UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.	)	Docket No. ER18-87-000

COMMENTS OF THE INDEPENDENT MARKET MONITOR FOR PJM

Pursuant to Rule 211 of the Commission's Rules and Regulations,[1] Monitoring Analytics, LLC, acting in its capacity as the Independent Market Monitor for PJM[2] ("Market Monitor"), submits these comments supporting the tariff revisions proposed by PJM Interconnection, L.L.C. ("PJM") on October 10, 2017. PJM states (at 1), "The purpose of these proposed revisions is to improve the performance of the PJM Regulation[footnote omitted] market, and to better reflect the value contributions of specific Regulation resources to system reliability." The Market Monitor agrees with PJM, except that the need for the reforms is understated. The design of the PJM Regulation Market has been seriously flawed for many years, and reform is long overdue. PJM has filed revisions that accomplish many of the needed reforms, and they should be accepted without delay.

I. BACKGROUND

A. The Regulation Market Is Flawed.

Regulation is an ancillary service procured by PJM from system resources to correct for Area Control Error (ACE), or differences between expected load plus exports and

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1 18 CFR § 385.211 (2017).

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

expected generation output plus imports. By correcting any short term imbalance between expected load and generation, regulation maintains system frequency and stability.

Since 2012, PJM has maintained regulation service based on resources following a RegA signal and resources following a RegD signal. The objective of PJM's regulation market design is to minimize the cost to provide regulation from a combination of resources following two different signals (RegA signal and RegD signal) in a single market.

The RegA signal is designed for resources (for example, thermal resources) with slower ramping speeds than RegD resources. The RegD signal is designed for resources (for example, batteries) with faster ramping speeds.[3] Although specific design criteria were the basis for the RegA signal and RegD signal, there are no resource/technology specific requirements to qualify to supply RegA or RegD service. A resource need only prove the ability to follow the RegA or RegD signal to offer the service. Some resources (combustion turbines and hydro resources) have qualified and successfully performed as both RegA and RegD. The original RegA and RegD signal controls were not coordinated, but responded separately to ACE.

When solving for the least cost combination of RegA and RegD MW to meet the effective regulation requirement, the regulation market substitutes RegD MW for RegA MW so long as it is economic to do so (reduces total cost while maintaining a fixed level of control). Correctly implemented, the engineering based rate of substitution defines the marginal rate of technical substitution (MRTS) between RegA and RegD, which is called a

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[3] RegD resources are at times referred to as energy limited resources. The amount of energy that can be produced before recharging is a function of the offered capability relative to the capacity of the resource, e.g. a battery. The amount of energy that can be produced continuously by a storage resource in a defined time period is a function of the capacity offered relative to the total storage capacity. The energy capability is a choice of the resource owner. The lower the capacity offered relative to the total storage capacity, the longer the time that the resource can provide the associated energy to the system.

marginal benefit factor (MBF) in the regulation market.[4] Problems arise when the MBF is not identical to the MRTS, e.g. when the MBF is modified from the actual, engineering based MRTS.

The MBF is used to convert incremental additions of RegD MW into incremental effective MW. Correctly implemented, the total effective MW for a given amount of RegD MW is the sum of the incremental effective MW contributions, which equals the area under the MBF function. This conversion into a common unit of measure, effective MW, allows a direct comparison of RegA and RegD offers. In a correctly implemented market design, all resources, either RegA or RegD, would be paid the same price per effective MW provided.

To meet the objective of minimizing cost, the marginal benefit factor (MBF) function must be correctly defined and consistently applied throughout the market design, from optimization to settlement. Consistently applying the MBF from optimization to settlement is the only way to ensure that the engineering relationship is reflected in the relative value of RegA and RegD resources in the market price signals. Consistently applying the MBF is the only way to ensure that PJM efficiently procures the optimal combination of RegA MW and RegD MW needed to provide a target level of regulation service. Consistently applying the MBF is the only way to ensure that you get what you pay for.

The MBF was not, and is not, correctly defined in the current PJM market rules and is not correctly or consistently implemented in the optimization, clearing and settlement of the regulation market. The MBF function, as implemented in the PJM Regulation Market, is not equal to the MRTS between RegA and RegD. The calculation of total regulation cleared

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[4] MRTS is a standard concept in economics. *See*, *e.g.*, Michael Katz and Harvey Rosen, *Microeconomics*, Richard D. Irwin, Inc. (1991) at 264–275. The Market Monitor will use the term MBF in this document because that terminology has been used by PJM and others in the discussion to date. MRTS would also be correct.

using the MBF is incorrect.[5] The result has been perverse economic incentives and PJM operational problems.

The result has been that the PJM Regulation Market has over procured RegD relative to RegA in most hours, has provided a consistently inefficient market signal to participants regarding the value of RegD in every hour, and has overpaid for RegD. In 2015, this over procurement began to degrade the ability of PJM to control ACE in some hours while at the same time increasing the cost of regulation. The problems were directly related to an incorrectly defined and implemented MBF function that both consistently overvalued RegD relative to RegA and caused too much RegD to clear the market. When the price paid for RegD is above the level defined by an accurate MBF function, there is an artificial incentive for inefficient entry of RegD resources. The result was that RegD actually hurt rather than helped ACE control.

B. PJM's Interim Fixes (Prior to the October 10th Proposal) Only Addressed Operational Issues.

The MBF related operational issues with the regulation market were raised in the PJM Operating Committee on May 26, 2015, by PJM. On October 22, 2015, the PJM Markets and Reliability Committee approved changes to Manual 11 that introduced an interim, partial fix to the operational problems associated with the relative and absolute over procurement of RegD in the regulation market.[6] The interim fix, implemented on December 14, 2015, was designed just to reduce the purchase of RegD to a manageable level in order

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[5] The MBF, as used in this report, refers to PJM's incorrectly calculated MBF and not the MBF equivalent to the MRTS.

[6] Regulation Performance Impacts, PJM Markets and Reliability Committee (Oct. 22, 2015) <*http://www.pjm.com/~/media/committees-groups/committees/mrc/20151022/20151022-item-05-regulation-performance-impacts-presentation.ashx*> and <*http://www.pjm.com/~/media/committees-groups/committees/mrc/20151022/20151022-item-05-regulation-performance-impacts-draft-manual-11-revisions.ashx*>.

to reduce the operational issues associated with the over procurement of RegD.[7] The goal was not to correct the structure of the MBF function and the broader issues in the market design, but to reduce the purchases of RegD MW in all hours, based on the relative value of RegD, and to cap purchases of RegD MW during critical performance hours, when the relative and absolute over procurement of RegD caused the most severe operational issues. The interim fix included a revised MBF function that reflected zero marginal benefit from RegD MW when RegD made up 40 percent (instead of the 62 percent under the initial MBF) of the effective regulation requirement.

In addition to the modification of the MBF function, the December 14, 2015, interim fix implemented by PJM defined, based on analysis of historic operational data, a subset of critical control hours when RegD was determined, on the basis of operational analysis, to be even less valuable as a replacement for RegA. These hours were called excursion hours (HE7, HE8, HE18, HE19, HE20, and HE21). During those excursion hours, the new MBF function was defined to end at an MBF value of 1.0 at 26.2 percent RegD (when 183.4 performance adjusted RegD MW clear). During these hours PJM would not clear any RegD in excess of 26.2 percent of the total regulation requirement in order to reduce operational issues.

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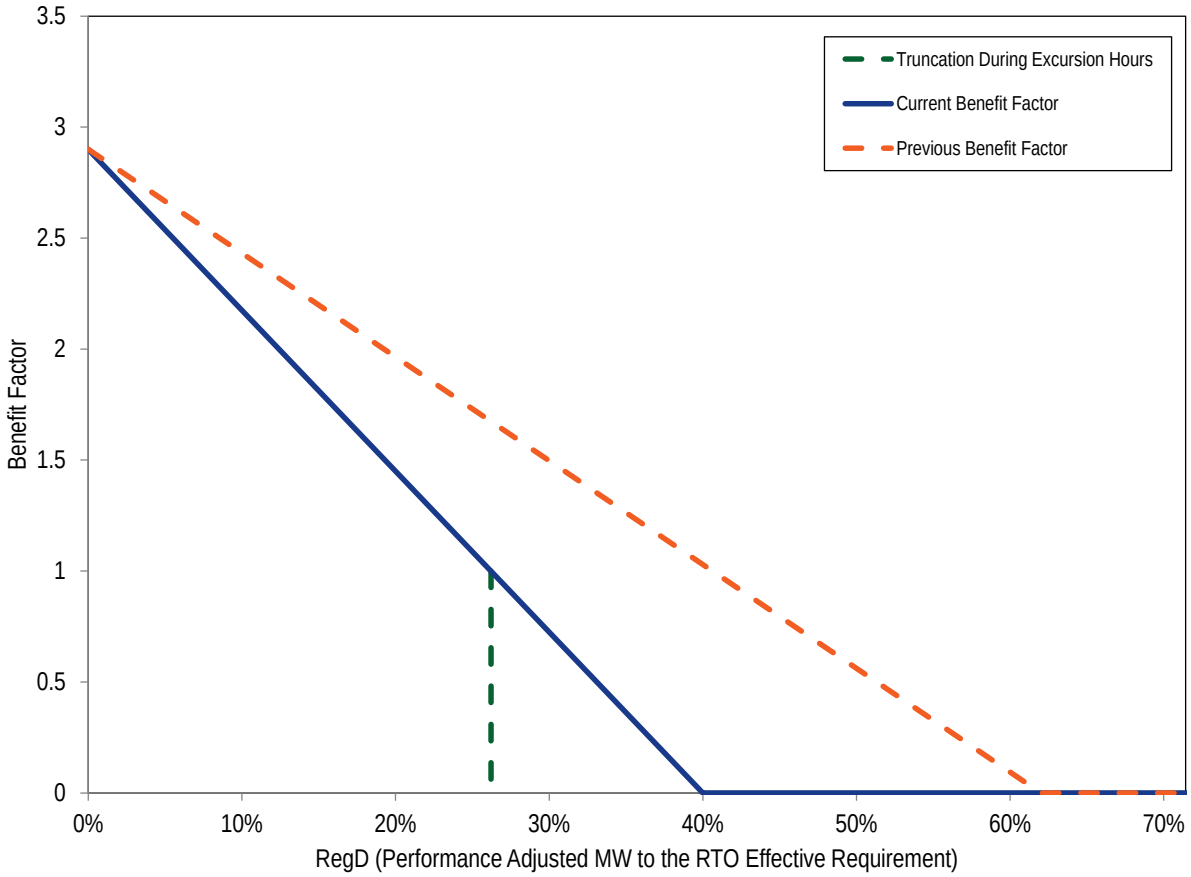
[7] The operational issues were the need for RegA pegging and the need for manual override of the RegD signal caused by an over procurement of RegD.

Figure 1 Marginal benefit factor curve before and after December 14, 2015 revisions by PJM



After implementing the interim fix, PJM began a review of the regulation signal design. As a result of this review, on January 9, 2017, PJM introduced new signal designs and regulation requirements intended to further improve system performance.[8] These modifications included changing the definition of off peak and on peak hours, adjusting the currently independent RegA and RegD signals to be interdependent, and changing the 15 minute energy neutrality requirement of the RegD signal to a 30 minute conditional energy neutrality requirement.

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8 Implementation and Rationale for PJM's Conditional Neutrality Regulation Signals, PJM White Paper, January 2017 (February 3, 2017) <*http://www.pjm.com/~/media/committees-groups/task-forces/rmistf/postings/regulation-market-whitepaper.ashx*>.

Rather than using off peak hours and on peak hours to define regulation requirements, the January 9, 2017, changes redefine hours as nonramp and ramp with specific time periods based on the season. PJM also increase the regulation requirement from 700 MW to 800 MW for ramp hours (Table 1). The set of excursion hours (HE7, HE8, HE18, HE19, HE20, and HE21), where the MBF is capped at 1 at 26.2 percent RegD remained.

Table 1 Seasonal Regulation Requirement Definitions

Season	Dates	Nonramp Hours	Ramp Hours
Winter	Dec 1 - Feb 28(29)	00:00 - 03:59 09:00 - 15:59	04:00 - 08:59 16:00 - 23:59
Spring	Mar 1 - May 31	00:00 - 04:59 08:00 - 16:59	05:00 - 07:59 17:00 - 23:59
Summer	Jun 1 - Aug 31	00:00 - 04:59 14:00 - 17:59	05:00 - 13:59 18:00 - 23:59
Fall	Sep 1 - Nov 30	00:00 - 04:59 08:00 - 16:59	05:00 - 07:59 17:00 - 23:59

The December 14, 2015, and January 9, 2017, changes did not address the fundamental market design issues in the regulation market. PJM and the Market Monitor recognized that correcting these problems would require substantive changes to the tariff. PJM and the Market Monitor created a joint proposal to address these issues, which is the basis for PJM filing in this proceeding.

C. The Current Rules Do Not Correctly Define Key Terms, Including MBF/MRTS/RRTS.

A fundamental issue with PJM's initial and current MBF function is that it is incorrectly defined as the RegD MW as a percentage of the effective MW target requirement, rather than as the RegD MW as a percentage of the total regulation MW cleared (total of RegA and RegD combined). The KEMA study defined the effective MW

target requirement as the RegD percentage of total regulation MW.[9] PJM's existing approach is inconsistent with the tradeoff between RegA and RegD defined in the KEMA study. The incorrectly defined MBF causes a mismatch between intended and realized proportions of RegD in the market clearing.

The current market clearing is done without confirming that the resulting combinations of RegA and RegD are consistent with the proportions incorporated in the MBF curve and therefore consistent with feasible market solutions. This approach clears RegD MW as long as it appears to be a cheap source of effective regulation MW regardless of whether it is feasible. This guarantees that an increasing proportion of RegD MW in the market incorrectly appears as a cheap feasible source of incremental effective regulation MW even when there are not enough RegA MW clearing the market to support this market solution. The result of the market design is that the market clears too much RegD relative to RegA MW. The problem is exacerbated by an increasing proportion of RegD offering at an effective price of zero.

The problem is illustrated in Table 2, for both the MBF curve used prior to December 14, 2015, and the current MBF curve. In the table, the contribution to the total regulation requirement of 800.0 MW for a ramp hour is given on both a performance adjusted RegD MW basis and effective RegD MW basis. For example, if the market cleared 320.0 MW of performance adjusted RegD (40 percent of the 800.0 performance adjusted MW needed) at a price of zero, the market would calculate that as 464.0 effective MW of RegD (area under curve) consistent with the MBF of 0.00, and determine it would need 336.0 MW of RegA to meet the 800.0 MW requirement using the current MBF curve. The resulting proportion of actual RegD MW to total regulation cleared would be 48.8 percent for the current MBF

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[9] KERMIT Study Report: To determine the effectiveness of the AGC in controlling fast and conventional resources in the PJM frequency regulation market (Dec. 13, 2011) ("KEMA Study") <*http://www.pjm.com/~/media/committees-groups/committees/oc/20150701-rpi/20150701-kema-study-report.ashx*>.

curve (320.0 actual RegD MW/(320.0 actual RegD MW + 336.0 actual RegA)), rather than the 40.0 percent defined by the MBF function. Although there is a smaller difference between the proportion of RegD cleared under the current MBF curve and the correct amount than under the prior MBF curve (48.8 percent versus 65.1 percent), the error is not eliminated. The result should be to maintain the desired proportions of RegA and RegD regardless of the amount of RegD cleared. To do this, the MBF must be defined as the relationship between RegA MW and RegD MW, rather than the percent of RegD.

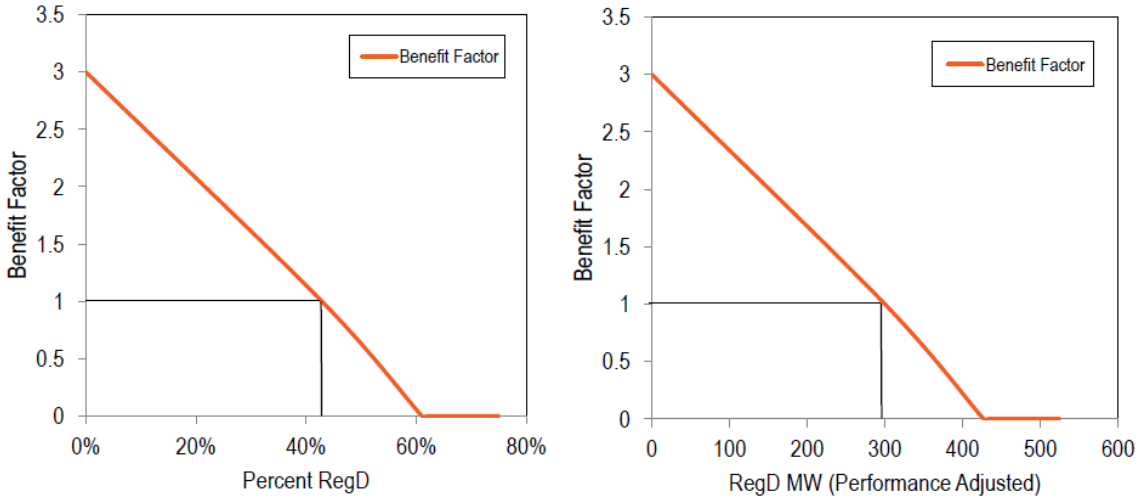
Table 2 MBF assumed RegD proportions versus market solution realized RegD proportions[10]

RegD Percent of 800 MW	RegD MW (Performance Adjusted)	MBF (Previous)	MBF (Current)	Effective MW from RegD MW (Previous)	Effective MW from RegD MW (Current)	Residual A (800 MW Target, Previous)	Residual A (800 MW Target, Current)	RegD/ (RegA+RegD, Previous)	RegD/ (RegA+RegD, Current)
5.0%	40.0	2.67	2.54	111.3	108.8	688.7	691.3	5.5%	5.5%
10.0%	80.0	2.43	2.18	213.3	203.0	586.7	597.0	12.0%	11.8%
15.0%	120.0	2.20	1.81	305.9	282.8	494.1	517.3	19.5%	18.8%
20.0%	160.0	1.96	1.45	389.2	348.0	410.8	452.0	28.0%	26.1%
25.0%	200.0	1.73	1.09	463.1	398.8	336.9	401.3	37.2%	33.3%
30.0%	240.0	1.50	0.73	527.6	435.0	272.4	365.0	46.8%	39.7%
35.0%	280.0	1.26	0.36	582.8	456.8	217.2	343.3	56.3%	44.9%
40.0%	320.0	1.03	0.00	628.6	464.0	171.4	336.0	65.1%	48.8%
45.0%	360.0	0.80	-	665.1	-	134.9	-	72.7%	-
50.0%	400.0	0.56	-	692.3	-	107.7	-	78.8%	-
55.0%	440.0	0.33	-	710.0	-	90.0	-	83.0%	-
60.0%	480.0	0.09	-	718.5	-	81.5	-	85.5%	-

An example illustrates the issue. Figure 2 shows the same MBF curve, in terms of RegD percent (left diagram) and RegD MW (right diagram) in a scenario where 700 MW of effective MW are needed and the market clears 300 MW of RegD (actual MW), all priced at $0.00, and 400 MW of RegA. Figure 2 shows that the 300 MW of cleared RegD are 42.9 percent of total cleared actual MW and that the MBF is 1.0.

10 This example assumes that the calculation of effective MW from RegD was calculated correctly as the area under the MBF curve.

Figure 2 Example MBF functions with percent RegD and RegD MW



D. Because the Current Rules Incorrectly Calculate Effective MW Contributions From RegD Resources, Too Much Regulation Is Procured.

In 2015, the Market Monitor determined that the PJM market design was buying too much RegD because the regulation market solution understates the amount of effective MW provided by RegD. PJM calculates the total effective MW of a unit as the simple product of the MW and the MBF, rather than the area under the MBF. The result is that 100 MW of RegD provided by a single resource (one 100 MW unit) will appear to provide fewer effective MW than 100 MW of RegD provided by two 50 MW units although they provide exactly the same total effective MW. This is the unit block issue.

The understatement of RegD was amplified by the treatment, in the market solution, of all RegD resources with the same price as a single resource for purposes of assigning a benefit factor and calculating total effective MW. All of the MW associated with multiple units with the same price were assigned the MBF of the last MW of the last unit of that block of resources. PJM calculates the total effective MW as the product of the MW and the marginal MBF, rather than the area under the MBF curve. This resulted in understating total effective MW from RegD resources cleared. This price block issue was solved by the modification of December 14, 2015.

The unit block issue was not addressed by the modification made on December 14, 2015. A complete correction of the effective MW calculation requires the use of the area under the curve.

Using PJM's unit block method, all RegD resources are assigned the lowest MBF associated with the last RegD MW purchased. In this example (Figure 3), all 300 MW have an MBF of 1.0. PJM calculates total effective MW from RegD resources to be 300 (300 MW x 1.0 = 300 effective MW). In Figure 3, PJM's price block/unit block calculation of total effective MW from RegD is represented by the area of the blue rectangle which is 300 effective MW.

The marginal benefit curve represents a marginal rate of substitution between RegD and RegA MW, and the area under the curve, at any RegD amount, represents the total effective MW supplied by RegD at that point. RegD is providing effective MW equal to the area of the green triangle plus the blue rectangle in Figure 3. This equals 600 effective MW from RegD resources, not 300 effective MW. The actual total effective MW cleared in the market is 300 more effective MW than needed to meet the regulation requirement.

Figure 3 Illustration of correct method for calculating effective MW

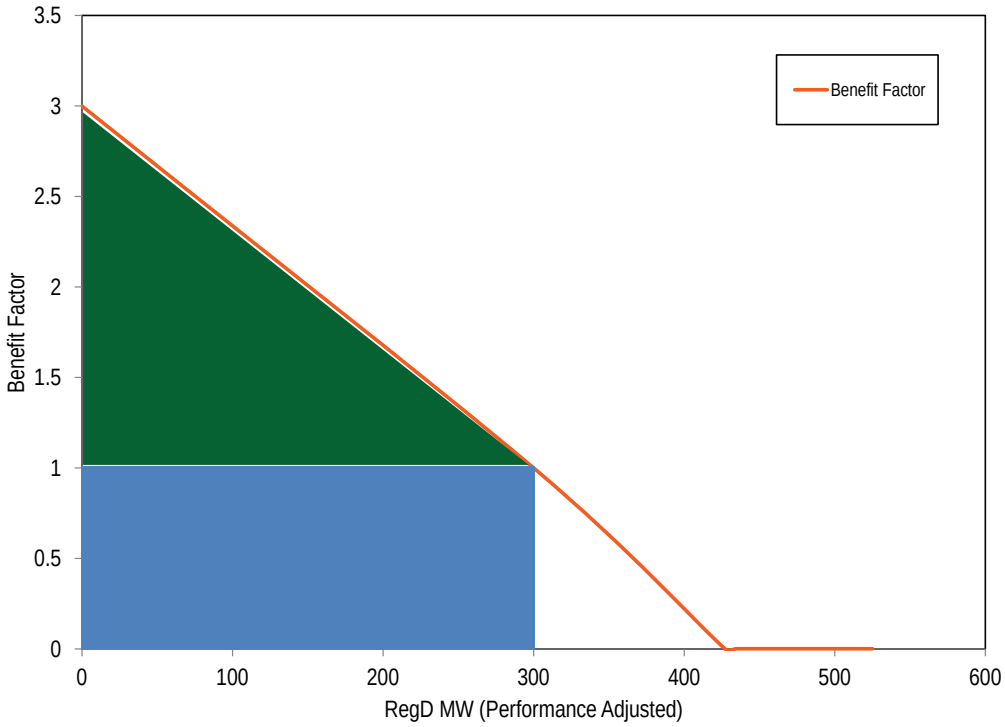
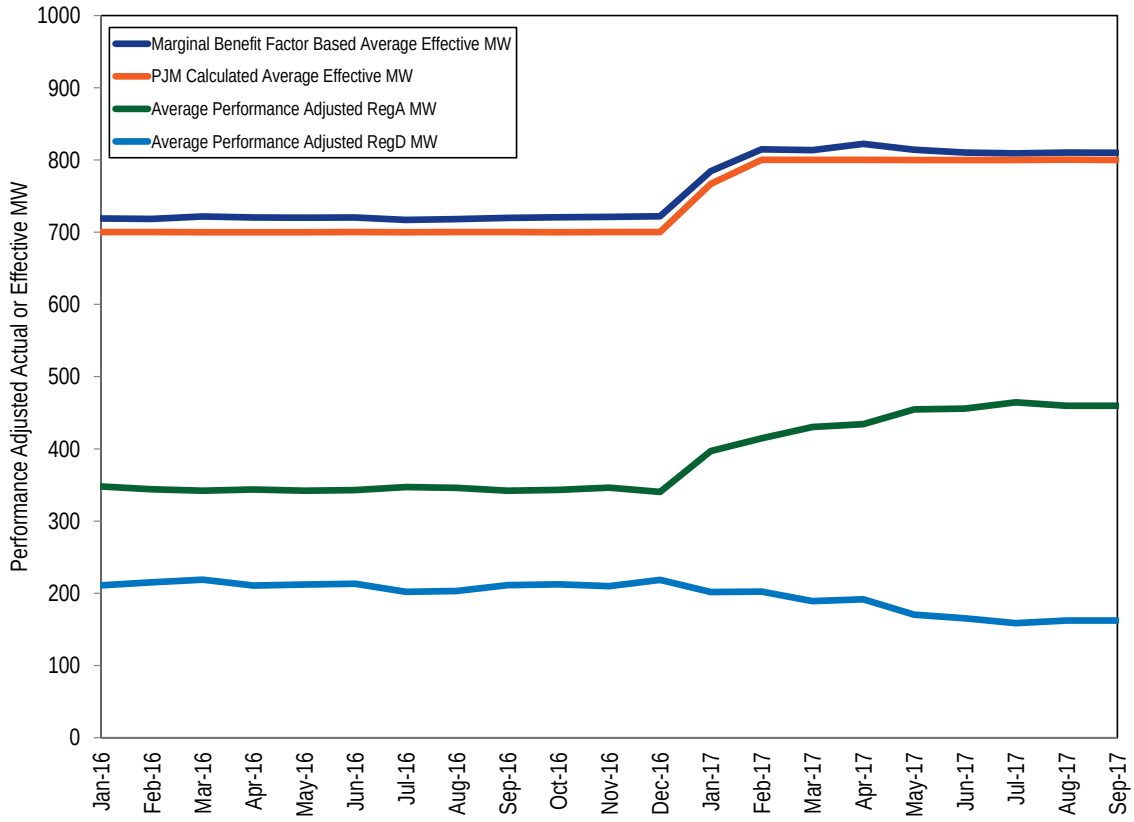


Figure 4 shows the average monthly peak and ramp hour total effective MW as calculated by PJM's MBF and as calculated by a correctly applied MBF for the January 1, 2016, through September 30, 2017, period. The figure also shows the monthly average performance adjusted RegA MW and RegD MW cleared in the regulation market for the period.

As a result of the changes made on January 9, 2017, the average cleared performance adjusted RegD MW during on peak hours decreased from 218.6 MW in December 2016, to 162.3 (a decrease of 25.7 percent) during ramp hours in September 2017. The average cleared performance adjusted RegA MW during on peak hours increased from 340.2 MW in December 2016, to 459.6 MW (an increase of 35.1 percent) during ramp hours in June 2017.

Figure 4 Average monthly total effective MW and RegA and RegD performance adjusted MW: PJM market calculated versus benefit factor based: January 1, 2016 through September 30, 2017



The excess procurement of RegD combined with the overpayment of RegD resulted in an increase in the level of $0.00 offers from RegD resources. RegD MW providers are ensured that $0.00 offers will be cleared and will be paid a price determined by the offers of RegA resources. Figure 5 shows, by month, the proportion of cleared RegD MW with an effective price of $0.00 from January 1, 2016, through September 30, 2017. The figure shows that all RegD MW clearing the market in the period between January 1, 2016, and April 30, 2017, had an effective offer of $0.00. From May 1, 2017, through September 30, 2017, an average of 98.2 percent of cleared RegD MW had an effective cost of $0.00. The total level of RegD clearing the market leveled off beginning in January 2016 because the market cleared the maximum allowed RegD MW. Due to the changes implemented in January 2017, the total level of RegD cleared in the market decreased 16.4 percent in the first nine months of 2017 compared to the first nine months of 2016.

Figure 5 Average cleared RegD MW and average cleared RegD with an effective price of $0.00 by month: January 1, 2016 through September 30, 2017

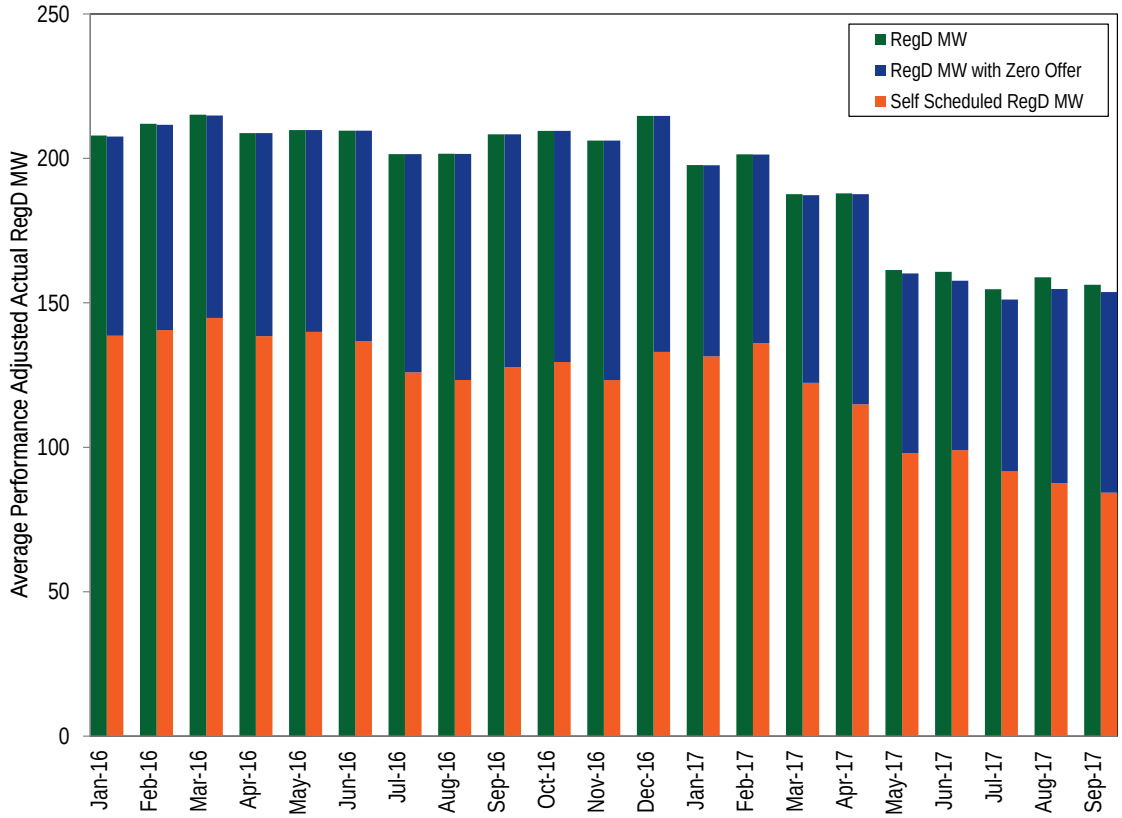
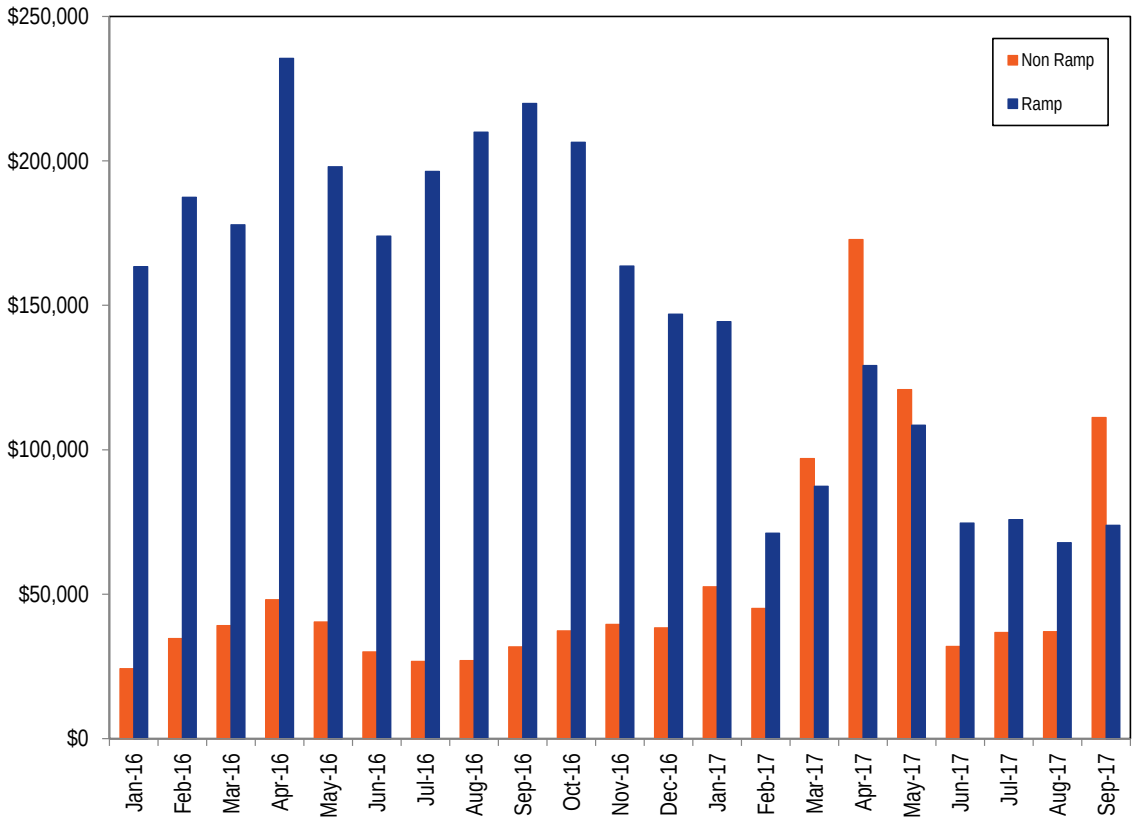


Figure 6 shows the estimated cost of the excess effective MW cleared by month, peak and off peak (and ramp and nonramp after January 9, 2017) , from January 1, 2017, through September 30, 2017, caused by PJM's calculation of effective MW from RegD resources using mileage rather than MBF. To determine this excess cost, the total effective MW of RegD are calculated using the full area under the PJM MBF curve, and the difference between that value and the value used by PJM is multiplied by the price in each hour. The calculation of excess cost shown in Figure 6 that is caused by purchasing too much RegD is conservatively underestimated because it does not incorporate how the market clearing price and settlement would have been affected by replacing the current optimization and settlement process with a correct and consistent utilization of the MBF. Specifically, the calculation only reflects differences in RegA and RegD proportions due to incorrect versus

correct application of the MBF, holding the actual market price and the mileage ratio based settlement constant and ignoring the actual MRTS.

In the first nine months of 2017, the estimated total cost of excess effective RegD MW during ramp and nonramp hours was $0.83 million and $0.71 million. In the first nine months of 2016, the estimated total cost of excess RegD MW during on peak and off peak hours was $1.76 million and $0.30 million. The implementation of the partial solution to the effective MW calculation and the changes in the MBF curve in December of 2015 reduced, but did not eliminate, the excess effective MW clearing in the regulation market.

Figure 6 Cost of excess effective MW cleared by month, peak and off peak: January 1, 2016 through September 30, 2017[11]



[11] Prior to January 9, 2017, on peak hours were defined between 05:00–23:59, off peak hours were defined as 00:00–04:59. After January 9, 2017, ramp and nonramp hours are defined seasonally. Please see Table 10-1 for a list of what hours are considered ramp and nonramp.

E. Under the Current Rules RegD Resources Are Not Properly Compensated on an Effective MW Basis.

The current market design does not properly compensate RegD resources on an effective MW basis. The MBF should be the marginal rate of technical substitution between RegA and RegD MW at different, feasible combinations of RegA and RegD that can be used to provide a defined level of regulation service. The objective of the market design is to find, given the relative costs of RegA and RegD MW, the least cost feasible combination of RegA and RegD MW. If the MBF function is incorrectly defined, or improperly implemented in the market clearing and settlement, the resulting combinations of RegA and RegD will not represent the least cost solution and may not be a feasible way to reach the target level of regulation.

The MBF is not included in PJM's settlement process. This is a design flaw that results in incorrect payments for regulation. The issue results from two FERC orders. From October 1, 2012, through October 31, 2013, PJM implemented a FERC order that required the MBF to be fixed at 1.0 for settlement calculations only. On October 2, 2013, FERC directed PJM to eliminate the use of the MBF entirely from settlement calculations of the capability and performance credits and replace it with the RegD to RegA mileage ratio in the performance credit paid to RegD resources, effective retroactively to October 1, 2012.[12] That rule continues in effect. The result of the current FERC order is that the MBF is used in market clearing to determine the relative value of an additional MW of RegD, but the MBF is not used in the settlement for RegD.

If the MBF were consistently applied, every resource would receive the same clearing price per marginal effective MW. But the MBF is not consistently applied and resources do not receive the same clearing price per marginal effective MW.

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[12] 145 FERC ¶ 61,011 (2013).

While prices are set on the basis of dollars per effective MW, only RegA resources receive payments based on this price per effective MW.[13] RegA resources are paid the RMCCP times MW times the performance factor times the MBF, plus the RMPCP times MW times the performance factor times the MBF. (The RegA MBF is 1.0.) RegD resources do not receive payments based on this price per effective MW. RegD resources are paid the RMCCP times MW times the performance factor, plus the RMPCP times MW times the performance factor times the mileage ratio.[14] As a result, the current market design does not send the correct price signal to the RegD resources.

Figure 7 compares the daily average MBF and the mileage ratio for excursion and nonexcursion hours. Excursion hours (hours ending 7:00, 8:00, 18:00-21:00) were hours in which PJM had decided that more RegA was needed and PJM did not clear any RegD with an MBF less than 1.0. Excursion hours were discontinued by PJM as of July 31, 2017. The shift in both the MBF values and the mileage ratio (Figure 7) resulted from the design changes implemented on January 9, 2017.

The change in design decreased RegA mileage (the change in MW output in response to regulation signal per MW of capability), increased the proportion of cleared RegD resources' capability that was called by the RegD signal (increased REG for a given MW) to better match offered capability, increased the mileage required of RegD resources and changed the energy neutrality component of the signal from a strict 15 minute neutrality to a conditional 30 minute neutrality. The changes in signal design increased the mileage ratio (the ratio of RegD mileage to RegA mileage). In addition, to adapt to the 30 minute neutrality requirement, RegD resources decreased their offered capability to

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[13] This is due to the fact that RegA resources performance adjusted MW are their effective MW as the MRTS of RegA resources is always equal to one, as effective MW are defined in terms of RegA performance adjusted MW.

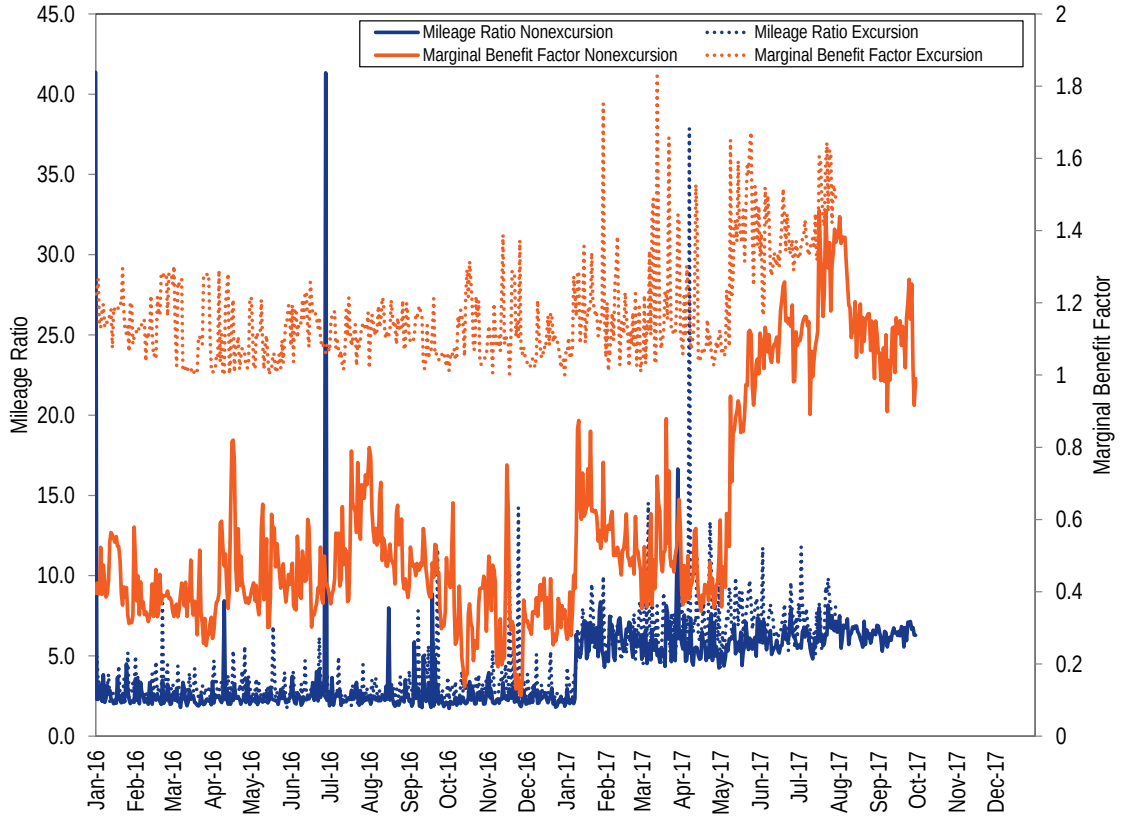
[14] Performance adjusted RegD MW are converted to effective MW by multiplying the performance adjusted MW by the market clearing MRTS.

maintain their performance. The reduction in offered capability reduced the amount of RegD MW clearing and increased the amount of RegA MW clearing, meaning a higher MBF in every hour.

The weighted average mileage ratio during nonexcursion hours increased from 2.81 in the first nine months of 2016, to 5.97 in the first nine months of 2017 (an increase of 112.4 percent). Spikes in mileage ratio values are the result of the mechanics of the mileage ratio calculation. The extreme mileage ratios result when the RegA signal is fixed at a single value for an extended period ("pegged") to control ACE and the RegD signal is not. If RegA is held at a constant MW output, mileage is zero for RegA. The result of a fixed RegA signal is that RegA mileage is very small and therefore the mileage ratio is very large.

These results are an example of why it is not appropriate to use the mileage ratio, rather than the MBF, to measure the relative value of RegA and RegD resources. In these events, RegA resources are providing ACE control by providing a fixed level of MW output which means zero mileage, while RegD resources alternate between helping and hurting ACE control, both of which result in positive mileage.

Figure 7 Daily average MBF and mileage ratio during excursion and nonexcursion hours: January 1, 2016 through September 30, 2017[15]



The increase in the average mileage ratio caused by the signal design changes introduced on January 9, 2017, caused a large increase in payments to RegD resources on a performance adjusted MW basis. The average daily payment per performance adjusted RegD MW increased by 57.2 percent, from $10.01 in the period from January 1, 2016, through January 8, 2017, to $15.74 in the period between January 9, 2017, and September 30, 2017.

Table 3 shows RegD resource payments on a performance adjusted MW basis and RegA resource payments on a performance adjusted MW basis by month, from January 1, 2016, through September 30, 2017. In the first nine months of 2016, RegD resources earned

[15] Excursion hours were discontinued as of 00:00 on July 31, 2017.

12.1 percent more per performance adjusted MW than RegA resources. In the first nine months of 2017, RegD resources earned 83.5 percent more per performance adjusted MW than RegA resources.

Table 3 Average monthly price paid per performance adjusted MW of RegD and RegA: January 1 through September 30, 2016 through 2017

		Settlement Payments		
Year	Month	RegD ($/Performance Adjusted RegD MW)	RegA ($/Performance Adjusted MW)	Percent Performance Adjusted RegD/RegA Under/Over Payment
2016	Jan	$17.20	$15.60	10.3%
	Feb	$19.55	$17.56	11.3%
	Mar	$15.00	$13.21	13.5%
	Apr	$21.10	$18.87	11.8%
	May	$18.31	$15.42	18.8%
	Jun	$14.93	$13.81	8.1%
	Jul	$19.34	$17.48	10.6%
	Aug	$18.57	$17.15	8.3%
	Sep	$19.38	$17.47	10.9%
	Oct	$17.58	$15.44	13.9%
	Nov	$15.39	$13.01	18.3%
	Dec	$12.38	$11.15	11.0%
Yearly		$17.39	$15.51	12.1%
Jan-Sep		$18.15	$16.28	11.5%
2017	Jan	$17.07	$13.62	25.4%
	Feb	$16.58	$10.64	55.8%
	Mar	$26.76	$15.06	77.7%
	Apr	$32.60	$15.58	109.2%
	May	$28.45	$17.89	59.0%
	Jun	$28.88	$13.23	118.2%
	Jul	$28.49	$15.00	89.9%
	Aug	$32.06	$13.24	142.1%
	Sep	$37.89	$21.33	77.6%
Jan-Sep		$27.64	$15.07	83.5%

The current settlement process does not result in paying RegA and RegD resources the same price per effective MW. RegA resources are paid on the basis of dollars per effective MW of RegA. RegD resources are not paid in terms of dollars per effective MW of RegA because the MBF is not used in settlements. When the MBF is above one, RegD resources are underpaid on a per effective MW basis, although this could be offset by a high mileage ratio. When the MBF is less than one, RegD resources are overpaid on a per

effective MW basis. The average MBF was less than 1.0 in 2016 (0.60) and the first nine months of 2017 (0.95), resulting in an average overpayment of RegD resources.

The effect of using the mileage ratio instead of the MBF to convert RegD MW into effective MW for purposes of settlement is illustrated in Table 4. Table 4 compares the monthly average payment to RegD per effective MW under the current settlement process to the monthly average payment RegD resources should have received using the MBF to convert RegD MW to effective MW. This also shows that using the MBF would result in RegA and RegD resources being paid exactly the same on a per effective MW basis. The MBF averaged less than one in each month of 2016, while the average daily mileage ratio was 2.79, resulting in RegD resources being paid $11.2 million (1,855.6 percent) more than they should have been paid per effective MW in the first nine months of 2016. In the first nine months of 2017, the MBF also averaged less than one, while the average daily mileage ratio was 6.24, resulting in RegD resources being paid $14.1 million (385.3 percent) more than they should have been.

Table 4 Average monthly price paid per effective MW of RegD and RegA under mileage and MBF based settlement: January 1 through September 30, 2016 through 2017

		RegD Settlement Payments				
Year	Month	Mileage Based ($/Effective RegD MW)	Marginal Rate of Technical Substitution Based ($/Effective RegD MW)	RegA ($/Effective MW)	Percent RegD Under/Over Payment	Total RegD Under/Over Payment ($)
2016	Jan	$30.61	$15.60	$15.60	96.2%	$1,319,364
	Feb	$43.33	$17.56	$17.56	146.8%	$1,591,651
	Mar	$70.02	$13.21	$13.21	430.1%	$1,375,711
	Apr	$90.59	$18.87	$18.87	380.1%	$1,335,655
	May	$449.89	$15.42	$15.42	2,817.9%	$1,452,512
	Jun	$181.02	$13.81	$13.81	1,210.8%	$996,391
	Jul	$782.84	$17.48	$17.48	4,378.3%	$884,677
	Aug	$43.91	$17.15	$17.15	156.1%	$985,398
	Sep	$1,057.96	$17.47	$17.47	5,954.5%	$1,259,051
	Oct	$166.40	$15.44	$15.44	977.9%	$1,251,166
	Nov	$36.01	$13.01	$13.01	176.8%	$1,109,221
	Dec	$57.00	$11.15	$11.15	411.4%	$1,041,258
Yearly		$258.17	$15.50	$15.50	1,565.7%	$14,602,055
Jan-Sep		$318.19	$16.27	$16.27	1,855.6%	$11,200,410
2017	Jan	$80.44	$13.62	$13.62	490.7%	$956,485
	Feb	$293.97	$10.64	$10.64	2,662.3%	$1,161,959
	Mar	$80.90	$15.06	$15.06	437.2%	$1,977,295
	Apr	$79.84	$15.58	$15.58	412.4%	$2,848,281
	May	$34.79	$17.89	$17.89	94.4%	$1,229,953
	Jun	$24.18	$13.23	$13.23	82.7%	$1,498,653
	Jul	$22.16	$15.00	$15.00	47.7%	$995,254
	Aug	$26.53	$13.24	$13.24	100.4%	$1,881,033
	Sep	$35.67	$21.33	$21.33	67.2%	$1,588,929
Jan-Sep		$73.27	$15.10	$15.10	385.3%	$14,137,842

II. COMMENTS

A. PJM's Proposal to Replace the MBF with a Regulation Rate of Technical Substitution Curve Will Correct a Long Standing Issue with the Regulation Market.

The Market Monitor supports PJM's proposal to replace the current Marginal Benefit Factor (MBF) curve with a set of Regulation Rate of Technical Substitution (RRTS) curves in the regulation market optimization, market clearing and price setting. PJM's proposal would replace the original single benefit factor curve implemented in 2012 with a number of RRTS curves based on the observed operational "engineering relationship between RegA and RegD resources" and ongoing simulation studies.[16]

Each RRTS curve in the set will be designed to reflect the expected rate of substitution between RegA and RegD resources under different expected system conditions, holding expected ACE control constant. The initial set of RRTS curves will include eight curves, defining the expected relationship between RegA and RegD for ramp and non-ramp hours for each of the four seasons.[17] It is expected that PJM will regularly review the performance of the regulation market using varying combinations of RegA and RegD resources under varying system conditions and update the set of RRTS curves as more operational experience is gained and as resource capability changes over time. The requirement to review and report on the performance should be required.

In developing each RRTS, PJM proposes to "define the engineering relationship between RegA and RegD resources by evaluating the ability for Regulation service to manage ACE using varying amounts of RegA and RegD inputs."[18] Using this information, PJM will plot isoquants defining combinations of RegA and RegD that will provide an

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16 PJM at 14–20.

17 *Id*. at 15.

18 *Id*. at 15.

equivalent level of ACE control.[19] PJM will pick a set of isoquants with the desired level of ACE control ramp for expected system conditions for ramp and nonramp for each season. The isoquant will be used to determine the marginal rate of substitution (the slope or derivative of the isoquant at every combination of RegA and RegD MW) between RegA and RegD MW at every combination of RegA and RegD on that isoquant. This will define the RRTS curve for each isoquant which will be used in the optimization and market clearing of the regulation market.[20]

As the RRTS is an essential component of the success of the regulation market, the engineering study used to determine the set of RRTS curves must be done correctly and the results must be revisited and be revised as more information and more operational experience becomes available over time. The objective should be to detect, identify and forecast distinct system conditions for which a unique RRTS would be applicable, thereby resulting in the development of the more refined and accurate RRTS curves. The more accurate the RRTS curves, the better the resulting system control and market efficiency.

The engineering studies should also include a review of the signal design. The signal design goal should be to determine the least cost way to provide needed regulation. The signal design introduced on January 9, 2017, while an improvement over the prior signal design, is not consistent with this goal. The RegA signal is now slower than it was previously, which makes RegA following resources less useful as ACE control. RegA is now explicitly used to support the conditional energy neutrality of RegD. The RegD signal is now the difference between ACE and RegA. RegA is used to offset RegD when RegD moves in the opposite direction of that required by ACE control in order to permit RegD to recharge. These changes in the signal design will allow PJM to accommodate more RegD in its market solutions. But that is not and should not be the goal. The goal is to provide

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19 *Id*.

20 *Id*. at 16–19.

regulation service at the lowest possible cost and is not to artificially favor a technology. This goal must be made explicit in the tariff to ensure that PJM does not create regulation signals that artificially favor a technology.

For example, with any signal design for substitutable resources, the RRTS functions should be determined by the signal design and the ability of RegA and RegD resources to follow that signal under different system conditions. In system conditions where RegD is energy limited and cannot follow the regulation signal in one direction for as long as required, the RRTS should show a rapid decrease in the RRTS value for every MW of RegD added. Conditional neutrality designs mean that RegD depends on the availability of excess RegA capability to support RegD and this should be reflected in the RRTS curves. .

B. PJM's Proposal to Replace the Calculation of Effective MW by Resource Block with the Area Under the RRTS Curve Calculation Will Correct a Long Standing Issue with the Regulation Market

The Market Monitor supports PJM's proposal to use the "full area under the RRTS curve to calculate the effective megawatts for a resource" to replace the current block method.[21]

Under the unit block method, all RegD MW from a resource are assigned the lowest MBF associated with the last RegD MW purchased from that resource. The block method provides an effective MW calculation that is inconsistent with the derivation of the marginal rate of substitution curve, causing market clearing results that are inconsistent with the isoquant that defined desired combinations of RegA and RegD MW.

Unlike the current block method, using the area under the marginal rate of substitution curve between RegD and RegA (Under the RRTS curve) for a given number of RegD MW to calculate total effective MW contributions provides results that are consistent with the derivation of the marginal rate of substitution curve, allowing market clearing

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[21] *Id*. at 18.

results that are consistent with the isoquant that defined desired combinations of RegA and RegD MW.

C. PJM's Proposal to Remove the Mileage Ratio and Include the RRTS in the Settlements Equations Will Correct a Long Standing Issue with the Regulation Market.

The Market Monitor supports PJM's proposal to remove the mileage ratio from the settlements equation and include the RRTS in the settlements equations for regulation service.

PJM notes that by including the mileage ratio, "[t]he current settlements construct for Regulation service does not properly take into account the effective megawatts of resources, thus incorrectly compensating resources and sending incorrect financial signals to the market."[22] PJM states "[f]or a consistent optimization, resources should be settled on the effective megawatts they provide to the system, consistent with clearing and operating the resources."[23] In order to make sure that every MW is evaluated, priced and settled on an effective MW basis, marginal RRTS used in the optimization, clearing and pricing of the regulation market must also be used in the settlement of the market.

The objective of the market design is to find, given the relative costs of RegA and RegD MW, the least cost feasible combination of RegA and RegD MW. If the RRTS is consistently applied, every resource would receive the same clearing price per marginal effective MW and the market solution will be consistent with the least cost feasible combination of RegA and RegD. PJM's proposal to remove the mileage ratio from the settlements equation and include the RRTS in the settlements equations will correct a long standing issue with the regulation market design.

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22 *Id*. at 22.

23 *Id*.

D. PJM's Proposal to Revise the Regulation Performance Score Metric Will Improve Performance Assessment of Resources.

PJM has proposed to replace the "the current performance score calculation, which is based on one-third accuracy, one-third delay, and one-third precision" with a performance score based solely on a revised precision calculation.[24] PJM notes that the current performance score calculation that includes accuracy and delay is "too lenient for performance assessments."[25] PJM states that "[u]nder the current construct, accuracy and delay can inflate a resource's performance score in some instances, and indicate that the resource is providing more system benefit than it actually is providing." The revised precision-only performance calculation will measure instantaneous error between the Regulation control signal and resource response.[26]

The Market Monitor agrees that removing the accuracy and lag components, as defined, from the performance score should provide a better measure of actual resource performance relative to its signal. The Market Monitor supports PJM's proposal to use the precision-only performance calculation to measure resource performance.

PJM notes that that "[t]he accuracy calculation is flawed because it does not take into account a resource's set point, or base point, value" when measuring how well the resource is following its signal instructions."[27] This allows a resource that is following the general movement of its signal but is deviating from its targeted regulation set point (either high or low) to still receive a high accuracy score, thereby inflating the resulting multiple component based performance score. Similarly, PJM determined that the delay component, which is based on a maximum fit five minute correlation between the regulation signal and

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[24] *Id*. at 2–21.

[25] *Id*. at 20.

[26] *Id*. at 21.

[27] *Id*. at 20.

resource response, is flawed as it can treat a low lag response equal to a long lag response, within the five minute lag window, even though, with lag, the response could be running counter to the instantaneous signal. This means the metric allows a resource that is potentially running counter to its assigned signal to still receive a high (good) lag score, thereby inflating the resulting multiple component based performance score.

While PJM is proposing a precision-only performance calculation, the precision metric that is proposed differs from the existing version of that score. The new precision metric will include modifications intended to improve it as a sole measure of resource performance. The proposed prevision metric will evaluate "resource response at t0 and t+10sec instead of only at t+10sec" and will use "a weighted denominator that takes into account signal magnitude and resource assignment amount."[28]

Although the Market Monitor supports PJM's proposal to use a modified precision only performance metric to measure unit performance, the Market Monitor recommends that PJM conduct a periodic review of the performance metric to determine whether further refinements are needed to better align performance scores with the ability of a resource to beneficially respond to its signal.

In the absence of a well defined RRTS, paying resources to move in a direction opposite the direction required by ACE control is a design issue.

E. PJM's Proposal to Use the Committed Energy Schedule of On Line Resources Will Correct a Long Standing Issue with the Regulation Market.

PJM proposes to use "the schedule on which the resource is committed for energy" as the basis for calculating the lost opportunity cost of providing regulation control.[29] This

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[28] *Id*. at 22.

[29] *Id*. at 28.

would replace the current lost opportunity cost calculation which "uses the lesser of the available market-based or highest cost-based energy offers from the resource."[30]

The Market Monitor supports PJM's proposal to replace the current lost opportunity cost calculation with an opportunity cost calculation based on the actual energy schedule of the resource committed for regulation service. Using the actual energy schedule of the resources "will allow PJM to properly reflect the real-time cost of not following economic dispatch, and will align the incremental costs of Regulation and energy to ensure a least-cost solution. "[31] The Market Monitor agrees with PJM that the current method using the lesser of the market or cost based offer, "(1) does not capture the realized lost opportunity cost in real-time, (2) reduces efficiency of the regulation market solution, and (3) can artificially increase the regulation clearing price if the resource is marginal."[32]

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30 *Id*.

31 *Id*. at 29.

32 *Id*. at 28–29.

III. CONCLUSION

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

Respectfully submitted,

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Dated: November 7, 2017

CERTIFICATE OF SERVICE

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

Dated at Eagleville, Pennsylvania,
this 7th day of November, 2017.

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