UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.	**)**	**Docket No. EL18-34-000**

INITIAL BRIEF OF PJM INTERCONNECTION, L.L.C.

In response to the December 21, 2017 Order of the Federal Energy Regulatory Commission ("FERC" or "Commission"),[1] PJM submits this initial brief on the pricing of fast-start resources in its energy markets. Specifically, PJM responds to various elements of pricing reform that the Commission should consider in establishing a just and reasonable reform package. As a threshold matter, PJM reads the 206 Order as directed at investigating pricing reforms for what the Commission refers to as 'fast-start' resources. Accordingly, PJM limits its comments to the need for pricing reforms as applied to fast-start resources. Although in this submittal, PJM is arguing for a different measure of what constitutes fast-start resources (defining those as having a hour start-up time of two hours or less and a minimum run time of two hours or less), PJM does not see this docket as addressing issues beyond the focus of this docket as directed toward pricing reforms for fast-start resources, and accordingly has not briefed issues beyond fast-start pricing reforms. Subject to the above caveats, PJM supports the proposed reforms with minor modifications as detailed herein.

[1] *PJM Interconnection, L.L.C.*, Order Instituting Section 206 Proceeding and Commencing Paper Hearing Procedures and Establishing Refund Effective Date, Docket No. EL18-34-000 (Dec. 21, 2017) ("206 Order") This proceeding was noticed in the Federal Register on December 28, 2017. 82 Fed. Reg. 61,562 (Dec. 28, 2017), triggering the deadline for submittal of an initial brief by February 12, 2018.

I. EXECUTIVE SUMMARY

The goal of Locational Marginal Prices ("LMP") is to provide market signals that support the efficient commitment and dispatch of the power system. As identified by the Commission in the fast-start Notice of Proposed Rulemaking ("NOPR"),[2] and as carried through to the 206 Order, certain resources operating at the direction of PJM are ineligible to set the LMP due to limitations contained in PJM's current rules. The NOPR and 206 Order focused on fast-start resources which the Commission generally characterizes as resources that can start quickly, are inflexible for the most part, and have a low minimum run time.[3] Such resources are committed in both the Day-ahead and Real-time Energy Market to meet system needs but, under the current rules, due to their inflexibility, are unable to set the LMP. This results in a set of prices that do not appropriately reflect the offers of resources scheduled by PJM which create the need for make whole payments to ensure that the fast-start units do not have the incentive to deviate from the efficient commitment and dispatch. In turn, the make whole payments result in charges that are allocated to market participants based on PJM's uplift allocation methodology. Thus, while the resource ultimately is compensated, the manner in which it is compensated creates distorted incentives that would diminish market efficiency. Moreover, such compensation is reflected outside of LMP and thus reduces market transparency.

To remedy this, the Commission has suggested that PJM implement an improved version of fast-start pricing than it uses today. This implementation will ensure that fast-start resources will efficiently and appropriately contribute to the LMP price setting when such resources are dispatched and that market prices that better reflect actions taken by system operators

[2] *Fast-Start Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators,* Docket No. RM17-3-000, Notice of Proposed Rulemaking, 157 FERC ¶ 61,213 (2016) ("NOPR").

[3] *See, e.g.,* 206 Order at P 2.

The Commission laid out various reforms for consideration and asked for PJM's and other interested parties to provide input through initial and reply briefs. PJM appreciates the opportunity to provide its input on fast-start pricing reforms. PJM agrees with many aspects of fast-start pricing reform articulated by the Commission in the 206 Order, with some modifications as discussed in detail herein.

PJM agrees that:

- Fast-start resources should be fully dispatchable between zero and their economic maximums in the pricing run. For the reasons stated herein, PJM proposes to accomplish this through integer relaxation.

- All fast-start resources scheduled by PJM should be eligible to set LMP.

- It is appropriate to alter PJM's real-time processes to execute the dispatch run prior to the pricing run.

- It is appropriate to reflect the commitment costs (i.e., start-up and no load) of fast-start resources in prices.

- As PJM has very few resources that meet the Commission's narrow definition of fast-start resources, PJM shows that the Commission's rationale and goals as applied to fast-start resources can best be accomplished by restating the fast-start definition as applied to the PJM footprint to consist of resources with start-up and minimum run times of two hours or less.

- It is appropriate to remove the incentive to deviate from dispatch for resources being dispatched down around inflexible fast-start resources. PJM proposes compensating such resources with lost-opportunity cost credits.

- Fast-start pricing rules should be reflected in PJM's governing documents. PJM stands ready to file such revisions to the PJM Open Access Transmission Tariff ("Tariff") and the Amended and Restated Operating Agreement of PJM Interconnection, L.L.C. ("Operating Agreement"), upon the Commission issuing its ruling in this proceeding.

The reforms for fast-start pricing should be implemented in the Day-ahead and Real-time Energy Markets with certain limited exceptions. That is because frequently PJM commits fast-start resources in both markets and believes it is appropriate to keep the pricing models between

the markets consistent to avoid inefficient arbitrage opportunities. For reasons discussed in more detail in section II.A. below, the pricing principles in the 206 Order should also be applied to fast-start resources in the Synchronized and Non-Synchronized Reserve Markets.

II. RESPONSE TO ISSUES IDENTIFIED BY THE COMMISSION

PJM generally agrees with pricing reforms for fast-start resources that the Commission laid out in this proceeding. Many of the concepts follow PJM's comments in the Fast-Start Pricing NOPR.

A. PJM Supports Treating Fast-Start Resources as Dispatchable from Zero to the Resource's Economic Maximum Operating Limit For the Purposes of Calculating Prices.

The NOPR proposed relaxation of the economic minimum operating limit of a fast-start resource to treat them as dispatchable from zero to the resource's economic maximum operating limit to calculate prices.[4] In the 206 Order, the Commission stated it remained concerned that "without allowing relaxation by up to 100 percent, prices will sometimes be set by the offers from lower cost flexible units that are dispatched down in order to accommodate the output of fast-start resources."[5] PJM agrees with the Commission that allowing fast-start resources to be fully dispatchable between zero and their economic maximums in the pricing run is just and reasonable. This will increase the ability of fast-start resources to set the price beyond PJM's current practice of relaxing block-loaded combustion turbine's economic minimums by a limited amount.[6]

[4] NOPR at P 54.

[5] 206 Order at P 15.

[6] The 206 Order refers to PJM's level of relaxation as 10% as that is the level PJM indicated in its response to the NOPR. PJM modified its relaxation threshold level from 10% to 20% on October 4, 2016.

As the Commission recognizes,[7] often fast-start resources are needed during times of tight system conditions and in many cases have costs higher than other resources. Removing the limitations that prevent fast-start resources from setting the price allows the price to more accurately reflect the costs of deploying these resources. Allowing fast-start resources to set LMP also will lead to improved performance incentives for all resources, especially during times of tight system conditions when fast-start resources are needed most. More specifically, if prices are suppressed due to inefficient fast-start pricing rules, such prices would send the wrong market signals to loads and generating resources in ways that create exactly the opposite incentive needed to maintain reliability during tight system conditions.

To achieve this result, PJM proposes to use an integer relaxation approach as defined and discussed in more detail in section II.A., along with the separate pricing and dispatch runs contemplated by the 206 Order and discussed in more detail in section II.C. The Midcontinent Independent System Operator ("MISO") has implemented a similar integer relaxation method in its fast-start pricing methodology, which also allows fast-start resources to be partially committed. Specifically, under its Commission-approved extended LMP rules, MISO implements separate dispatch and pricing runs. As Dr. Giacomoni, PJM's Senior Market Strategist, Emerging Markets explains, under the separate dispatch and pricing runs, MISO "allow[s] fractional commitments of fast-start Resources in the pricing run to set prices, despite the fact that such resources cannot physically achieve the outcome. This is analogous to integer relaxation, which will allow a fast-start resource to be partially committed. . ."[8]

[7] *See, e.g.,* NOPR at P 9.

[8] *PJM Interconnection L.L.C.,* Affidavit of Dr. Anthony Giacomoni on Behalf of PJM Interconnection, L.L.C., at ¶ 12, Docket No. EL18-34-000 (Feb. 12, 2018) ("Giacomoni Affidavit"). Dr. Giacomoni's affidavit provided as Attachment A, hereto.

As explained by Dr. Giacomoni:

> The "integer" in integer relaxation refers to the commitment status of a particular resource. During the commitment and dispatch processes, the commitment variable is represented by a value of zero or one indicating whether the resource has been committed or not, respectively. In the optimization problem, the commitment variable is multiplied by the commitment costs of a resource (i.e., start-up cost and no-load cost). The commitment variable is also multiplied by operating parameters that must be enforced if the resource is committed. These operating parameters include Economic Minimum and Economic Maximum as well as others. In integer relaxation, the commitment variable is allowed to fluctuate between zero and one rather than being forced to an integer state of one or the other.[9]

While the 206 Order contemplated achieving this by reducing the economic minimum by up to 100 percent,[10] using integer relaxation achieves the same objectives that the Commission is pursuing while simplifying the implementation, as described herein. And this approach also follows the MISO approach to fast-start pricing, as noted above.

Upon the Commission requiring PJM to implement fast-start pricing reforms, PJM plans to alter its Real-time Energy Market clearing process to execute the dispatch run prior to the pricing run.[11] Under that construct, PJM will execute the dispatch run first. In doing so, PJM will determine the security constrained economic dispatch through a straightforward optimization that enforces the full set of operating limitations on all generators as well as the integer commitment state (between zero and one).[12] The dispatch run produces a set of dispatch instructions which are sent to generation resources to control the system.[13] Next, in the pricing run, the commitment state of each fast-start resource will be allowed to vary between zero and

[9] *Id.* at ¶ 7.

[10] 206 Order at PP 15, 30.

[11] *See* subsection II.C., *infra.*

[12] Giacomoni Affidavit at ¶ 8

[13] *Id.*

one.[14] This is achieved by relaxing the integer variables normally fixed at either zero or one in the dispatch run, where zero represents a unit that is offline and one represents a unit that is online. As explained by Dr. Giacomoni, "each fast-start resource in the pricing run will be allowed to be partially committed. For example, if a 100 MW inflexible fast-start resource's commitment variable is set to 0.5 in the pricing run, it indicates that 50 percent of the output of the unit was needed. If it was set to 0.75, 75 percent of the output of the unit was needed."[15] These resources can set LMP as a result of being allowed to be partially committed.

1. Integer Relaxation is Superior to Economic Minimum Relaxation

There are several benefits to integer relaxation over relaxation of the economic minimum. First, integer relaxation naturally incorporates commitment costs into the clearing price calculation consistent with sound principles without the additional administration required by economic minimum relaxation. Commitment costs include both start-up and no-load costs. Specifically, as Dr. Giacomoni explains, the start-up and no-load costs are multiplied by the commitment variable in the optimization model.[16] In optimizing the commitment state as it is flexed between zero and one, the calculation naturally reflects start-up and no-load costs appropriately. This is superior to economic minimum relaxation which does not consider commitment costs without calculating adjusted offers. Dr. Giacomoni further explains:

> [I]n economic minimum relaxation, the flexible dispatch range of a resource is increased in the pricing run by relaxing a resource's economic minimum (and down ramp rate) to zero to increase its ability to set the price. Doing this alone, though it allows fast-start units to set price, does not permit the inclusion of start-up and no-load costs into the LMP. To achieve this recognition of start-up and no-load costs under an economic minimum relaxation approach, start-up and no-load costs must then be amortized over an

[14] *Id.*

[15] *Id.*

[16] *Id.* at ¶ 10.

> administratively determined output level and time period, typically economic maximum and minimum run time, and added into an adjusted energy offer calculated to set price.[17]

In the NOPR, the Commission suggested an approach to include commitment costs which would require an amortization of the costs.[18] The Commission proposed to calculate a fast-start resource's amortized start-up costs as equal to its start-up cost divided by the product of its economic maximum operating limit and its minimum run time. Similarly, the Commission proposed to calculate the resource's amortized no-load cost as the no-load cost in $/hour divided by the resource's economic maximum. To determine the enhanced energy offer for price setting purposes, the amortized start-up and no-load costs would be added to the incremental energy offer. Upon expiration of the minimum run time, the Commission proposed to remove the amortized start-up and no-load cost terms from the enhanced energy offer so that beyond the minimum run time, the resources incremental energy offer would be used in price setting. This administrative process of calculating adjusted energy bids adds unneeded complexity to the fast-start implementation. PJM's proposal to use integer relaxation would greatly reduce the need for this amortization process but would achieve the same desired result.

Second, integer relaxation is relatively straightforward to implement in the economic commitment and dispatch software as it requires no changes to the optimization model in the pricing run, compared to the dispatch run, except for the relaxation of the integer commitment variables and allowing them to be continuous between zero and one.[19]

Consistent with the way PJM calculates prices, the integer relaxation methodology will be implemented with a single-period pricing approach. A single-period pricing approach

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[17] *Id.*

[18] NOPR at P 39.

[19] Giacomoni Affidavit at ¶ 11.

calculates prices for one pricing period at a time (1-hour for day-ahead and 5-minutes for real-time) with no history of previous intervals or foresight into future ones. This method is used today in the PJM Day-ahead and Real-time Energy Markets and would therefore remain the same.

2. PJM Proposes Using a Methodology Similar to Integer Relaxation to Fast-Start Resources Providing Reserves

PJM believes a method similar to the integer relaxation methodology can be extended to reserve pricing of fast-start reserves. In the Synchronized Reserve Market PJM often commits demand resources and synchronous condensers to provided synchronized reserves. These resources are essentially block-loaded resources[20] that provide reserves and therefore are ineligible to set the reserve clearing price when committed due to their inflexible reserve assignment. In the Non-Synchronized Reserve Market the same phenomenon occurs when PJM commits resources to provide that service that can start quickly but they have inflexible operating parameters and, thus, they are committed to provide reserves but are not permitted to set the reserve price. In both of these cases, the reserve market price formation is deficient and results in unnecessary out-of-market make-whole payments to such resources for providing reserves.

In the Synchronized Reserve Market, synchronous condensers that provide Synchronized Reserves in PJM incur a start-up cost to start the resource in condensing mode and also incur an energy usage cost which is the cost of the energy consumed from the grid by the resource to operate in condensing mode. These costs are analogous to the start-up and no-load costs incurred by fast-start resources when they generate and could be similarly included in the

[20] A block-loaded resources is one whose economic minimum operating limit is equal to its economic maximum output. *See* NOPR at P 1, n.1, citing *Price Formation in Energy and Ancillary Services Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. AD14-14-000, 153 FERC ¶ 61,221 at P 9, n.9 (2015) ("Order Directing Reports")

Synchronized Reserve Market clearing price using integer relaxation. In the Synchronized and Non-Synchronized Reserve Markets, integer relaxation could also make inflexible commitments flexible to calculate better clearing prices.

In PJM, nearly 65 percent of the compensation provided for Synchronized Reserves is through reserve market make-whole payments and not through the reserve clearing price. This occurs in-part because many of the resources selected to provide reserves are inflexible and unable to set the reserve market clearing price. This is the identical affliction that plagues the energy market that the Commission rightfully seeks to address in this proceeding. Because these resources meet the fast-start definition, and because permitting these resources to be flexible during the determination of the reserve market clearing prices follows the same principle the Commission proposes in the energy market and would solve the same problem, it would be appropriate to allow fast-start reserve resources to also be able to set the reserve price and this would be consistent with the reforms addressed in this proceeding.

B. PJM Proposes to Apply Integer Relaxation to all Fast-Start Resources, and Not Just Block-Loaded Fast-Start Resources.

PJM agrees that relaxation should apply in a technology-neutral manner to all fast-start resources scheduled by PJM, and not just block-loaded fast-start resources.[21] PJM agrees that, by restricting the relaxation of the economic minimum operating limit to block-loaded resources as is the case currently, the current rules have unduly limited the set of dispatch circumstances in which fast-start resources could set prices. This results in prices that may be set by the offers from lower-cost flexible units dispatched down to accommodate the output of fast-start resources, and which may not reflect the need for the fast-start resource to help maintain system

[21] 206 Order at P 15.

control. Consistent with the 206 Order, therefore, PJM proposes to apply fast-start pricing logic to all resources that meet the fast-start criteria proposed, regardless of technology type. PJM agrees with the Commission application of relaxation to all fast-start resources is just and reasonable because "it ensures that no resource that can perform the same service is unnecessarily excluded from fast-start pricing treatment."[22]

In doing so, PJM clarifies some of the finer details here. Fast-start pricing logic should not be applied to self-scheduled resources even if they meet the definition of a fast-start resource based on their operating parameters. Therefore PJM would not apply integer relaxation to self-scheduled, non-dispatchable resources (which are self-committed resources that do not intend to follow PJM's dispatch instructions at any output level) or self-scheduled dispatchable resources (which are self-committed resources that intend to follow PJM's dispatch instructions for quantities above economic minimum output). The decision to commit a self-scheduled resource and to incur the commitment costs of doing so is one that is made outside of the market by the resource owner. It would therefore be inappropriate for the market to bear the responsibility of paying for those commitment costs when the commitment decision was not made economically by the market or by PJM system operators. Further, self-scheduling a resource indicates that the resource seeks to operate as a price-taker in the energy market for quantities up to its offered minimum output level. Therefore, it would not be appropriate to consider the quantities below the economic minimum output level as eligible to set price when the resource seeks to operate as a price-taker within this range.

[22] 2016 Order at P 17.

C. PJM Proposes to Alter its Real-Time Energy Market Clearing Process to Execute the Dispatch Run Prior to the Pricing Run in a Way that Follows Minimizing Production Costs, Subject to Operational and Reliability Constraints.

PJM's proposal to implement fast-start pricing via integer relaxation is consistent with the Commission's desire to apply fast-start pricing logic in a way that would not change the dispatch of resources away from the cost-minimizing dispatch. Should the Commission adopt the fast-start pricing reforms as described herein, PJM would alter its Real-time Energy Market clearing process to execute the dispatch run prior to the pricing run. PJM agrees with the Commission it is logical to first determine the cost-minimizing dispatch solution through a straightforward optimization that considers the full set of operating limitations on all generators, honoring system power balance. That dispatch run will produce the dispatch instructions that are sent to supply resources. After the dispatch run, PJM would then perform a pricing run to determine prices and would not impact the dispatch instructions sent to supply resources. This approach is just and reasonable as it helps avoid reliability issues that could otherwise result if the system power balance does not remain intact. And PJM agrees with the Commission that this approach is more consistent to minimize production costs than PJM's current method.[23]

D. PJM Proposes to Modify the Pricing Logic to Allow the Commitment Costs of Fast-Start Resources to be Reflected in Prices.

In the 206 Order, the Commission suggested that "incorporating commitment costs of fast-start resources in prices more accurately represents the marginal cost of serving load, which will help inform investment decisions and reduce reliance on uplift payments."[24] PJM supports the recommendation to allow the commitment costs of fast-start resources to be reflected in

[23] *See* 206 Order at P 19.

[24] 206 Order at P 23.

prices. To achieve this result, PJM proposes to use an integer relaxation approach which will naturally include commitment costs in the pricing run under the desired circumstances, as described in section II.A. PJM agrees with the Commission that upon expiration of the minimum run time, the start-up cost for a fast-start resource should be removed from the price calculation. In contrast to the NOPR, however, PJM proposes that the no-load cost for a resource should continue to be included in the price calculation during the time the resource runs. This is because the no-load cost is an hourly cost incurred by the resource for its entire run time and therefore is a cost that continues to be incurred even beyond the minimum run time.

Upon the Commission's order in this proceeding, PJM would implement the aforementioned pricing methodology in both the Day-ahead and Real-time Energy Markets. Note, however, that PJM only intends to include the start-up and no-load cost of a fast-start unit in LMPs in the market where the commitment decision is made. For example, if a fast-start resource was committed in the Day-ahead Energy Market, its start-up and no-load costs would be reflected in Day-ahead Energy Market LMPs. If that resource then operated in real-time per its day-ahead schedule, its start-up and no-load costs would not be included in the calculation of real-time LMPs. This is because the decision to commit that resource was made in the Day-ahead Energy Market and therefore its start-up and no-load costs are sunk in the real-time market. This implementation is necessary to ensure that prices reflect market decisions when they are made and that they also reflect the fact that commitment costs associated with day-ahead market commitment decisions are sunk in real-time. Inclusion of commitment costs in the manner described is just and reasonable because it will ensure LMP will accurately commitment decisions of fast-start resources.

E. PJM Proposes that Fast-Start Resources Include those Resources which have a Start-Up and Minimum Run Time of Two Hours or Less.

PJM appreciates the Commission's support for regional differences in determining the definition of fast-start resources. As described in PJM's NOPR response, the composition of generation fleets differs from region to region, as do the operational practices, and therefore, the definition should be accommodating to each region to achieve the desired pricing outcomes and reduction in uplift.[25]

PJM understands the Commission's desire for the definition of a fast-start resource to align with a resources' marginal decision to meet real-time needs of the system.[26] PJM agrees. As supported in the Affidavit of Christopher Pilong, Director, Dispatch of PJM, PJM proposes that fast-start resources with a minimum start-up time[27] of two hours or less and a minimum run time of two hours or less aligns with PJM's marginal decisions, given how PJM utilizes it real-time operational tools for commitment decisions.[28]

Specifically, PJM's real-time dispatch tool known as the Intermediate Term Security Constrained Economic Dispatch ("IT SCED") application is an integral component of PJM real-time applications. As Mr. Pilong states: "The IT SCED application is a two hour look-ahead optimization engine with an objective function to provide the least cost solution to meet projected load, reserve requirements and interchange, while ensuring all transmission system

[25] *PJM Interconnection, L.L.C.,* Comment to Notice of Proposed Rulemaking, Docket No. RM17-3-000 (Feb. 28, 2017).

[26] *See, e.g.,* 206 Order at P 25.

[27] Consistent with the way in which the Commission defines start-up, PJM considers a resource's total time to start, which is the sum of the resource's start-up time and notification time. *See* 206 Order at n.59.

[28] *PJM Interconnection, L.L.C.,* Affidavit of Christopher Pilong on Behalf of PJM Interconnection, L.L.C., at ¶ 9, Docket No. EL18-34-000 (Feb. 12, 2018) ("Pilong Affidavit"). Mr. Pilong's Affidavit is provided as Attachment B, hereto.

constraints are maintained within limits."[29] The IT SCED application provides resource commitment recommendations to system operators to maintain reliability and calculates the projected energy dispatch and reserve trajectory for multiple intervals over a two-hour look-ahead period.[30] As Mr. Pilong explains, the two-hour look ahead is used because PJM "has determined that the most accurate reflection of what the system will look like, while providing some lead time, is two hours."[31] The set of resources this application makes commitment recommendations for in real-time are those resources that can start in less than or equal to two hours and have a minimum run time of two hours or less.[32] The decision to commit resources with these operating parameters are *truly the marginal decisions* made by PJM system operators in the real-time market based on the operating practices and generation fleet in PJM, and satisfy the Commission's criteria related to marginal decision-making.

Failure to reflect the costs of these resources in LMPs would propagate the same price formation issues that exist today. As shown in the tables below, capturing the resources which have a start-up time and minimum run time of two hours or less will include approximately 17,000 additional MWs in LMP and provide an opportunity to reduce roughly 57% of the uplift in PJM than if PJM were to employ a definition of fast-start resources that is limited to resources[33] which have a start-up and minimum run time of one hour or less.

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[29] *Id.* at ¶ 6.

[30] *Id.* at ¶¶ 6-7.

[31] *Id.* at ¶ 7.

[32] *Id.*at ¶ 9.

[33] PJM notes that the determination of whether a resource is fast-start will depend on the schedule the resource is committed on and if that schedule reflects MWs that have a start-up time and minimum run time of two hours or less. For instance a dual fuel resource may operate on one fuel that could not be considered fast-start due to the relevant operating parameters, and the other fuel can. PJM will determine if those MWs are fast-start based on which schedule it is committed.

Table 1. Comparison of Start-Up and Minimum Run Times

Resource Type	Start Time (minutes)	Minimum Run Time (minutes)	Total Resource Count[2]	Total Resource MW[3]	Percent of Total Resources	Percent of Total Resource MW
All Units[1]	<= 60	<= 60	470	7,942	38.78%	7.80%
	<= 120	<= 120	706	25,211	58.25%	18.17%

Table 2. Comparison of Uplift Under Different Start-Up and Minimum Run Times

Resource Type	Start Time (minutes)	Minimum Run Time (minutes)	Total 2017 Uplift	Percent of Total 2017 Uplift
All Units[1]	<= 60	<= 60	$ 21,870,668	20.27%
	<= 120	<= 120	$ 61,584,944	57.07%

1) Excluding hydro

2) Total resources that submitted supply schedules to RT on July 19, 2017 (2017 peak load day)

3) Sum of economic maximums

In its 206 Order, the Commission stated: "the accurate pricing of fast-start resources advances [the Commission's price formation] goals by transparently reflecting the marginal cost of serving load and the value fast-start resources provide in meeting system needs, which will reduce uplift costs and improve price signals to support efficient investments in facilities and equipment."[34] Given that PJM's operational tools reflect the marginal decision of PJM' operators in considering resources which have a start-up and minimum run times of two hours or less, and will result in significantly less uplift, PJM's proposal satisfies the Commission's goals and is just and reasonable.

F. PJM Supports Compensating Resources Which Are Redispatched as a Result of Implementing Integer Relaxation through Lost-Opportunity Cost Compensation

As the Commission acknowledged in the 206 Order, PJM is concerned that relaxing the economic minimum by up to 100 percent will result in prices that will incentivize lower cost

[34] 206 Order at P 10, *citing* NOPR at P 35 and Order Directing Reports at P 2.

flexible resources that are dispatched down to "make room" for inflexible fast-start resources to deviate from dispatch.[35] If left unaddressed this could create control problems for system operators due to over-generation. The Commission suggested PJM should consider approaches to address this issue. PJM supports incentivizing resources to follow dispatch instructions in this case by compensating such resources for the lost opportunity cost they incur by doing so. While the Tariff and Operating Agreement provide that PJM can compensate when it redispatches resources for transmission constraints and to provide certain ancillary services, those provisions do not capture the repricing reforms for fast-start resources being addressed int this proceeding.

To the extent possible, prices and settlement rules should provide market participants a more effective incentive not to deviate from dispatch instructions. There have always been circumstances when the market clearing prices do not provide sufficient incentive to support the optimal commitment and dispatch, creating the incentive for a resource to deviate from PJM's commitment or dispatch instructions. Scenarios like this can occur when a resource is dispatched below its profit-maximizing output level to maintain power balance due to the need to accommodate the inflexibility of fast-start resources as well as the inclusion of commitment costs into the LMP. This can cause situations where a resource owner can increase profits by deviating from dispatch instructions and generating more than directed. In scenarios where a resource owner can increase profits by increasing its output beyond its dispatch point, the resource owner is being instructed to act in a manner counter to its self-interest and to forego profits. Therefore, by following PJM's commitment and dispatch instructions, the resource incurs a lost-opportunity cost because it was not permitted to increase output to its profit-

[35] 206 Order at P 31, *citing* PJM NOPR comments at 11.

maximizing level. Unless the market design properly addresses this issue, resources will have an incentive to deviate from dispatch instructions.

To ensure that market signals support efficiency and system balance, the pricing and compensation rules for pool-scheduled resources must include compensation for lost-opportunity costs incurred while following commitment and dispatch instructions.[36] Such lost-opportunity costs would be equal to the difference between the profits the resource would have collected had it operated at its physically feasible, profit maximizing output level, and the profit collected based on following PJM's dispatch instructions.

PJM proposes that all online, flexible resources in the Day-ahead and Real-time Energy Markets should be eligible for lost opportunity cost credits. This includes resources scheduled by PJM in addition to self-scheduled, online, dispatchable resources. Self-scheduled resources that have elected to follow the dispatch instructions sent by PJM have the same incentive to deviate from dispatch when instructed to operate inconsistent with their profit-maximizing output level and therefore require a lost opportunity cost payment to remove the incentive to do so. As stated above, compensating resources for lost opportunity cost effectively neutralizes incentives for profit maximizing resources to deviate from dispatch instructions and provides strong incentives for resources to offer more flexible operating parameters.

G. Other Considerations

Throughout this brief, PJM is supportive of the Commission's efforts to provide additional opportunities for fast-start resources to set LMP. PJM is actively working on identifying what other market rules may be affected to ensure the efficient and effective

[36] Currently, PJM compensates resources for lost opportunity cost for forgone revenue or increased costs incurred when dispatched uneconomically to provide regulation service.

implementation of fast-start pricing reforms. For example, as PJM implements the pricing reforms contemplated herein, it expects that part and parcel of those reforms would be consideration of details around issues such as price-sensitive demand, virtual transactions, interchange transactions, and false positive/false negatives in reserve shortages that may occur in separating the dispatch and pricing runs. PJM asks the Commission order in this proceeding allow room for PJM to address issues such as these in implementing reforms for fast-start resources.

III. CONCLUSION

Wherefore, PJM asks the Commission take into consideration PJM's comments and proposals concerning fast-start pricing reforms as contained in its Initial Brief herein.

Respectfully submitted,

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On behalf of
PJM Interconnection, L.L.C.

Dated: February 12, 2018

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 Audubon, PA, this 12th day of February, 2018.

/s/ *Jennifer H. Tribulski*
Jennifer H. Tribulski
Associate General Counsel
PJM Interconnection, L.L.C.

ATTACHMENT A

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.	)	**Docket No. EL18-34-000**

AFFIDAVIT OF DR. ANTHONY GIACOMONI ON BEHALF OF PJM INTERCONNECTION, L.L.C

1. My name is Anthony Giacomoni. My business address is 2750 Monroe Blvd., Audubon, Pennsylvania, 19403. I am Senior Market Strategist, Emerging Markets, of PJM Interconnection, L.L.C. ("PJM"). I am submitting this affidavit on behalf of PJM in support of its Initial Brief concerning fast-start pricing reforms the Commission is considering in PJM's markets. Specifically, I provide support for PJM's proposal to implement integer relaxation as an appropriate means to treat fast-start resources as dispatchable from zero to the resource's economic maximum operating limit for the purpose of calculating prices.

Qualifications

2. I joined PJM in May 2017. As a Senior Market Strategist, I conduct research and analysis relating to emerging issues in the energy industry and their relevance to wholesale electricity markets. I also support the tracking of issues affecting PJM's strategy as well as the development and expansion of PJM's market and service offerings. Prior to joining PJM, I was a Market Analyst and later Senior Engineer at ISO New England. As a Market Analyst, I worked in the internal market monitoring department where I helped assess the competitiveness of New England's wholesale electricity markets. As a Senior Engineer, I worked in the resource adequacy department where I performed production-cost simulations and electricity market studies related to renewable energy integration, transmission congestion, economic transmission planning, resource planning, and fuel consumption analysis.

3. I hold a Doctor of Philosophy degree in Electrical Engineering and a Master of Science degree in Electrical Engineering from the University of Minnesota. I also hold a Bachelor of Science degree in electric power engineering and economics from Rensselaer Polytechnic Institute.

Overview

4. To effectuate the goal of allowing fast-start resources to be eligible to set price when such resources are needed during times of tight system conditions, as I understand the Commission's goal to be in this proceeding, it is necessary to relax any limiting parameters that would prevent such resources from setting prices. Otherwise, prices may be set by offers from lower cost more flexible resources even though those resources may be dispatched

down to allow the fast-start units to be utilized to fulfil the system's needs, thus ensuring reliability.

5. I have reviewed the Commission's Notice of Proposed Rulemaking ("NOPR") concerning fast-start pricing as well as the Commission's Order in this proceeding concerning fast-start pricing in PJM. I agree with the Commission's premise that allowing fast-start resources to be fully dispatchable between zero and their economic maximums in the pricing run is an appropriate method to allow fast-start resources to set the price – i.e., Locational Marginal Price ("LMP").

6. There is more than one way to achieve this objective. The Commission set forth one method: economic minimum relaxation whereby the economic minimum of a resource is relaxed down to zero. PJM proposes an alternative method: integer relaxation whereby the commitment variable is allowed to fluctuate between zero and one rather than being fixed at zero or one. Integer relaxation is superior to economic minimum relaxation for various reasons, which I will discuss herein.

Description of Integer Relaxation

7. The "integer" in integer relaxation refers to the commitment status of a particular resource. During the commitment and dispatch processes, the commitment variable is represented by a value of zero or one indicating whether the resource has been committed or not, respectively. In the optimization problem, the commitment variable is multiplied by the commitment costs of a resource (i.e., start-up cost and no-load cost). The commitment variable is also multiplied by operating parameters that must be enforced if the resource is committed. These operating parameters include Economic Minimum and Economic Maximum as well as others. In integer relaxation, the commitment variable is allowed to fluctuate between zero and one rather than being forced to an integer state of one or the other.

8. PJM proposes to separate the dispatch run from the pricing run, as I understand the Commission suggested it do. Under that construct, PJM will execute the dispatch run first, determining the security constrained economic dispatch through a straightforward optimization that enforces the full set of operating limitations on all generators as well as the integer commitment state. The output of the dispatch run is the set of dispatch instructions that are sent to generation resources to control the system. In the pricing run, the commitment state of each fast-start resource will be allowed to vary between zero and one. This is achieved by relaxing the integer variables normally fixed at either zero or one in the dispatch run, where zero represents a unit that is offline and one represents a unit that is online. As a result, each fast-start resource in the pricing run will be allowed to be partially committed. For example, if a 100 MW inflexible fast-start resource's commitment variable is set to 0.5 in the pricing run, it indicates that 50 percent of the output of the unit was needed. If it was set to 0.75, 75 percent of the output of the unit was needed. Permitting these resources to be partially committed is what makes them eligible to set the LMP.

Integer Relaxation is Superior to Economic Minimum Relaxation

9. There are several benefits to integer relaxation over economic minimum relaxation.

10. First, integer relaxation automatically incorporates commitment costs (start-up and no-load costs) into the clearing price calculation without the additional administration required by economic minimum relaxation. In the optimization model, the commitment variable is multiplied by the start-up and no-load cost parameters. Thus, increasing the commitment state of a resource causes the objective function to incur start-up and no-load costs automatically.

    This is superior to economic minimum relaxation, which does not consider commitment costs without calculating adjusted offers. That is, in economic minimum relaxation, the flexible dispatch range of a resource is increased in the pricing run by relaxing a resource's economic minimum (and down ramp rate) to zero to increase its ability to set the price. Doing this alone, though it allows fast-start units to set price, does not permit the inclusion of start-up and no-load costs into the LMP. To achieve this recognition of start-up and no-load costs under an economic minimum relaxation approach, start-up and no-load costs must then be amortized over an administratively determined output level and time period, typically economic maximum and minimum run time, and added into an adjusted energy offer calculated to set price.

    I understand that in the NOPR the Commission proposed to use the following method to amortize start-up costs for fast-start resources. Amortized start-up costs would be set as equal to a resource's start-up cost divided by the product of its economic maximum operating limit and its minimum run time. The NOPR method for amortizing no-load costs would be established as the no-load cost in $/hour divided by the resource's economic maximum. The amortized start-up and no-load costs would then be added to the incremental energy offer to determine the enhanced energy offer for price-setting purposes. Upon expiration of the minimum run time, the Commission proposed to remove the amortized start-up and no-load cost terms from the enhanced energy offer so that beyond the minimum run time, the resources incremental energy offer would be used in price setting.

    This administrative process of calculating adjusted energy bids adds unneeded complexity to the fast-start implementation. PJM's integer relaxation method greatly simplifies this complex administrative process.

11. Second, integer relaxation requires no changes to the optimization model in the pricing run, compared to the dispatch run, except for the relaxation of the integer commitment variables and allowing them to be continuous between zero and one. In the economic minimum relaxation implementation, down ramp rates must also be relaxed to ensure that a fast-start resource is truly dispatchable down to zero MW and is not limited by its ramp rate. Otherwise, simply relaxing a fast-start resource's economic minimum limit would not guarantee that it would be dispatchable down to zero MW. Instead, the amount that it would be able to be dispatched down would be limited by its down ramp rate. Integer relaxation

eliminates the need to modify multiple constraints in the optimization model as in economic minimum relaxation.

12. Finally, the Midcontinent Independent System Operator, Inc., ("MISO") employs a relaxation methodology for fast-start resources that is analogous to integer relaxation. Specifically, MISO implements separate dispatch and pricing runs to allow fractional commitments of fast-start resources in the pricing run to set prices, despite the fact that such resources cannot physically achieve the outcome. This is analogous to integer relaxation, which will allow a fast-start resource to be partially committed, as I described above.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.) **Docket No. EL18-34-000**

Dr. Anthony Giacomoni, being first duly sworn, deposes and states that he is the Dr. Anthony Giacomoni referred to in the foregoing document entitled "Affidavit of Dr. Anthony Giacomoni" that he has read the same and is familiar with the contents thereof, and that the facts set forth therein are true and correct to the best of his knowledge, information, and belief.

Anthony Giacomoni

Subscribed and sworn to before me, the undersigned notary public, this 12TH day of February, 2018.

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Linda Spreeman, Notary Public
Lower Providence Twp., Montgomery County
My Commission Expires Nov. 17, 2019
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

Linda Spreeman
Notary Public

My Commission expires: November 17, 2019

ATTACHMENT B

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.	)	**Docket No. EL18-34-000**

AFFIDAVIT OF CHRISTOPHER PILONG
ON BEHALF OF PJM INTERCONNECTION, L.L.C

1. My name is Christopher Pilong. 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 in support of its Initial Brief concerning fast-start pricing reforms the Commission is considering in PJM's markets.

2. Specifically, I provide support for PJM's proposal to define fast-start resources in a manner that reflects how PJM commits resources to meet the needs of the system. In PJM, such commitments are made through Intermediate Term Security Constrained Economic Dispatch ("IT SCED") which is based on a two-hour look ahead and commits resources with a start-up time of two hours or less and a minimum run time of two hours or less.

Qualifications

3. I joined PJM in November of 2001. As Director, Dispatch, I am responsible for the oversite and operation of the Valley Forge and Milford Control Centers. This function includes ensuring the reliable operation of the power grid, in accordance with all PJM and NERC standards pertaining to the functions of 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. Prior to this position, I served as a Reliability Engineer and then the Manager – Reliability Engineering. As the Manager for the Reliability Engineering group, I managed the group responsible for coordinating day ahead and real time operating plans between PJM, its members Transmission Owners and Generation Owners and our neighboring entities. As a Reliability Engineer prior to this, I performed these functions directly.

4. I hold a Bachelor of Science degree in Electrical Engineering from Lehigh University and a Master of Business Administration from Villanova University

Need for Fast-Start Resources

5. System operators need to be able to call on fast-start resources during real-time system conditions that can be short term in nature. Having the ability to dispatch fast-start resources allows operators to efficiently manage net demand and control transmission constraints by only scheduling the resources the system needs. By waiting until closer to real time, the

inherent forecasting error from day ahead forecasts can be mitigated. This results in more accurate system prices and reduces over scheduling of the system. In addition, fast-start resources provide reliability attributes in the form of system reserves and the ability to rapidly respond to unforeseen system conditions.

Classification of Fast-Start Resources in PJM Operations

6. PJM utilizes real-time operational tools for commitment decisions. Specifically, PJM's real-time dispatch tool known as the IT SCED application is an integral component of PJM real-time applications. The IT SCED application is a two hour look-ahead optimization engine with an objective function to provide the least cost solution to meet projected load, reserve requirements and interchange, while ensuring all transmission system constraints are maintained within limits.

7. By design, IT SCED tool only looks at system conditions two hours out to arrive at a recommendation that is most likely to meet actual system conditions. That is, PJM has determined that the most accurate reflection of what the system will look like, while providing some lead time, is two hours. Given this, the output of the IT SCED solution is fast-start resource commitment recommendations to ensure this objective function is met.

8. This solution set represents the marginal decision for commitments in PJM, based on PJM's operational tools. Allowing these resources to set price will have the benefits of ensuring price is consistent with operator actions and reducing uplift.

9. The set of resources for which this application makes commitment recommendations in real-time are those resources that can start in less than or equal to two hours and have a minimum run time of two hours or less.

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Christopher Pilong, being first duly sworn, deposes and states that he is the Christopher Pilong referred to in the foregoing document entitled "Affidavit of Christopher Pilong" that he has read the same and is familiar with the contents thereof, and that the facts set forth therein are true and correct to the best of his knowledge, information, and belief.

Subscribed and sworn to before me, the undersigned notary public, this 12th day of February, 2018.

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Linda Spreeman, Notary Public
Lower Providence Twp., Montgomery County
My Commission Expires Nov. 17, 2019
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