July 31st Filing states, PJM dispatchers should be trained on the revised tool, and the tool calibrated based on the experience to target a five minute frequency.[37] PJM reduced the RT SCED ramp time from 15 minutes to 10 minutes in 2017 without prolonged testing or training. PJM has provided no reasons why a change of the ramp time from 10 minutes to five minutes would require testing for a long and apparently indeterminate period. The proposal is to use better and more timely input data. It is not clear what the downside is.

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35 Automated approval of RT SCED solutions was proposed by PJM staff after their evaluation of the dispatch processes in other RTOs. PJM subsequently withdrew their support for this proposal.

36 Carroll Affidavit at 14–17.

37 Carroll Affidavit at 12.

Using information from the previously approved RT SCED case to model resource initial MW will facilitate the five minute ramp time and increase RT SCED accuracy. Using the state estimator MW as resource initial MW leads to an inaccurate input by design, because SE MW do not reflect where units actually are when they receive the dispatch signal. It takes three to five minutes between the time when the SE snapshot is taken until an RT SCED solution that uses that snapshot is approved. Under the Market Monitor's proposal, the modeled resource initial MW would only be incorrect in the instances where a resource (i) significantly and suddenly deviates from dispatch and (ii) this deviation has not been captured in the adjustments proposed. For all other resources, the previous dispatch MW, with the proposed adjustments, is a better representation of the resource initial MW than using stale SE MW data in all instances.

The Market Monitor appreciates the NERC requirements that PJM is required to operate to, that PJM alluded to in the July 31st Filing. However, the concerns about compliance with reliability standard BAL-001-2 due to updating the resource ramp time and initial status are unclear.[38] PJM operators continue to have regulation as a tool for time frames under five minutes, continue to have the ability to use load bias to account for forecast errors, and continue to have the ability to manually execute and approve additional cases, if needed for reliability. The Market Monitor's proposal does not eliminate other efforts for accurate modeling in the PJM market tools, such as the need to improve generator modeling in PJM's energy market, including accurate ramp rates, generator transitions, and generator output during start up. The status quo approach to addressing these inaccuracies is to use nontransparent, manual interventions such as intermittent case approval and load bias. This results in a disconnect among dispatch, pricing, and settlements, and erodes confidence in the market results. The Market Monitor's proposal, if fully implemented, will reduce inconsistencies some of which lead dispatchers to manually intervene. The Market Monitor's proposal will ensure that PJM tools are using the most

[38] *Id.* at 19.

current information about generator status. PJM cannot resolve the underlying causes of resources not following dispatch as long as its tools do not provide resources routine achievable dispatch signals and consistent pricing incentives.

III. CONCLUSION

The Market Monitor respectfully requests that the Commission afford due consideration to these comments and reject the July 31st Filing.

Respectfully submitted,

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Date: August 21, 2020

CERTIFICATE OF SERVICE

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

Dated at Eagleville, Pennsylvania,
this 21st day of August, 2020.

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