UNITED STATES OF AMERICA

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

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

REPLY BRIEF OF THE PJM POWER PROVIDERS GROUP

Pursuant to the order instituting a Section 206 proceeding and commencing paper hearing procedures and establishing a refund effective date, issued December 21, 2017 ("Fast Start Order"),[1] the PJM Power Providers Group ("P3")[2] hereby submits a reply brief and an expert affidavit from Robert B. Stoddard ("Attachment A: Affidavit of Robert B. Stoddard"). P3 respectfully submits these reply comments in response to the briefs filed by PJM Interconnection, L.L.C. ("PJM"),[3] the PJM Independent Market Monitor ("PJM IMM")[4] and the

[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 (issued December 21, 2017) ("Fast Start Order").

[2] P3 is a non-profit organization dedicated to advancing federal, state and regional policies that promote properly signed and well-functioning electricity markets in the PJM Interconnection, L.L.C. ("PJM") region. Combined, P3 members own over 84,000 MWs of generation assets, produce enough power to supply over 20 million homes and employ over 40,000 people in the PJM region covering 13 states and the District of Columbia. For more information on P3, visit www.p3powergroup.com. The comments contained in this filing represent the position of P3 as an organization, but not necessarily the views of any particular member with respect to any issue.

[3] Initial Brief of PJM Interconnection, L.L.C., Docket No. EL18-34-000 (filed February 12, 2018) ("PJM Initial Brief").

[4] Initial Brief of the Independent Market Monitor for PJM, Docket No. EL18-34, (dated February 12, 2018) ("IMM Initial Brief").

Department of Market Monitoring for the California Independent System Operator ("CA DMM").[5]

As stated in its initial comments, P3 agrees with the Commission's finding that PJM's practices related to the pricing of certain generation resources are unjust and unreasonable and urges the Commission to expeditiously rectify the inequities in PJM's current energy market so as to ensure just and reasonable rates.

On February 12, 2018, PJM submitted its initial comments in response to the Commission's directive. PJM's proposal included in its Initial Brief largely tracks the reforms suggested by the Commission with notable improvements in order to tailor the Commission's directive to PJM's market ("PJM proposal"). P3 generally believes that PJM's response to the Commission's Fast Start Order is appropriate and should be accepted – with one notable exception. In support of the PJM proposal, P3 is pleased to offer the attached affidavit from Robert B. Stoddard. P3 continues to urge the Commission to require PJM to take action by expeditiously issuing a final order in this proceeding in order to bring much needed reform to PJM's energy markets.

I. Existing PJM rules are not just and reasonable

As both PJM and the Commission have observed, PJM's existing tariff provisions governing the pricing of fast start resources are not just and reasonable. Because of limitations embedded in PJM's existing rules, certain units that are running at the specific direction of PJM

[5] Comments of the Department of Market Monitoring for the California Independent System Operator, Docket No. EL18-34 (dated February 9, 2018); Errata to February 9, 2018, Comments of the Department of Market Monitoring for the California Independent System Operation Corporation in the PJM Interconnection, L.L.C. under EL18-34 (February 9, 2018).

are not eligible to set price. This logical disconnect needs to change if PJM's markets are going to appropriately price energy and provide the correct signal to buyers and sellers in PJM.

The attached affidavit from Robert B. Stoddard strongly supports the conclusion that reforms are necessary in PJM and the Commission's preliminary finding that PJM's current tariff is not just and reasonable is "well-supported by economic theory and the particular facts of the PJM energy markets."[6] As it relates to fast start units specifically, the fundamental problem is that PJM's current pricing design does not generally allow these units to set price and, in the limited situations when it does, start-up and no-load costs are not included. As a result of this market design flaw, as Mr. Stoddard observes, the incremental costs of these units are understated and the resulting LMPs do not appropriately reflect the value these resources provide to the grid. Therefore, as Mr. Stoddard concludes, "LMPs are providing inadequate market signals to customers to reduce energy consumption, to developers to build or upgrade generation to meet actual system needs, and to transmission planners to build costs-effective infrastructure."[7]

Instead, PJM leans on uplift payments in order to make individual generators whole at the expense of the appropriate price signals to the market. The Commission has gone to great lengths in other proceedings to reduce the occurrence of uplift payments in the organized markets.[8] In many respects, this proceeding represents an opportunity to build on the progress the Commission has made in these other dockets.

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[6] Affidavit of Robert B. Stoddard on Behalf of the PJM Power Providers Group, dated March 14, 2018 ("Stoddard Affidavit"), p. 2.

[7] Stoddard Affidavit, p. 3.

[8] *Uplift Cost Allocation and Transparency in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. RM17-2; 158 FERC ¶ 61,047 (January 19, 2017).

Moreover, the current PJM market design leads to energy imbalances as different assumptions related to the economic minimum operating limits in the pricing run and the dispatch run can lead to the over-procurement of generation. When a resource generates more power than is anticipated by the pricing run, PJM must correct for this imbalance by procuring regulation down service. In effect, creating a lose-lose for consumers who are required to not only pay for the additional generation, but also the regulation service necessary to balance the system.

II. PJM's Proposed Response is Generally Just and Reasonable

P3 generally supports the proposed tariff changes proffered by PJM. With one notable exception regarding the inclusion of commitment costs in the Day-Ahead and Real-Time markets, PJM has put forth a just and reasonable framework that addresses the problems embedded in the current market design. If enacted, PJM's proposal will reduce uplift, produce price signals that are more reflective of market conditions and improve the over-generation problem caused by the current market design. Specifically, P3 offers the following comments on specific aspects of PJM's proposal:

A. Integer Relaxation is an Appropriate Means to Establish the Clearing Price for Fast Start Resources.

The Commission, in its Fast Start Order, recognized that the current binary nature of a unit's commitment in PJM (either on or off) was not appropriate and proposed that units should be considered dispatchable up to the unit's economic minimum. By doing so, energy prices will be eligible to be set by the fast start unit (which is needed to meet system needs), instead of a lower cost unit that is being dispatched down in order to accommodate the output of the fast start resource.

PJM proposes that pricing and dispatch runs be separated and that fast start resources be allowed to have fractional commitments in the pricing run in order to set price. In other words, if only half of a fast start unit is needed to meet the system's needs then PJM would set the price based on that unit instead of the current paradigm that would set the price based on a lower cost unit and compensate the fast start resource with an uplift payment. A similar approach to fast starting commitment is already employed in the Midcontinent Independent System Operator ("MISO") and generally achieves the goals the Commission is looking to achieve in this proceeding.

This approach proposed by PJM represents a logical deviation from the Commission's proposed approach of simply relaxing a unit's economic minimum up to 100 percent. As PJM articulates, integer relaxation easily incorporates commitment costs into the pricing run as opposed to economic minimum relaxation which excludes commitment costs and then amortizes those costs over the minimum run time. Moreover, PJM offers that integer relaxation is easier to administer and achieves the "same desired result."[9]

P3 agrees with PJM that integer relation represents a preferable means of achieving the Commission's goal of allowing market prices to be set by fast start units and is certainly a just and reasonable means of accomplishing the goal. As Mr. Stoddard concludes in his affidavit, "The 206 Order seeks to allow a fast-start resource to set the energy price regardless of what portion of that resource is needed to serve load. The Commission indicated a particular method to achieve this goal, namely relaxation of EcoMin to zero. PJM's proposal differs only in its

[9] PJM Initial Brief, p. 8.

technical implementation but is as fully effective achieving the policy goal laid out in the 206 Order."[10]

B. In PJM, the Definition of Fast-Start Resources Should include those Resources which have a Start-Up and Minimum Run Time of Two Hours or Less.

As PJM noted in its filing, PJM's employs a two hour look ahead optimization engine that evaluates projected needs and current system conditions/capabilities while maintaining transmission limitations. The two hour look ahead was chosen because it provides "…the most accurate reflection of what the system will look like, while providing some lead time. . ."[11] Consequently, the resources that PJM decides to commit to the market 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.

As a result of PJM's long-standing optimization engine, two hours has become the benchmark for fast start capability and resources have been developed accordingly. Not surprisingly, 57% of the uplift payments made in 2017 were to units with start-up and minimum run times of less than two hour hours while a mere 20% of the 2017 uplift payments made last year were to units with start-up and minimum run times of less than sixty minutes.[12]

In short, the use of two-hour minimum run and start up times for PJM simply makes sense. With PJM's resource mix and current operating practices, a two hour standard for start-up and minimum run times will most effectively address the commission's desire to properly price fast-start resources and reduce uplift. As Mr. Stoddard concludes, "Given the institutional

[10] Stoddard Affidavit, p. 11.

[11] PJM Initial Brief, p. 15.

[12] PJM Initial Brief, p. 4.

history in PJM and the reality that PJM commits on a two-hour look ahead, PJM's proposal will reflect its actual operations better than a narrower definition."[13]

C. PJM's Proposal Should be Modified So Commitment Costs are Reflected in Both Real-Time and Day-Ahead Prices

As noted above, P3 generally agrees with PJM's brief, however regarding commitment costs the PJM proposal needs revising. As PJM noted in its brief, it is "appropriate to keep the pricing models between the markets consistent to avoid inefficient arbitrage opportunities."[14] Unfortunately, the PJM proposal strays from this principle by applying start-up and no-load costs only in the market in which the commitment is made. So, as PJM proposes, a unit could be committed in the Day-Ahead market with its costs included in the price used to make the commitment decision, but if run in Real-Time market those commitment costs would not be used to calculate LMP.

As Mr. Stoddard explains in his affidavit, such a market design is likely to lead to unintended outcomes:

> "Under PJM's proposal, however, day-ahead LMPs could be set by a Fast-Start Unit, but then in real-time the LMPs would be set not by this Fast-Start Unit but rather by the highest cost flexible resource (as today). This creates a troublesome opportunity for arbitrage through virtual bidding between these two markets. My concern is compounded by the asymmetric knowledge of when these conditions occur: the owner of the Fast-Start Unit knows that its bid set the day-ahead LMP, but others may not, giving the owner an advantaged position to exploit the potential price divergence between the two markets."[15]

To remedy this concern, P3 offers that there should be a symmetry in the treatment of fast start resources in the Day-Ahead and Real-Time markets. Specifically, no load and start-up costs

[13] Stoddard Affidavit, p. 12.

[14] PJM Initial Brief, p. 3.

[15] Stoddard Affidavit, p. 17.

should be reflected in the prices of the Day-Ahead AND Real-Time markets. Such an outcome is entirely consistent with the goals articulated by the Commission in this docket, appropriately sets the price of energy in both markets, and eliminates a troublesome arbitrage opportunity that currently exists in the PJM proposal.

III. Concerns Expressed by the PJM IMM and the CA DMM Do Not Render PJM's Proposal Unjust and Unreasonable

The PJM IMM and the CA DMM raise a myriad of issues – none of which render PJM's proposal unjust and unreasonable. For example, the PJM IMM suggests that conservative operator practices in PJM lead to a false view of actual system conditions in PJM preventing scarcity pricing from being triggered in situations when it is warranted. While noting that the PJM proposal will help to mitigate the impact of operator actions, P3 agrees that the impact of conservative operator practices is an issue that is worthy of further explanation and suggests that this issue be addressed in another forum; however, the matter is beyond the scope of this proceeding.

At the core of the Market Monitors' (PJM and CA) preferred approach for pricing all units, not just fast start units, is a position that is fairly consistent with the status quo. Specifically, the Market Monitors espouse a rigid view that, "Locational Marginal Price is the additional cost incurred to meet an additional MWh of load at any pricing location." The Commission has found such a doctrinal approach to be not just and reasonable as applied to PJM, because of the numerous irrational outcomes it creates in the market. Specifically, the Commission in the Fast Start Order that has preliminarily found just and reasonable minimum start-up and run times far in excess of the five-minute view taken by the PJM IMM.[16] In

[16] Fast Start Order, p. 15.

addition, the Commission has already accepted fast-start pricing mechanisms in ISO-NE, MISO, NYSIO and PJM (albeit on a watered-down basis).

In his attached affidavit, Mr. Stoddard challenges the economic theories underpinning both Market Monitors' views. As Mr. Stoddard states, "The principal point in dispute is what "marginal cost" or "incremental cost" should encompass. [The] position [of the IMM and CA DMM] is that prices must be set looking only at the change in total costs from serving a small increment of load within one dispatch period. … The increment of load, and the time over which it persists on the system, must be tied to a commercially reasonable and meaningful timeframe. But, as we move from infinitesimal [changes] to larger increments, the commercially reasonable level to assess need not be one MWh and five minutes, as advocated by the IMM and CA DMM."[17]

In the end, the comments of both Market Monitors do not render the PJM approach unjust and unreasonable. Indeed, the Market Monitors fundamentally disagree with prior Commission orders on fast-start pricing and the conclusion in this proceeding that reforms in PJM are necessary. PJM has put forth a just and reasonable framework to transition the pricing of fast start resources to a just and reasonable tariff construct. Nothing raised by the Market Monitors should provide the Commission pause.

IV. Conclusion

While P3 appreciates the Commission's continued interest in addressing energy market reforms in PJM, as it pertains to the pricing of Fast Start resources, it is well past the time for action. The Commission is currently on a trajectory to be evaluating these issues for over four

[17] Stoddard Affidavit, p. 12-14.

year. While admittedly these issues are challenging, additional deliberations are no longer necessary and the time for action is upon us.

PJM has put forth a reasonable proposal to address the challenge of appropriately pricing Fast Start units in the market that will reduce uplift and improve energy market price signals. While P3 supports a modification to eliminate an arbitrage opportunity between the Day-Ahead and Real-Time markets, the PJM proposal is generally just and reasonable and a significant improvement over the status quo. The Commission should approve the PJM proposal, with the modification suggested by P3, and bring this matter to a close before even more time passes contemplating an identified yet unaddressed set of problems that continue to plague the market.

Respectfully submitted,

On behalf of the PJM Power Providers Group

By: */s/ Glen Thomas*

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March 14, 2018

CERTIFICATE OF SERVICE

I hereby certify that in accordance with Rule 2010 of the Commission's Rules of Practice and Procedure, 18 C.F.R. § 385.2010 (2017), I have served a copy of the foregoing to all parties on the official service list in these proceedings.

Respectfully submitted,

On behalf of the PJM Power Providers Group

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March 13, 2018

Attachment A

Affidavit of
Robert B. Stoddard

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

AFFIDAVIT OF ROBERT B. STODDARD
ON BEHALF OF THE PJM POWER PROVIDERS GROUP (P3)

I, Robert B. Stoddard, being duly sworn, depose and say:

I. QUALIFICATIONS

1. My name is Robert B. Stoddard. I am an economist and principal of Power Market Economics LLC at 28 Monument Square, Portland, Maine 04101. I am also the president and chief executive of GWave LLC, an ocean wave energy technology firm. As CEO of GWave, I provide executive leadership for a technology startup developing a new generation of ocean wave energy converters. Prior to joining GWave, I led the energy practice at Charles River Associates, a global consultancy, where I remain a senior consultant. My consulting work focuses on electricity industry restructuring, capital investment in power markets, and providing both strategic analyses and testimony for utilities, generation owners, and governments regarding the practical implications of market design. I have frequently testified to the Federal Energy Regulatory Commission ("the Commission") as well as to state utility commissions and legislatures on competitive market design, rates, and market power issues, particularly in the regions managed by the northeastern Regional Transmission Organizations. I am an active participant in PJM's Energy Price Formation Senior Task Force, which is considering broader pricing reforms to supplement those proposed by PJM in this docket. I hold degrees in economics from Amherst College and Yale University. My complete *curriculum vita* is attached as Exhibit RBS-1.

II. PURPOSE AND OVERVIEW

2. I have been asked by P3 to respond to PJM's proposed tariff changes responsive to the Commission's order in this docket (the "206 Order")[1] and the positions presented in the

[1] *PJM Interconnection, L.L.C.*, Order Instituting Section 206 Proceeding and Commencing Paper Hearing Procedures and Establishing Refund Effective Date, 161 FERC ¶ 61,295 (issued December 21, 2017) ("206 Order")

briefs and comments by other parties, particularly those of the Independent Market Monitor for PJM ("IMM")[2] and the Department of Market Monitoring for the California Independent System Operator Corporation ("DMM").[3]

3. This affidavit addresses a series of economic and market design questions raised by PJM and others. First, I discuss the flaws in PJM's current pricing treatment of fast-start units that led to the Commission's preliminary conclusion that important elements of PJM's tariff are neither just nor reasonable, and that would be remedied by PJM's proposed Fast-Start Unit pricing. Second, I explain why I support the three particular market design choices PJM proposes that diverge from the initial guidance given by the Commission. Third, I explain why I support the changes proposed by PJM and contrary to the opposing views presented by the IMM and DMM. Finally, I raise concerns with PJM's proposed asymmetrical treatment of fast-start resources in the Day-Ahead and Real-time Energy Markets.

III. PJM'S CURRENT FAST-START UNIT PRICING CREATES ECONOMIC INEFFICIENCIES

4. After extensive deliberations over the past five years by the Commission on issues of energy market pricing,[4] the Commission in its 206 Order reaches preliminary conclusions that several aspects of the PJM Fast-Start Unit pricing are not just and reasonable. On the basis of my personal knowledge of the markets in PJM and elsewhere, as well as the materials from these earlier dockets, I believe that the Commission's preliminary findings are well-supported by economic theory and the particular facts of the PJM energy markets. In particular, PJM's current practices result in inefficiencies because:

    a. The resulting LMPs do not reflect the incremental costs of serving load, including no-load and start-up costs, considered in the appropriate timeframe;

    b. The modest level of economic minimum operating level ("EcoMin") relaxation used today creates many situations in which Fast-Start Units dispatched to meet load are not eligible to set LMP and fails to price relevant commitment costs;

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[2] Initial Brief of the Independent Market Monitor for PJM ("IMM Brief") and Reply Brief and Answer of the Independent Market Monitor for PJM ("IMM Reply Brief").

[3] Comments of the Department of Market Monitoring for the California Independent System Operator Corporation ("DMM Comments").

[4] Particularly under *Fast-Start Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket No. Rm17-3-000 and *Price Formation in Energy and Ancillary Services Markets Operated by Regional Transmission Organizations and Independent System Operators*, Docket. No. AD14-14-000.

c. The order of the pricing and dispatch runs results in inefficient system operations created today by imbalanced energy schedules;

d. The actual costs of meeting load are collected in uplift instead of energy prices, thus socializing costs across time and space that should be localized. Thus LMPs are providing inadequate market signals to customers to reduce energy consumption, to developers to build or upgrade generation to meet actual system needs, and to transmission planners to build cost-effective infrastructure.

5. I take up each of these points in turn. PJM's outlined proposal for fast-start unit pricing would, I believe, correct the most serious of these issues.

III.A PJM'S PRICING MODEL SHOULD CAPTURE COSTS INCURRED IN COMMERCIALLY RELEVANT TIMEFRAMES

6. First, the academic literature is clear that there is no single correct way of pricing energy. As Harvard economist Professor William Hogan writes:

> Unit commitment with economic dispatch introduces discontinuities into the electricity market model; e.g., the plant is committed or not. The usual interpretation of market-clearing prices has the economic dispatch as consistent in the sense that the dispatch is a profit-maximizing solution for the individual generators and load that take the prices as given. However, this market-clearing definition ignores the effects of the discrete decisions that define the discontinuities. In the presence of these conditions, there may be no set of prices that supports the economic dispatch as the market clearing solution. In other words, given the prices some generators or loads may have an incentive to deviate from the economic dispatch.[5]

7. The full optimization problem that PJM must attempt to solve is to minimize the total cost of serving load reliably, subject to many physical constraints. The pricing run, however, uses a simplified form of the operational problem for two reasons, discussed below. The pricing run computes LMPs looking only at a restricted problem, ignoring whole classes of costs, dropping some units from the pricing model, and ignoring constraints across time in order to determine a unique set of energy and ancillary service prices in a computationally tractable way. Thus the pricing solution and the dispatch solution can, and do, systematically diverge, resulting in non-transparent LMPs that do not well reflect

[5] William W. Hogan (2014), "Electricity Market Design and Efficient Pricing: Applications for New England and Beyond," p.17 at https://sites.hks.harvard.edu/fs/whogan/Hogan_Pricing_062414.pdf.

the costs of units dispatched to serve load or reserve requirements. This divergence between LMPs and dispatch results in the need for out-of-market payments. Including more of the constraints that drive the commitment and dispatch run into the pricing run provides a more visible and accurate price signal to load and supply alike. LMPs that better match actual system operations also reduce the required uplift payments. The challenge is selecting the constraints and costs to price that are computationally tractable and commercially relevant. The take-away should be, though, that there is no single "right" way to price power: any pricing model involves making certain tradeoffs to yield market-clearing prices. Each tradeoff has consequences on the short- and long-run efficiency of the energy markets.

8. As I noted, there are two fundamental problems developing market-clearing energy prices. First, the fully specified model is computationally intractable because it is a mixed-integer program; that is, some of the control variables take integer values (*e.g.* a generator is either on or off), while other variables are continuous (*e.g.* the dispatch level of a generator). Modern computer science simply does not have the capability of guaranteeing exact solutions to mixed-integer programs, especially when they are of the scale and complexity as PJM's system.[6] Moreover, when PJM originally needed to implement LMPs and nodal dispatch signals, computer software and hardware were far less capable than they are today. PJM, therefore, develops prices by taking unit commitment (and associated costs) as fixed, as well as ignoring cross-period constraints in pricing and other simplifications, to convert the pricing run from a mixed-integer program to a linear program, which as a class are computationally feasible.

9. Second and more fundamentally, the full pricing model fails to meet standard preconditions for efficient markets. For markets to work efficiently and converge to a "no-trades" solution, it must be the case that supply is (weakly) increasing with price, and that demand is (weakly) decreasing. When all costs are considered, however, this fundamental requirement is not met in the energy markets. Although the optimal commitment and dispatch yield total costs that (weakly) increase at each level of demand, this increase is not smooth, but has kinks as the slope changes with each successive unit added in commitment. Put formally, the total cost function is neither convex nor continuously differentiable. Therefore the supply curve, which is the first derivative of the total cost function, is also neither convex nor non-decreasing. If demand were sloped, these ups-

[6] See Richard M. Karp (1972), ""Reducibility Among Combinatorial Problems" in R. E. Miller and J. W. Thatcher (editors). *Complexity of Computer Computations*. New York: Plenum. pp. 85–103, and Zuckerman, David (1996). "On Unapproximable Versions of NP-Complete Problems". *SIAM Journal on Computing* 25 (6): 1293–1304.

and-downs in the supply curve could result in there being several dispatch points at which supply and demand intersect, and thus no unique set of prices that meet demand.

10. I provide a simple example of the issues raised by one contributor to non-convexity in Exhibits RBS-2 and RBS-3.[7] In this example, two units, A and B, are available to meet load. Unit B has a start-up cost, Unit A does not, as shown in the table on Exhibit RBS-2. Given the costs of these units, the least-cost commitment and dispatch uses Unit A only up to a particular load level, then commits Unit B. Unit B has lower marginal energy costs than Unit A, however, causing the slope of the aggregate cost function to flatten at load levels where it is economic to commit Unit B. Consequently the marginal cost function—that is, the supply curve—does not (weakly) rise as load levels rise, as shown in Exhibit RBS-3. A hypothetical demand curve D may cross the supply curve at several points, as shown. Thus non-convexity leads to non-uniqueness of energy pricing. Because PJM models demand response as a supply rather than a modifier to load, the energy market demand curve is effectively a vertical line, but the non-convexity of the supply curve means that prices can (and do) fall even as load *and total cost* increase, even without any other changes to the system (*e.g.* unit availability, fuel prices, *etc.*).

11. To address both issues—computational feasibility and convexity—PJM's energy pricing runs currently simplify the program by not reflecting any commitment costs of units and generally not allowing generators with inflexible operations to set clearing prices. This is one approach, but it is not the only approach. As I discussed in a recent affidavit on a parallel matter, there are a range of ways to create computationally feasible and convex pricing problems that are more closely linked to the actual costs of the system.[8] PJM's current pricing design is close to one extreme of simplification (arguably, to the point of oversimplification), with no fixed costs and only some non-dispatchable units modeled only in a limited way. Its proposal moves the pricing procedure along this continuum of potential solutions, closer to the Convex Hull Pricing approach studied by Commission staff in AD14-14 and implemented, in part, by the Midwest ISO.[9]

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[7] Both exhibits are drawn from Paul R. Gribik, William W. Hogan, and Susan L. Pope (2007) "Market-Clearing Electricity Prices and Energy Uplift", December 31, 2007, available at https://sites.hks.harvard.edu/fs/whogan/Gribik_Hogan_Pope_Price_Uplift_123107.pdf (henceforth "Gribik *et al.* (2007)").

[8] *Grid Reliability and Resilience Pricing,* Docket No. RM18-1-000, Affidavit for Robert B. Stoddard on behalf of PJM Power Providers, at PP 8–18.

[9] Potomac Economics, Independent Market Monitor for MISO (June 2016), *2015 State of the Market Report for the MISO Electricity Markets*, at page xi. (https://www.potomaceconomics.com/wp-content/uploads/2017/02/2015-State-of-the-Market-Report.pdf) ("2015 MISO Market Report").

12. PJM's use of the restricted LMP model carries with it serious market inefficiencies. Many of these issues have been identified in earlier dockets on Fast-Start Pricing.[10] The inefficiencies are clearest as the timeframe of the analysis moves out from beyond one five-minute dispatch interval to those timeframes that are economically important. Energy prices should include those costs that are variable in the relevant time step.

13. Although it is important for both dispatch and settlements to use a short time step (e.g. five minutes), that need does not likewise compel the exclusion of all costs incurred over a longer time step from being included in energy and reserve prices. Prices should reflect costs incurred, and inform decisions made, over a long enough time to drive the market towards efficient solutions by evoking changes in supply and demand. From one five-minute dispatch interval to the next, however, there are relatively few commercial decisions made. Few consumers buy power at real-time prices. Any changes in operating conditions are almost always met by on-line resources, adjusting their operating points based on their filed offer prices. Imports and exports do not flow on a five-minute block. In short, having LMPs that reflect only five-minute costs achieve little marginal efficiencies.

14. Rather, most commercial decisions are made on a longer horizon, both on the supply and demand sides of the market. The most important decisions on the supply side are unit commitments by PJM. While most commitments are made day-ahead, either in the Day-ahead Energy Market or the Reliability Unit Commitment ("RUC"), some commitments are made closer to real time. As PJM has testified, a two-hour window is the timeframe it uses to decide on close-to-real-time unit commitment.[11] Even fast-start units that have been included in day-ahead do a check-back with PJM's system operators before physically committing the unit. Therefore, to match pricing to commercial decisions, it makes sense to include in energy prices those costs associated with fast-start units, including not only their marginal energy cost but also their start-up and no-load costs, suitably amortized. Similarly, the demand side of the market does not operate principally on a five-minute basis. Most price-responsive customers participate in a Demand Resource ("DR") program, so as to qualify for capacity payments. DR requires notification and activation time longer than five minutes. Under PJM rules, DR has up to 120-minute notification and activation time, and offer parameters (prices and quantities) are fixed 65

[10] See dockets referenced in fn. 4. In particular, these issues were discussed in the "Staff Analysis of Operator-Initiated Commitments in RTO and ISO Markets", Docket No. AD14-14-000 (December 2014).

[11] *PJM Interconnection, L.L.C.*, Docket No. ER18-34-000, Affidavit of Christopher Pilong on behalf of PJM Interconnection, L.L.C., Attachment B to the Initial Brief of PJM Interconnection, L.L.C.

minutes ahead of each hour.[12] Therefore, PJM's proposal to include the full costs of fast-start units is well matched to the reality of commercial decision-making of both supply and demand in the PJM market and, consequently, is likely to yield the greatest efficiency by sending appropriate prices to inform commercial decisions. The "increment of load" that is relevant is not a notional 0.1 MWh increment in a five-minute period; it is the load change that PJM forecasts from one two-hour commitment window to another.

III.B. ALL FAST-START UNIT COSTS SHOULD AFFECT PRICES

15. PJM's current pricing design does not generally include these fast-start costs, and even when these units can set price, their start-up and no-load costs are not included.[13] This omission masks the incremental cost of these units in LMPs, distorting the price signal needed for both short- and long-run efficiency. As discussed above, in the commercially relevant time frame of two hours, these costs are not sunk, but clearly variable. Even those fast-start units committed in the Day-ahead Energy Market are not sunk costs: P3 members inform me that in actual operations, the owner of a "committed" fast-start unit will not actually turn on the unit without first confirming with system operators, in real time, that the unit will be needed.

16. Moreover, for block-loaded units, the concept of "marginal energy cost" doesn't really apply—the incremental cost is having the unit on. PJM's current practice of artificially relaxing EcoMin creates a fiction unlinked from the change in the system costs when these units are activated to serve an increment of load.

17. Failure to include all of a fast-start unit's costs in the LMP sends incorrect price signals to the market. Suppose a large demand-side resource would curtail load at $400/MWh, but the marginal energy cost of a fast-start unit was only $300/MWh, but including commitment costs, the total cost is $450/MWh. If the LMP reflects only the $300/MWh energy cost, then the demand side resource would buy energy. Had it curtailed, though, and the fast-start unit not been called, the system would have saved $50/MWh (the $450/MWh savings in cost from the fast-start unit, net of the $400/MWh cost of DR).

III.C. PJM'S CURRENT PRACTICE RESULTS CREATES NEEDLESS INEFFICIENCY

18. As the Commission observed in its 206 Order, PJM's current implementation of fast-start unit pricing creates a needless inefficiency in physical dispatch. In today's Real-time

[12] PJM Manual 11: Energy & Ancillary Services Market Operations, §10.3

[13] The exception is that the energy cost of fast-start units can set the clearing price if at least 80% of the unit's EcoMin was needed.

Energy Market, PJM first executes a pricing run and then the dispatch run. In the pricing run, the EcoMin of qualified fast-start units is partially relaxed, thereby allowing these resources to set price in limited circumstances. In the ideal dispatch run, the actual parameters would be used. Today, however, the pricing run and the dispatch run are one and the same in in the Real-time Energy Market. This practice creates the potential for energy imbalance that must be corrected by operator actions. If, for example, because of partial EcoMin relaxation a block-loaded 100 MW fast-start unit is nominally dispatched at 82 MW, then a flexible unit has been dispatched up by 18 MW to maintain nominal energy balance. In physical reality, though, the block-loaded resource generates 100 MW, resulting in 18 MW of over-generation, which has to be compensated for by regulation or other flexible resource redispatch. The reality of these energy imbalances has been cited by PJM as the reason it only allowed a small relaxation in EcoMin.[14]

19. PJM's proposal to reverse the order of the pricing run corrects this energy imbalance and its resulting inefficiencies. It could, however, raise the potential of creating an economic incentive for generators to deviate from their instructed dispatch level. Specifically, units whose energy was not part of the least-cost commitment and dispatch, but whose marginal energy cost is below the LMP set by a fast-start unit, have an incentive to over-generate. This problem is a familiar one in energy and reserves markets, as it arises whenever posted prices create economic incentives to operate inconsistently with dispatch instructions. For example, reserve units forego earning margin in the energy markets; units are committed by PJM for reliability even if they do not earn enough margin in the energy market to cover their operating costs; block-loaded fast-start units operate even if the real-time LMP is below their energy cost. So the deviation incentive is a familiar problem with established solutions. The core principle, however, should be to set prices transparently and consistent with the actual dispatch of the system, but acknowledge that there is no set of energy prices that can actually support the least-cost commitment and dispatch without the need for additional payments to align the financial signals from the market with the dispatch signals from the operator.

20. PJM proposes, consistent with guidance in the 206 Order, to use lost opportunity cost ("LOC") credits to align the financial incentives of operators of those resources dispatched below their EcoMax to accommodate the actual EcoMin of needed fast-start units. When the price is set by a fast-start unit, these flexible units would realize higher profits by over-

[14] Presentation of Dr. Anthony Giacomoni, Senior Market Strategist, PJM Interconnection, L.L.C. to the Energy Price Formation Senior Task Force, "FERC Docket EL18-34-000 Fast-Start Resources" (December 18, 2017), available at http://pjm.com/-/media/committees-groups/task-forces/epfstf/20180118/20180118-fast-start-pricing.ashx .

generating. The LOC credits solve the incentive problem directly by leaving the generator financially whole by following dispatch instructions rather than pursuing the profit-maximizing course indicated by market prices alone. Such payments are already used by PJM in its ancillary service markets and by other ISOs/RTOs in their markets.

21. The Midwest ISO has adopted fast-start pricing rules that are generally similar to PJM's proposal, but they include a different incentive mechanism to avoid over-generation: penalties. In principle these have the same net financial effect but create a more adverse "do this or else" situation that, from a behavioral economics perspective, may be less effective than PJM's proposal to extend its existing practices to align generator incentives with LMPs set under fast-start unit-pricing.

III.D. PJM'S CURRENT PRACTICE SUPPRESSES PRICE INFORMATION

22. By failing to reflect the full costs of fast-start units in LMPs, PJM's current practice removes important price signals from the market. When PJM needs to deploy fast-start units to meet load reliably, it incurs real and substantial costs to serve customers. Today, however, prices do not reflect these costs. Instead, most of these costs are assigned to uplift, which is collected broadly from loads (both in terms of time and geography), greatly diluting any economic signal associated with the costs. The lack of a price signal has practical implications both for customers and suppliers.

23. On the customer side, the lack of a strong price signal during times when fast-start units are required lowers the incentive to invest in load management capability. Load management takes the form of load reduction, load shifting, or self-generation. Each of these three requires that prices run high enough in particular hours to justify the cash or lost-opportunity cost to reduce load. Moreover, there needs to be enough such hours to justify the upfront capital investment needed to develop and maintain the capability to manage load actively. Artificially trimming peak prices, but shifting these costs to generic uplift charges, removes these financial incentives for efficient demand-side programs.

24. On the supply side, current practice creates an inefficiently low price signal for the development of new, flexible resources or investment in increasing the flexibility of existing units. Today, flexible units set the LMP, even when more costly fast-start units are needed to meet load. This price-setting unit is consequently being paid a lower price than the fast-start unit and earning no energy margin in that interval, despite offering the higher-valued service of providing flexible dispatch. Under PJM's proposal, the two unit types would be paid the same LMP, allowing the flexible resource to earn energy margin. If this extra margin is signaled in LMPs and creates enough total profit, competition from

existing resources seeking to maximize profits by cutting costs or enhancing unit flexibility and from new, more efficient resources will lower prices—first in the capacity market, and second in the energy market, as the need to dispatch inflexible, high-cost unit declines. Without any signal from the energy markets, however, competitors will not see the reliability need nor see a financial opportunity from competing to serve that need.

25. A third source of long-term economic inefficiency created by PJM's current practices, and remedied by PJM's proposal, is the suppression of transmission congestion costs and, therefore, the undervaluing of transmission investment. PJM's transmission planning process considers the costs and benefits of alleviating transmission congestion through new investment. By failing to reveal the costs of managing transmission constraints with fast-start units in the LMP, PJM's current practice systematically understates the cost-savings that new transmission could achieve.

IV. PJM'S PROPOSED CHANGES FROM THE 206 ORDER ARE SENSIBLE

26. PJM's proposed market design diverges from the indicative design in the Commission's 206 order on three points:

    a. Implementing fast-start pricing by integer relaxation of the commitment rather than of EcoMin;

    b. The method of including start-up and no-load costs in LMP, and the duration over which these costs are included; and

    c. The definition of an eligible fast-start unit as having two-hour notification and start and two-hour minimum runtime, rather than one hour.

27. I have considered each and believe each to be well reasoned in the context of PJM's proposal. Specifically:

28. The 206 Order seeks to allow a fast-start resource to set the energy price regardless of what portion of that resource is needed to serve load. The Commission indicated a particular method to achieve this goal, namely relaxation of EcoMin to zero. PJM's proposal differs only in its technical implementation but is as fully effective achieving the policy goal laid out in the 206 Order. PJM today models unit commitment as an "indicator variable," taking the integer value zero or one. By allowing the unit commitment variable to assume any non-integer values between zero or one, as PJM proposes, all other characteristics of the unit, including the EcoMin, also scale. Consequently, the "integer relaxation" proposed by PJM allows qualified fast-start resources to set the clearing price whenever PJM

dispatches the fast-start resource to serve load. While the mechanism differs from what the 206 Order contemplated, its effect does not.

29. PJM's proposed integer relaxation has also the practical effect of amortizing start-up and no-load costs without administrative adjustments to the unit's energy bid that would be needed were PJM to relax the EcoMin. PJM's proposal would include in the system cost function the start-up and no-load costs multiplied by the commitment indicator variable. PJM proposes to include start-up costs only for the minimum up-time of the resource, consistent with the 206 Order. PJM further proposes to model the no-load costs in all hours the unit is required to serve load, rather than just the minimum up-time. I support this proposal because it follows basic cost-causation principles of sound ratemaking. No-load costs are incurred in each hour of operation, and therefore price transparency is increased by incorporating those costs into the energy price.

30. PJM's proposal also diverges from the 206 Order in its proposed definition of a Fast-Start Unit. I support these divergences in the context of the particular nature of the generator fleet in PJM. As the Commission notes in the 206 Order, fast-start resources are those that generally can respond to short-term and unforeseen system needs. (206 Order at P15) PJM has used a two-hour scheduling window in its real-time commitment software for many years and views its ability to respond to short-term unforeseen needs within that timeframe. Consequently, generation owners have built peakers to meet PJM's stated requirements. As PJM documents in its Initial Brief, there is a significant portion of the resource base that it routinely commits and dispatches in real-time that meets this long-standing definition of quick-start, but not the one-hour definition proposed in the 206 Order. Given the institutional history in PJM and the reality that PJM commits on a two-hour look ahead, PJM's proposal will reflect its actual operations better than a narrower definition.

V. INITIAL OBJECTIONS TO PJM'S ARE NOT WELL-FOUNDED

31. The most substantial comments opposing elements of PJM's proposal were parallel arguments made by the IMM and the DMM. I disagree with most of their critiques.

32. The principal point in dispute is what "marginal cost" or "incremental cost" should encompass. Their position is that prices must be set looking only at the change in total costs from serving a small increment of load within one dispatch period: "Locational Marginal Price is the additional cost incurred to meet an additional MWh of load at any

pricing location."[15] and "The LMP is the derivative of the cost minimization [L]agrangian with respect to power injections at a location, i.e. the change in the total cost from a marginal change in injections at a location."[16] This point of view adopts the "restricted model" discussed above, that recasts the complex, nonconvex problem into a simple, convex problem by simply assuming away all the nonconvexities. It is not the only way to recast the complex cost-minimization problem, nor is it the only way supported by academic literature.[17]

33. Energy prices should always be set reflecting the costs to serve load. That is not in dispute. The pertinent question is: which costs should be reflected in prices? Here the Commission's guidance in the 206 Order is clear, and PJM's proposal is generally aligned with that order. To answer a point raised by the DMM cited above, PJM's proposal also sets LMPs as the derivative of a cost minimization Lagrangian, but it defines that Lagrangian differently, including costs from fast-start units that are otherwise excluded from the Lagrangian used, say, by the California Independent System Operator, as directed by the 206 Order.[18] As I discussed earlier, in the face of non-convexities there is no single "right" set of prices to support the system dispatch.

34. The importance of the choice of a time step and load increment is illustrated by taking the positions of the IMM and DMM to another extreme, namely an infinitesimal increase in load (∂D) for an infinitesimally short period of time (∂t)—the usual definition of a mathematical derivative. As ∂D and ∂t go to zero, the electrical properties of the grid require no operator action at all. A twinkling LED light does not measurably affect grid operations. Should we conclude, therefore, that the correct marginal price for energy is everywhere and always zero? No—such a theoretical view has no relationship to actual PJM operations. The increment of load, and the time over which it persists on the system, must be tied to a commercially reasonable and meaningful timeframe. But, as we move

[15] IMM Initial Brief at 3.

[16] DMM Comments at 3.

[17] See, *e.g.*, Brendan J. Ring, "Dispatch Based Pricing in Decentralized Power Systems," Ph.D. thesis, Department of Management, University of Canterbury, Christchurch, New Zealand, 1995; William W. Hogan and Brendan J. Ring, "On Minimum-Uplift Pricing for Electricity Markets," March 19, 2003; Alexis L. Motto and Francisco D. Galiano, "Equilibrium of Auction Markets with Unit Commitment: the Need for Augmented Pricing," *IEEE Transactions on Power Systems*, Vol. 17, No. 3, August 2002, pp. 798–805; Ramteen Sioshansi, Richard O'Neill, and Schmuel S. Oren, "Economic Consequences of Alternative Solution Methods for Centralized Unit Commitment in Day-Ahead Electricity Markets," January 2007 (http://www.ieor.berkeley.edu/~ramteen/papers/mip_lr.pdf), and Gribik *et al.* 2007.

[18] The DMM overstates the purity of the California design, though, insofar as there is a limited and rarely used ability for certain fast-start units to set prices in that market.

from infinitesimal ∂D and ∂t to larger increments, the commercially reasonable level to assess need not be one MWh and five minutes, as advocated by the IMM and DMM. Each choice of time step and load increment should be considered.

35. Both the IMM and DMM incorrectly argue that this restricted LMP is the only set of prices that optimize total surplus. This argument rests implicitly on economic theorems that have at their core certain conditions that are simply not met by power markets, as I discuss above at PP 6–11. Their efficiency claims need to be evaluated within a commercially relevant timeframe; otherwise, there is no opportunity for trades that increase welfare.[19] As I argue above, a five-minute dispatch interval is not the commercially relevant time step for the vast majority of commercial transactions.[20] When the commercially relevant time step proposed by PJM of two hours is used, more costs become variable and should, therefore, be included in the price. Likewise, with dispatch treating load as fixed in any dispatch interval, the relevant increment of demand is changed from one time step to the next, and, as a result, changes to total costs from meeting that change in demand should be reflected in prices.

36. I disagree with the DMM that the situation is comparable to the nonconvex supply created when there are economies of scale. In that example, well studied by Ronald Coase, average costs of production always exceed marginal cost, either as the result of a fixed cost or continuous economies of scale. The efficient solution in this situation is to adopt a two-part tariff: a fixed plus marginal charge. This solution is commonly used in regulated industries to cover infrastructure costs without discouraging efficient use of incremental services that are cheap to provide. For example, most cellular phone plans have replaced per-minute or per-MB charges with a flat fee, correctly recognizing that the vast majority of the provider's cost is fixed.

37. The case before us, however, differs in several relevant facts that render a simple two-part tariff inapplicable. First and most critically, the commitment costs of fast-start units are not sunk when considered over the appropriate, commercially relevant time step: hours, not minutes. Second, pure LMP markets lack a way of allocating the fixed costs of a fast-start unit to the customers whose consumption caused its commitment costs to be incurred. Instead, these costs are spread widely among many customers and many hours though uplift charges.

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[19] *Contra* to DMM Comments at 3.

[20] Five-minute settlements, however, are important to assure that payment follow actual performance within the hour and to assure that the price signal matches the dispatch signal in real time.

38. Regarding uplift charges, I disagree with two claims made by the IMM.

39. First, my understanding of the Commission's goal and PJM's design metric is to better reflect costs of system operations in prices, creating more price transparency.[21] By contrast, the IMM states that PJM's plan has the "objective … to minimize uplift." (p.3) PJM's design certainly builds on ideas from recent academic literature on energy pricing in which uplift minimization is used to score different options,[22] but a careful reading of these articles makes clear that uplift minimization is not the *objective* of improved pricing methods *per se*, but instead uplift is used to measure how far off a pricing methodology diverges from a set of prices that would support the least-cost system operations. If the commitment and dispatch runs are cost-minimizing, then minimizing uplift is a meaningful metric of how well the pricing run provides the correct financial incentives to support that cost-minimizing dispatch.

40. Second, the IMM challenges lost opportunity cost payments as a "new form of uplift [that] would undermine the transparent functioning of the market by creating a split between the dispatch signal … and the price…." (p.4) That split already exists, and uplift is already paid to remedy that split. Today, fast start units are given a dispatch signal that is out of step with market prices, and they are paid a make-whole guarantee to support that dispatch. The question really boils down not to whether there should be uplift payments, but on what time step the "marginal" of Locational Marginal Prices should be evaluated. Moreover, PJM's proposal is consistent with the 206 Order and adopts pricing methodologies that more closely align prices to system operations; it should therefore increase the transparency of the market, supporting sound business decisions by customers, suppliers, and transmission providers. Better pricing should result in competition that will result, over time, in diminishing lost opportunity payment, coupled with improved market efficiency, which will be a marked improvement over perpetual uplift coupled with market price opacity.

41. The IMM goes on to assert that this proposal would "erode incentives for flexibility." (p.4) and that "[t]he question of how to provide market incentives for investment in flexible units … should be addressed directly." As I discuss above at P 24, however, the current system undervalues flexible units and offering the full flexibility of units. Take the case of a block-loaded fast-start unit with a total cost of $100/MWh; but in order to maintain

[21] Based on my reading of Fast-Start Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators, Notice of Proposed Rulemaking, Docket No. RM17-3-000 (2016).

[22] See, e.g., Gribik *et al.* (2007) and Hogan (2014).

energy balance, PJM backs down a flexible unit with a dispatch cost of $60/MWh. Currently, the flexible unit sets the LMP at $60/MWh and so earns no margin in that interval; likewise, the fast-start unit also is paid the $60/MWh LMP plus a make-whole payment of $40/MWh, and so it also earns no margin. Under PJM's proposal, the fast-start unit would set the LMP at $100/MWh. Because this is the fast-start unit's cost, it earns no margin. The flexible unit, however, is now rewarded for its flexibility by earning a margin of $40/MWh above its $60/MWh for both its output and the backed-down portion of its unit. Consequently PJM's proposed pricing provides a clear financial incentive for suppliers to improve operations, cut costs, and develop new resources or new capability on existing resources to earn margins by offering flexibility to the system. Thus, PJM's proposal *does* address directly the need for market incentives for flexibility by calculating LMPs using the appropriate set of costs.

42. Finally, the IMM incorrectly conflates fast-start pricing with scarcity pricing.[23] Activation of fast-start units does not necessarily imply that the system is facing a resource scarcity problem. Fast-start units (using PJM's proposed definition) comprise 18 percent of the total system resources, which is greater than the planning reserve requirement of 16.1 percent.[24] Activating fast-start units in real-time reflects prudent cost management—avoiding incurring fixed commitment costs that may not be required by real-time conditions—rather than necessarily implying that the system has entered into a scarcity condition. While proper scarcity pricing is an important element of the energy and reserves markets, it is not a substitute for better aligning the energy prices with actual system dispatch of fast-start units, as contemplated by the 206 Order.

VI. PJM SHOULD RECONSIDER THE TREATMENT OF FAST-START UNITS COMMITTED IN THE DAY-AHEAD ENERGY MARKET

43. Fast-Start Units are most often committed in-day, rather than day-ahead. Therefore, their pricing treatment in the Real-time Energy Market is the principal concern in this docket. Under various circumstances, such as high load or low unit availability, however, PJM may include Fast-Start Units in the Day-ahead Energy Market commitment and dispatch.

44. PJM makes the following proposal regarding the treatment of such commitments:

> PJM would implement the aforementioned pricing methodology in both the Day-ahead and Real-time Energy Markets. Note, however, that PJM only intends to

[23] *E.g.* IMM Brief at 2.

[24] PJM Brief at 16; 2017 PJM Reserve Requirement Study, available at http://pjm.com/-/media/planning/res-adeq/2017-pjm-reserve-requirement-study.ashx?la=en.

> 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. (p.13)

45. This proposal drives a wedge between posted prices in the Day-ahead Market and the prices that market participants should reasonably expect to occur in real-time. Ideally, if conditions anticipated day-ahead play out exactly in real-time, then there would be no difference between LMPs in the Day-ahead and Real-time Energy Markets. Under PJM's proposal, however, day-ahead LMPs could be set by a Fast-Start Unit, but then in real-time the LMPs would be set not by this Fast-Start Unit but rather by the highest cost flexible resource (as today). This creates a troublesome opportunity for arbitrage through virtual bidding between these two markets. My concern is compounded by the asymmetric knowledge of when these conditions occur: the owner of the Fast-Start Unit knows that its bid set the day-ahead LMP, but others may not, giving the owner an advantaged position to exploit the potential price divergence between the two markets.

46. Moreover, PJM's logic proceeds from a false premise: that "commitment costs associated with day-ahead market commitment decisions are sunk in real-time." As I noted above at P 15, fast-start units committed in the Day-ahead Energy Market will, in general practice, only activate after operator confirmation in real-time. While the *expected* cost of commitment is reflected in the day-ahead LMPs, the societal cost of the physical start is only incurred in real-time and, therefore, should be reflected in both markets' energy prices.

47. The Commission has preliminarily endorsed the need for a consistent approach in the day-ahead and real-time markets:

> We further preliminarily find that requiring consistent pricing practices in both the day-ahead and real-time markets will lead to better price convergence, and therefore we believe these benefits merit implementation of fast-start pricing in both the day-ahead and real-time markets. Absent consistent pricing in both the

> day-ahead and real-time markets, day-ahead and real-time market prices may be different even under similar market conditions. For example, the day-ahead and real-time markets in ISO-NE could produce different energy prices even under identical market conditions because the day-ahead market does not incorporate the commitment costs of fast-start resources in energy prices.[25]

48. DC Energy, LLC *et al.* filed comments in Docket No. AD14-14 that I endorse.[26] In relevant part, they say:

> For the pricing of fast-start resources, the day-ahead market should use the same method as the real-time market to avoid introducing a disconnect between the two markets. Day-ahead models and real-time models utilized by the RTOs and ISOs should be very similar, if not identical, in nature in order to facilitate convergence between the two markets. Intentionally creating differences between the two models may create barriers that could prevent such convergence. … One can easily imagine a situation where there are expected high load conditions coupled with the outage of critical generators and/or transmission equipment that may lead to the need to commit fast-start resources in the day-ahead market. Failure to utilize the same fast-start pricing logic in the day-ahead market as the real-time market could lead to divergent outcomes between the two markets on a day when convergence is highly valued. To ensure that proper price signals are sent to all market participants in both the day-ahead and real-time markets, both markets must utilize the same fast-start pricing methodology.

49. I suggest to the Commission, therefore, that its order should require PJM to provide a symmetric treatment of fast-start unit pricing in both Day-ahead and Real-time Energy Markets, such that any Fast-Start Units committed day-ahead are priced in both markets.

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[25] 157 FERC ¶61,213, at P 62 (2016)

[26] *Price Formation in Energy and Ancillary Services Markets Operated by Regional Transmission Organizations and Independent System Operators,* Docket No. AD14-14-000, Comments of DC Energy, LLC, Inertia Power, LP, and Vitol, Inc. at pp. 9–10.

EXHIBIT RBS-2: AGGREGATE COST CURVE WITH COMMITMENT COSTS

	q (MW)	Plants A	Plants B
Fixed Cost ($)		0	6000
Var cost1 ($/MWh)	100	65	40
Var cost2 ($/MWh)	100	110	90

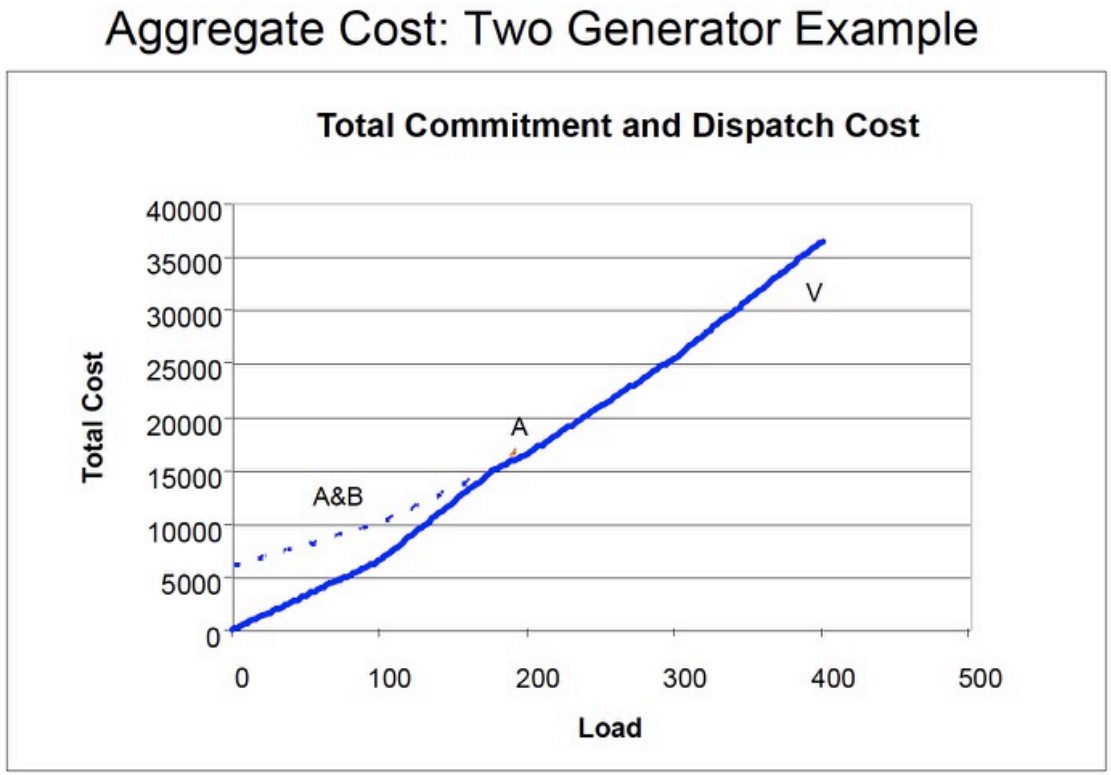
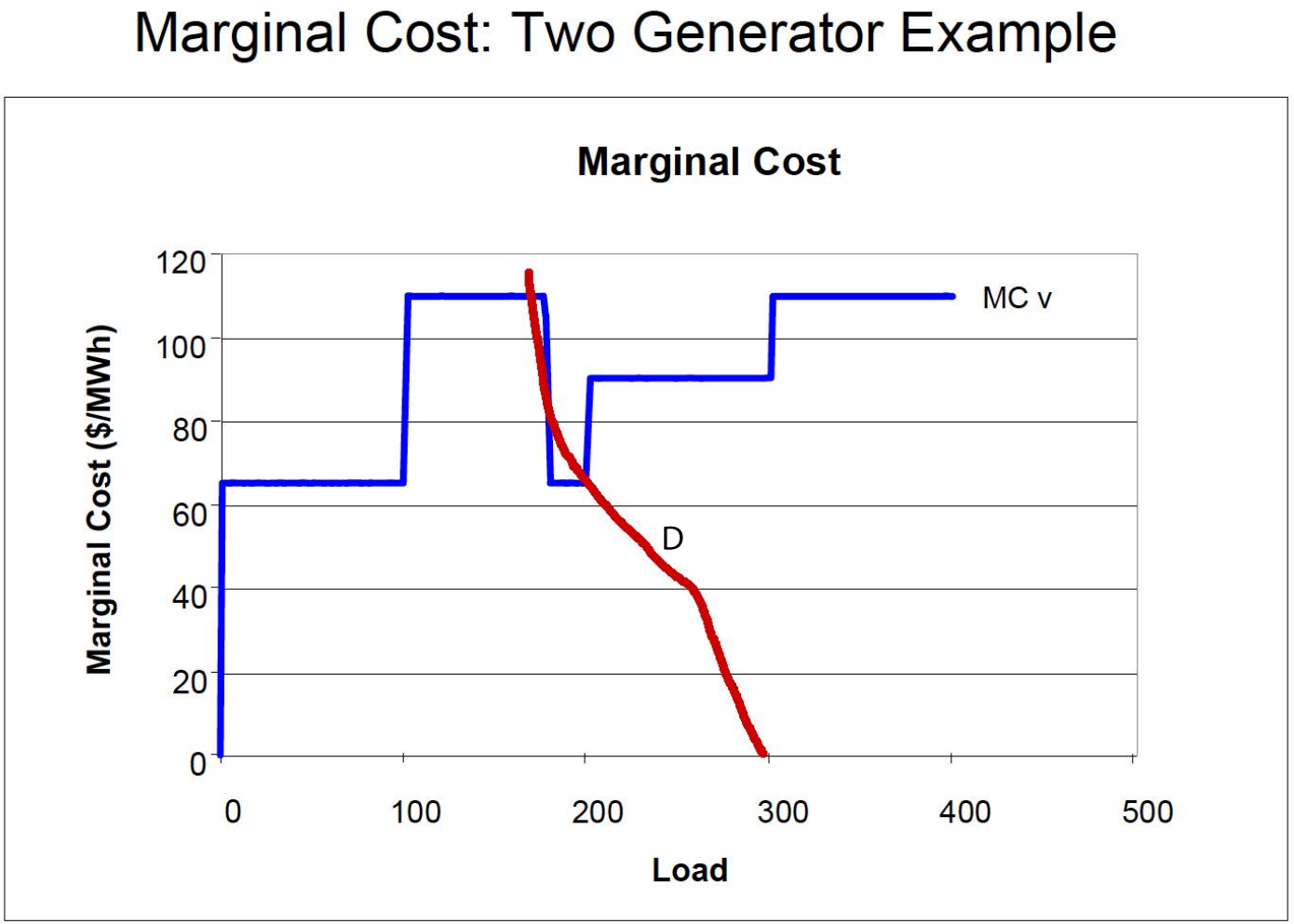


EXHIBIT RBS-3: MARGINAL COST CURVE WITH COMMITMENT COSTS



UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

AFFIDAVIT OF ROBERT B. STODDARD
ON BEHALF OF THE PJM POWER PROVIDERS

I, Robert B. Stoddard, being duly sworn, depose and state that the contents of the foregoing Affidavit on behalf of the PJM Power Providers is true, correct, accurate and complete to the best of my knowledge, information and belief.

Robert B. Stoddard

SUBSCRIBED AND SWORN
before me this 14 day of March, 2018

Kathleen Dodge
Notary Public • State of Maine
My Commission Expires August 4 2022

Notary Public

My commission expires: 8/4/22