UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

PJM Interconnection, L.L.C.	)	Docket No. ER12-2391-001

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 on PJM's response to the Commission's deficiency notice ("Deficiency Letter") filed by PJM on September 17, 2012 ("September 17th Answer").

The September 17th Answer provides additional supporting arguments and information regarding the use of the "benefits factor" in the Regulation Market clearing and settlement process that PJM proposed on August 2, 2012 ("August 2nd Filing"). With these comments, the Market Monitor seeks to supplement the record concerning Commission Requests Nos. 1B,[3] 2A[4] and 2B,[5] which address the use and meaning of PJM's benefits factor.

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1 18 CFR § 385.211 (2012).

2 PJM Interconnection, L.L.C., a Regional Transmission Organization. Capitalized terms used herein and not otherwise defined have the meaning used in the PJM Open Access Transmission Tariff ("OATT").

3 Request 1B: If the marginal benefits factor can go below one, please include an explanation and a numerical example where the marginal benefits factor is less than one but greater than zero.

4 Request 2A: Please provide a range of benefits factors that can be assigned to a resource following the dynamic regulation signal. Please provide a detailed explanation and a graphical illustration.

There are two types of benefits factor, a unit specific benefits factor and a system or marginal benefits factor. In its August 2nd Filing, PJM proposes to retain the unit specific benefits factor, which is determined on the basis of the unit's relative position in the total regulation resource supply stack and the proportion of quick response ("fast") and traditional ("slow") resources that would clear at that relative position. The unit specific benefits factor allows PJM to rank fast resources relative to slow resources in the regulation supply stack used in the resource selection and optimization. More importantly, PJM proposes that the marginal benefits factor, which is based on the cleared proportion of fast to slow resources in the market solution, determine the optimal resource mix and settlement. In light of the results of PJM's commissioned engineering study from KEMA ("KEMA Study") on using combinations of regulation resources to meet its regulation requirements, the Market Monitor agrees that this approach to the use of the marginal benefits factor is appropriate and reasonable and is the only correct way to clear the market.[6]

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[5] Request 2B: If the marginal benefits factor for resources following the dynamic regulation signal can go below one, please explain and provide a numerical example of how such resources will be appropriately compensated for the work performed given that the benefits factor for the last dynamic regulation signal megawatt selected will be used to adjust the compensation for all resources following the dynamic regulation signal. Please explain if under certain scenarios it is possible for dynamic resources to be compensated less than traditional resources and if so, why such a result would be appropriate.

[6] *See* KEMA Inc., KERMIT Study Report: To Determine the Effectiveness of the AGC in Controlling Fast and Conventional Resources in the PJM Frequency Regulation Market, <http://www.pjm.com/committees-and-groups/task-forces/~/media/committees-groups/task-forces/rpstf/postings/pjm-kema-final-study-report.ashx> .

I. COMMENTS

The August 2nd Filing clarified that PJM's use of a unit specific benefits factor was limited to rank ordering resources in the supply stack in the total regulation resource supply stack. The August 2nd Filing clarified that the unit specific benefits factor of the last fast resource cleared, the marginal benefits factor, would be used for the purposes of optimization and settlement. The Market Monitor agrees that this is an appropriate application of the marginal benefits factor. As defined by PJM, the benefits factor represents the rate of substitution between fast and slow regulation resources for the provision of regulation service at varying ratios of cleared, effective MW of fast and slow regulation.

A. Regulation Is a Single Product with Two Inputs, Fast and Slow, That Require a Defined Rate of Substitution, the "Benefits Factor"

Due to their varying characteristics, fast and slow resources are not perfect substitutes for one another for purposes of providing regulation as defined in PJM's market. But because regulation is a single product in PJM's market design, the clearing rules must account for and optimize the selection of fast and slow resources included in the market clearing.

Fast and slow resources, depending on technology type, have different cost structures, different sources, and different capabilities. Fast resources, for example, tend to be non-generation resources. Fast resources have quick response times but limited total response capability in one direction relative to slow resources. PJM has historically met its regulation requirements via the use of slow resources following a single regulation signal (RegA) designed to reflect the characteristics of slow resources in meeting ACE and frequency control requirements. Although fast resources can respond quickly to changes in RegA, they cannot always successfully track the RegA signal. When RegA is negative or positive for a significant period of time, non-generator, fast response units, such as fly wheels and batteries, quickly exhaust their capability to follow the signal. When RegA has many small displacements and crosses zero often, non-generator fast response units can more closely track RegA than traditional slow resources.

Generally speaking, fast response units are better suited to follow a signal that makes frequent changes from negative to positive and slow resources are better suited to follow a signal that makes less frequent changes from negative to positive. Regulation service defined around only one signal cannot take full advantage of the capability that either fast or slow resources can provide. A signal designed to take advantage of a particular resource type (fast or slow), will tend to diminish the ability of the other resource type to contribute to ACE and frequency control.

Due to the nature of the Regulation Market in PJM it is possible to meet PJM's regulation requirements (the regulation performance target) entirely with slow resources following RegA. PJM cannot, however, meet its regulation requirements (regulation performance target) using only fast resources, even with a fast resource specific regulation signal (RegD).

Although PJM cannot replace its slow regulation fleet with a fast regulation fleet, the KEMA Study indicated that a combination of fast and slow resources, following separate fast (RegD) and slow (RegA) regulation signals, could do a more effective job of meeting PJM's regulation requirement (regulation performance target) than slow resources alone. According to the study, the smaller the proportion of fast regulation MW and the greater the proportion of slow regulation used, the more benefit there is to substituting fast regulation MW for slow regulation MW. In other words, the smaller the proportion of fast regulation used, the more slow regulation each MW of fast regulation can replace.

Conversely, as the proportion of fast resources increases, the benefit of substituting fast capability for slow capability in meeting a specific regulation performance target decreases. In other words, the larger the proportion of fast regulation used, the less slow regulation each MW of fast regulation can replace. This is not surprising and follows a normal diminishing returns pattern. This relationship is the benefits factor, or rate of substitution, between fast and slow resources. The benefits factor decreases as the amount of fast resources increases.

The KEMA Study indicated that, for a given regulation performance target, there is a limit to this ability to substitute fast for slow regulation MW and reduce total combined regulation MW when trying to achieve a specific regulation performance target. This is why PJM cannot entirely replace its slow regulation fleet following a RegA signal with a fast regulation fleet following a RegD signal. Although the rate of substitution is greater than 1.0 when the level of fast regulation is low (one MW of fast can replace more than one MW of slow while holding regulation performance target constant), the rate of substitution falls as more fast regulation MW are added. The rate of substitution is the marginal benefits factor. Eventually, the addition of another MW of fast capability actually requires adding rather than replacing MW of slow capability to maintain a regulation performance target. At this point the rate of substitution is negative (less than zero) and the addition of fast resources makes it harder to maintain a regulation performance target. A flaw in the PJM proposal is that PJM proposes to arbitrarily prevent the rate of substitution (the benefits factor) from falling below zero.[7] While this is incorrect, it is unlikely to have any practical effect as the price of fast resources is likely to be very high under those conditions.

B. Defining a Market Solution with Two Inputs and One Product

The KEMA study indicated that, depending on the relative costs of fast and slow resources, a mix of fast and slow resources could provide regulation service at a lower cost than using slow resources alone. PJM's objective is to minimize the total cost to meet a specific regulation performance target given two types of regulation capability. The rate of substitution is a key component of any optimized solution to this problem.

Given a defined relationship between the two inputs (the production model that defines the rate of substitution), and the objective of minimizing costs, the market design solution to this optimization problem can be achieved in one of two ways: two input markets or one market for normalized input units.

1. Two Input Market Solution

The direct approach is to recognize a single service (regulation) that can be met with a combination of two inputs through a defined production model (the source of the rate of substitution), with each input type purchased in a separate market, one market for fast capability and the other for slow capability. The least cost combination of fast and slow regulation resources to meet a specific regulation performance target occurs where the marginal cost of fast (the clearing price for fast in the market for fast regulation MW), divided by the marginal contribution to the regulation performance target equals the

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[7] See September 17th Answer at 4–5. PJM limits the range of benefits factors from 2.9 to 0.00001.

marginal cost for slow (the clearing price for slow in the market for slow regulation MW), divided by the marginal contribution to the regulation performance target of slow.

2. One Market for Normalized Input Units

The Commission required a single market clearing approach, which required PJM to procure two input types in a single market, with a single supply curve including two types of regulation, with a single clearing price.[8] For this approach to work effectively, the two input types must be defined in common units in the production model. This is done by defining the market in terms of one of the two input types (either fast or slow capability), which becomes the base unit of measure, and using the rate of substitution (the marginal benefits factor) from the production model to convert the other input into equivalent units of the base units of measure.

a. Using the Marginal Benefits Factor to Convert to Common Input Units

In the PJM proposal, slow resource capacity is the base unit of measure. The conversion factor for any given regulation performance target for any given ratio of fast to slow is the rate of substitution, or the marginal benefits factor. This approach defines the supply curve for regulation in terms of slow regulation capability and dollars per unit of slow regulation capability, with fast resources offers represented in the supply stack in terms of equivalent slow regulation capability and prices. The conversion rate is the benefits factor defined at any point along the common supply curve.[9]

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8 *Frequency Regulation Compensation in the Organized Wholesale Power Markets*, Order No. 755, 137 FERC ¶ 61,064 at P 99 (2011); *order on reh'g*, Order No. 755-A, 138 FERC ¶ 61,123 (2012).

9 September 17th Answer at 4–5.

Take an example where, at the current ratio of fast to slow found at a defined point in the supply stack, the benefits factor (rate of substitution) is 2.0. This means that if the market clears at this point of combined supply, the resulting resource mix has a *marginal* rate of substitution between fast and slow capability of 2.0. This means that at this point in the supply curve, 1 MW of fast is providing as much regulation capability as 2 MW of slow. If a unit cost $2 per MW of fast, it would cost $1 per MW when translated into equivalent slow MW ($2/2 MW = $1/MW). If the unit were marginal, the marginal benefits factor at the clearing point would be 2.0, and the unit would set the price in terms of slow units at a price of $1 per MW of slow capability. It would be paid $1 for each MW of slow capability it provided. Since it is providing 2 MW of slow capability for every 1 MW of fast capability, it is paid $2 per MW of fast capability. It supplied 1 MW of fast at a cost of $2. The price received per unit is equal to its offer per unit, which is consistent with the treatment of a marginal resource in any market.

Any unit that is inframarginal, in this example, would have an offer that is less than the marginal unit, i.e., it would have to have an effective price of less than $1/MW of slow. If this resource has a cost of $1 per MW of fast, its offer in terms of slow would be $0.50 per MW in terms of slow at the clearing point of the market. It would be paid the $1/MW of slow capability clearing price (the clearing price), or $2 per MW of fast ($1 x Marginal Benefit Factor of 2). It would earn a margin of $1 ($2 - $1) per MW of fast supplied.

Take an example where, at the current ratio of fast to slow found at a defined point in the supply stack, the benefits factor (rate of substitution) is 0.5. This means that if the market clears at this point of combined supply, the resulting resource mix has a *marginal* rate of substitution between fast and slow capability of 0.5. This means that at the resource mix at this point in combined supply, 1 MW of fast is providing as much regulation capability as 0.5 MW of slow. If a unit cost $2 per MW of fast, it would appear to cost $4 MW when translated into equivalent slow MW ($2/0.5 MW = $4/MW). If the unit was marginal, the marginal benefit factor would be 0.5, and the unit would set the price in terms of slow units at a price of $4/MW of slow capability. It would be paid $4 for each MW of slow capability it provided. Since it is providing 0.5 MW of slow capability for every 1 MW of fast capability, it is paid $2 per MW of fast capability. It supplied 1 MW of fast at a cost of $2. The price received per unit is equal to its offer per unit, which is consistent with a marginal resource.

Any unit that is inframarginal, in this example, would have an offer that was less, in slow equivalent capability $/MW, than $4 per MW of slow capability. Assuming another fast resource cleared, it would have to have an effective price of less than $4/MW of slow. If this resource has a cost of $1 per MW of fast, its offer in terms of slow would be $2 per MW in terms of slow at the clearing point of the market ($1/ marginal benefit factor of 0.5). It would be paid the $4/MW of slow capability clearing price (the clearing price), or $2 per MW of fast ($4 x Marginal Benefit Factor of 0.5). It would earn a margin of $1 ($2 - $1) per MW of fast supplied.

b. Settlement Should Be Based on the Marginal Benefits Factor

As noted in the Market Monitor's March 26th Protest and the March 5th Proposal, the KEMA study, which provides the theoretical engineering basis for PJM's approach to its regulation market design, showed decreasing rates of substitution between fast and slow resources as the proportion of fast resources increases. This means that the marginal benefits factor (rate of substitution) decreases as the amount of fast resources used increases. This means that the benefit of every fast resource being used, not just the last one, is declining as more fast resources are added to the regulation commitment. The correct way to include this result in the settlement solution is to reflect the marginal rate of substitution when determining the relative substitutability of fast and slow resources and therefore the correct market equilibrium. The correct approach results in a uniform price in a common unit of measure (slow resource MW and price per MW of slow) that reflects the marginal value of the resources used.

II. 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: October 9, 2012

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 9th day of October, 2012.

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