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PJM Interconnection, L.L.C.	)	Docket Nos. ER12-1204-001, -002
	)	and ER12-2391-000

**COMMENTS, MOTION FOR TECHNICAL CONFERENCE,
AND MOTION TO ACCEPT COMMENTS FILED OUT-OF-TIME
OF THE INDEPENDENT MARKET MONITOR FOR PJM**

Pursuant to Rules 211 and 212 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 the filing of PJM Interconnection, L.L.C. on January 15, 2013 ("January 15th Compliance Filing") in compliance with the order issued November 16, 2012 ("November 16th Order") on PJM's prior compliance filing dated August 15, 2012 ("August 15th Compliance Filing").[3] The Market Monitor moves for a technical conference to consider the issues raised in this proceeding. The Market Monitor also moves that the Commission accept its comments out-of-time.

The January 15th Compliance Filing constitutes PJM's effort to comply with its understanding of the November 16th Order, but it should be rejected for the reasons explained by PJM in the January 15th Compliance Filing, and as further explained in this pleading. PJM's August 15th Compliance Filing should be accepted instead, because this approach best balances the need for an efficient and functional regulation market with the Commission's policy objectives.

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[1]   18 CFR § 385.211 & 385.212 (2012).

[2]   Capitalized terms used herein and not otherwise defined have the meaning used in the PJM Open Access Transmission Tariff ("OATT").

[3]   *PJM Interconnection, L.L.C.*, 139 FERC ¶ 61,130 (2012).

The Commission's objective with regard to the regulation market design, as outlined in Order No. 755, is to provide a structure in which organized markets can take advantage of new technologies to meet their regulation needs in the most cost effective and efficient way possible. The Commission recognized that new, fast response technologies could be used, in combination with traditional resources, to reduce the amount of resources needed to meet regulation requirements and thereby reduce the cost of regulation. The Commission directed that the new and traditional resources be purchased in a single market, with compensation for both capacity and miles provided. PJM's August 15th Compliance Filing was designed to meet these objectives.

The Market Monitor recognizes that the Commission has concerns about the approach adopted in the August 15th Compliance Filing. The Market Monitor endeavors to address those concerns below. However, because the issues raised here are complex, the Market Monitor believes that a technical conference would be a constructive approach for exploring the issues raised here. The Market Monitor is concerned that in spite of a consensus about the compliance objectives, PJM's recent filing means that the regulation market will not work as either the Commission or PJM intends. The Market Monitor requests that the Commission, if appropriate, convene a technical conference to consider the technical issues raised in this proceeding.

I. BACKGROUND

A. The Need for the Consistent Application of the Marginal Benefits Factor: Optimization and Settlement.

The Commission's November 16th Order accepted the concept of two distinct types of frequency response (Reg A and Reg D) service, with Reg A service supplied by resources following the Reg A signal and Reg D service provided by resources following the Reg D signal, being used to provide regulation. This concept requires that the offers of Reg A and Reg D service be comparable and that a single clearing price be payable to all cleared resources, including both Reg A and Reg D resources.

The November 16th Order accepted that, in order to achieve this comparability, the marginal benefits factor, defined as the rate of substitution between Reg A and Reg D at the market clearing point, allows a direct comparison of Reg A and Reg D.[4] But the Order did not follow through the logic to recognize that the marginal benefits factor must govern both the optimal quantity of each resource type and the payment of each resource type.

The November 16th Order states, "the benefits factor represents a measure of the substitutability of fast-response resources for traditional resources, and thus the use of the benefits factor to settle capability payments is justified as a payment for Effective MW of regulation capability."[5]

But the November 16th Order rejected the use of the marginal benefits factor in the settlement of the market results.[6] The November 16th Order explains "in Order No. 755, the Commission required that resources that are asked to, and do, provide the same regulation service be paid the same, and that resources that are asked to, and do, perform different amounts of service be paid differently." The November 16th Order found that "PJM's proposal to use a benefits factor in settlement allows resources to perform the same amount

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[4]   November 16th Order at P 30. "We find that PJM's proposal satisfies the directives of the May 17 Order with respect to market clearing. Consistent with the May 17 Order directives, PJM provides sufficient information as to how the benefits factor will be calculated. For example, PJM proposes to calculate both a unit-specific benefits factor and a marginal benefits factor for the fast responding and traditional regulation signals. Under PJM's proposal, each resource will be assigned a unit-specific benefits factor based on its order in the merit stack for the applicable regulation signal. PJM's proposal also provides that the unit-specific benefits factor is the point on the benefits factor curve that aligns with the last MW, adjusted by historical performance that a given resource will add to the fast-responding resource stack. We also find that the use of the benefits factor in market clearing allows PJM to minimize the total capability it needs to procure, while maintaining its compliance with NERC's Control Performance Standard 1. For the above reasons, we accept PJM's proposal to use the benefits factor in market clearing. We discuss in section III, below, our rejection of PJM's proposed benefits factor, as applied to the settlement process.

[5]   November 16th Order at P 88.

[6]   November 16th Order at P 88.

of work and receive different levels of compensation."[7] In support of this conclusion, the November 16th Order stated "(for) example, assuming the same capability, performance, and accuracy score, a fast-responding resource with a marginal benefits factor of two would receive twice the performance payment as a traditional signal resource."[8] The Commission's conclusion is not correct. PJM's proposed design would result in paying both fast and slow regulation resources the same amount of dollars for the same amount of work.

Using FERC's hypothetical facts, each equivalent unit of regulation is compensated equally. A 1 MW fast-responding resource provides twice as much regulation service, on the margin, as 1 MW of slow-responding resource when the marginal benefits factor is two. Thus, assuming the same capability, performance, and accuracy score, a fast-responding resource with a marginal benefits factor of two would receive exactly the same performance payment as a traditional signal resource per equivalent unit of regulation.

The correct market outcome, in a market that is purchasing units of regulation, is to pay the same price per equivalent unit of regulation. The fast-responding resource is providing two units of regulation, measured in MW of slow capability and associated slow miles, for every MW of fast capability and associated miles. It should therefore be paid for two units, two MW worth of slow capability and miles, for every one MW of fast and its associated miles.

Resources are self-divided into two groups, those that choose to follow Reg A (traditional and slower oscillation signal) and those that choose to follow Reg D (faster oscillation signal).

A resource following Reg A provides regulation service measured in MW of capability and miles of movement per MW of capability. A resource following Reg D also

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[7]   November 16th Order at P 86–88.

[8]   November 16th Order at P 86.

provides regulation service, and the amount of regulation service provided is measured in terms of Reg A. The conversion of units of Reg A into units of Reg D uses the benefits factor.

The marginal benefits factor is based on the physical, engineering characteristics of the system and the resultant relative effectiveness of Reg A and Reg D resources in meeting the system's need for regulation. The amount of regulation provided by a unit of Reg D measured in terms of Reg A units depends on these observed system characteristics. The marginal benefits factor describes how much regulation can be provided by the next increment of a Reg D resource, measured in terms of equivalent Reg A regulation MW.[9] This translation into equivalent Reg A MW of regulation is required in order to have an efficient market clearing mechanism with a single price.

The November 16th Order recognizes that the marginal benefits factor describes the substitutability of Reg D resources for Reg A resources at any given ratio of Reg D to Reg A being used to provide a given amount of total regulation.[10] If the marginal benefits factor is two, the last MW of a Reg D following resource is providing twice as much work, in terms of regulation service provided, per MW of capability, as the last MW of a Reg A following resource.

In a market where every MW (and associated miles) is being sold in Reg A equivalent MW (and associated miles) work, the clearing price will be in terms of dollars per MW of Reg A (and associated Reg A miles) work. As noted in the November 16th Order, for the market result to be nondiscriminatory, every unit of Reg A work provided must be paid the same price per unit of Reg A work. If the market clears at $1/MW of Reg A work,

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[9]   PJM could have taken the opposite approach, and developed a marginal benefits factor that describes how much Reg D equivalent can be provided by the next increment of a Reg D following resource. It does not matter which signal establishes the base value.

[10]   November 16th Order at P 88.

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every cleared MW of Reg A work must be paid \$1/MW per MW of Reg A work. In the November 16th Order example, a marginal benefits factor of two indicates that Reg D provided as much work as two units of Reg A in the market solution.

A resource that cleared 1 MW of Reg A should be paid \$1. A resource that cleared 2 MW of Reg A should be paid \$2 total, with each MW of cleared Reg A work paid \$1. The Reg D resource clears its 1 MW of Reg D in the Reg A market with a marginal benefits factor of 2 which means that the 1 MW of Reg D work is providing 2 MW of Reg A work. If it is paid \$1 per MW of Reg A work, it will receive \$2, with each MW of cleared Reg A work paid \$1. This is appropriate and non-discriminatory, as required by Order No. 755.

In contrast, it would be discriminatory to pay the Reg D resource according to the November 16th Order. The November 16th Order would pay the Reg A clearing price to each Reg D MW in the settlement process, without applying the benefits factor. Applying this method would pay the 1 MW of Reg D only \$1 despite providing 2 MW of Reg A work. The November 16th Order would, if implemented, cause the fast and slow resources to be paid different amounts for the same amount of service provided and would cause fast resources to be underpaid if the marginal benefits factor is greater than one.

The application of the same marginal benefits factor in both the market clearing and the settlements calculations ensures that resources that perform the same amount of work, measured in effective units of Reg A (slow), receive the same levels of compensation per effective units of Reg A (slow). The same logic holds true regardless of the component of price under consideration (total price, capability price or performance price), and whether payment is made in terms of units of effective MW and/or effective actual miles.

B. The Marginal Benefits Factor is not Used as a Substitute for the Use of Actual Miles in the PJM Proposal.

The November 16th Order states:

PJM has not demonstrated that the benefits factor is a substitute for including actual mileage in the settlement process. Therefore, we are not persuaded by arguments suggesting that the benefits factor must be included in the

settlement process or that the benefits factor should displace the use of actual mileage in the settlement process.[11]

This does not correctly describe the August 15th Compliance Filing. PJM's August 15th proposal does include actual mileage in the settlement process. Expected miles are necessarily used to determine the supply curve, the resources that clear and the clearing price prior to operation. PJM's August 15th proposal uses actual equivalent miles in the after the fact settlement process, not expected miles.

C. Application of Actual Within Hour Unit Performance in Settlement Addresses the Commission's Concerns Regarding the Use of Actual Miles.

The November 16th Order rejected the use of the ratio of Reg A and Reg D signals (the ratio of mileage requested) as a substitute for (the ratio of) actual miles in settlement,[12] explaining: "PJM has failed to provide sufficient evidence that the ratio of control signals is an accurate measure of a resource's later-dispatched mileage or performance;" the "Regulation Market Performance Clearing Price is affected by only the estimated mileage of the marginal resource, and any deviation by the resource in real-time would require a true-up, absent in PJM's proposal"; and "[e]ach Commission-approved independent system operator or regional transmission organization that has a tariff that provides for the compensation for frequency regulation service must provide such compensation based on the actual service provided, including … a payment for performance that reflects the quantity of frequency regulation service provided by a resource when the resource is accurately following the dispatch signal." The November 16th Order concluded that "by failing to include actual mileage in the settlement equation, PJM appears to be inconsistent with Order No. 755."[13] The Commission directed "PJM to either explain why its proposal

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[11]   November 16th Order at P 87.

[12]   November 16th Order at P 46.

[13]   November 16th Order at P 46.

provides a reasonable basis for paying for resources based on the actual service provided or to submit an additional compliance filing that proposes a reasonable method for paying resources based on mileage within 60 days of the date of the order."[14]

PJM's August 15th Compliance Filing correctly provides for paying regulation resources on actual performance, measured after the fact. This is the correct way to pay for regulation and is consistent with the Commission's statements.

The expected performance does not provide an accurate measure of a resource's actual (within hour) performance.

As noted by PJM in its January 15 compliance filing, PJM's August 15 proposal did include actual mileage from each interval in the clearing prices to ensure that clearing prices reflected actual mileage of the marginal resource for the interval.[15] Under PJM's August 15 proposed approach, the regulation price, for purposes of market clearing, was based on the marginal unit's estimated miles. However within hour pricing and settlement were based on actual miles within the hour. As the Commission notes, frequency regulation service providers should receive compensation based on the actual service provided. That is the basis of PJM's proposal in the August 15 filing.

In the PJM market design all service in the market solution is provided in terms of slow equivalent effective MW of service. Compensation does include a performance adjusted payment for performance (miles) that reflects the actual mileage of regulation service provided by a resource, in slow equivalent miles, when the resource is accurately following its respective dispatch signal. It does not matter whether the resource is following Reg A or Reg D. Correct application of the performance factor and the benefit factor will, as proposed in PJM's August 15 compliance filing, achieve the correct result.

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[14] November 16th Order at P 47.

[15] January 15th Compliance Filing at 5.

D. Equal Compensation for Equal Work, Measured in Miles, Requires the Consistent Use of the Marginal Benefits Factor.

The objective of the August 15th Compliance Filing's regulation market design is to pay equivalent work the same price per unit of work, consistent with Order No. 755.[16] Because all regulation service is defined in terms of resources following Reg A, the marginal benefits factor describes how much Reg A equivalent regulation can be provided by the next increment of a resource following Reg D, given current levels of Reg A and Reg D employed. In other words, the benefits factor describes the substitutability of Reg D miles for Reg A miles at any given ratio of dispatched resources following Reg A or Reg D. The benefits factor, therefore, provides a direct means by which to compare the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement.

Once directly comparable, the single market solution involving Reg A and Reg D resources is a tractable optimization problem that allows a single price and quantity for the market solution, in terms of the single, defined product (Reg A capability and associated miles). So long as resources are paid on a per equivalent unit basis, based on the marginal value of an equivalent unit basis on the margin, the results are consistent with a least cost, efficient and non-discriminatory result, whether the valuation is based on MW or miles. This means that for a market with single clearing price for a specified unit of work to be efficient and non-discriminatory, every specified unit of work supplied in that market must be paid the same price per unit of work. A market that results in different prices being paid for the same amount of work is inefficient and discriminatory.

Removing the marginal benefits factor from the market solution, either in the optimization or the pricing determination, eliminates the direct means by which to compare

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[16]   The November 16th Order states (at P 85), "in Order No. 755, the Commission required that resources that are asked to, and do, provide the same regulation service be paid the same, and that resources that are asked to, and do, perform different amounts of service be paid differently."

the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement. Using the benefits factor in the optimization but removing the benefits factor from the settlement eliminates the ability of the market to pay Reg A and Reg D resources on a per equivalent unit basis. As a result, a regulation market design that clears Reg A and Reg D based on an equivalent unit of work basis but prices and settles on a non-equivalent basis (as apparently suggested by the November 16th Order) will provide market results that are not consistent with a least cost, non-discriminatory result, whether the valuation is based on MW or miles.

In the absence of a price based on an equivalent unit of work for Reg A and Reg D, a regulation market with single clearing price for capability and miles will be inefficient and discriminatory, as every equivalent unit of work supplied by Reg D will be paid a different price than every equivalent unit of work provided by Reg A. The price per unit of work in such a market will therefore not reflect the marginal price of the marginal resource that clears the market and there will be no guarantee that that every resource that cleared in the market solution will have an incurred marginal cost of deployment equal to or less than the market price. There will be no guarantee that the price used for settlement will be sufficient to cover the costs of cleared resources. The removal of the marginal benefits factor from the settlement of the market will result in different prices being paid to Reg D and Reg A resources for the same amount of work. Removing the marginal benefits factor from the settlement portion of the market design will thereby cause the PJM regulation market design to be in inefficient and discriminatory.

A detailed set of examples that illustrate the issue created by an inconsistent application of the marginal benefits factor to the two input market for regulation for the purpose of forcing a uniform per mile rather than a uniform price per normalized unit of work (Reg A equivalent regulation service) is provided in the Appendix to this pleading.

II.   MOTION FOR TECHNICAL CONFERENCE

The Market Monitor believes that PJM can develop an efficient design for its Regulation Market that is consistent with Commission's policy directives. The technical complexity of this market has made it difficult to address all of these concerns. Accordingly, the Market Monitor believes that a technical conference open to all parties and including the technical experts on this subject at PJM, the Market Monitor, the Commission and other interested parties would contribute to the successful resolution of the issues raised here.

A technical conference would provide an opportunity to fully explore the market design included in PJM's initial proposal, particularly the role of the marginal benefits factor in maintaining the relative value and cost of Reg D and Reg A resources in the optimization, the unit selection, the pricing and ultimate settlement of the Reg D and Reg A services in providing regulation. The Market Monitor does not believe that the Commission intends to require that PJM implement a market design where the clearing prices for resources is not consistent with the settlement values paid to the resources. That would be the definition of a market failure. A technical conference would offer the best opportunity to sort out these issues. Accordingly, the Market Monitor moves that the Commission convene a technical conference in this proceeding.

III.   MOTION TO ACCEPT COMMENTS OUT-OF-TIME

The Market Monitor moves that the Commission accept these comments filed out-of-time. The Commission granted the Market Monitor's motion to intervene on November 16, 2012, and the Market Monitor has actively participated in this proceeding.[17]

Because the outcome of this proceeding will have an impact on the efficient operation of PJM markets, and the Market Monitor is charged to promote and protect that objective, no other party can represent the Market Monitor's interests here and

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[17]   *PJM Interconnection, L.L.C.*, 141 FERC ¶ 61,134 at PP 6–7 (2012).

consideration of the Market Monitor's comments is in the public interest. Because it is early in this phase of the proceeding, accepting these comments out-of-time will not cause disruption or delay. Accordingly, good cause exists to grant this motion, and the Market Monitor respectfully requests that the Commission grant this motion to submit comments out-of-time.

IV. CONCLUSION

The Market Monitor respectfully requests that the Commission afford due consideration to these comments, grant the motion for a technical conference, and grant the motion to accept these comments out-of-time as the Commission resolves the issues raised in this proceeding.

Respectfully submitted,

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Dated: February 7, 2013

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 February, 2013.

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The objective of the August 15th Compliance Filing's regulation market design is to pay equivalent work the same price per unit of work, consistent with Order No. 755.[18] Because all regulation service is defined in terms of resources following Reg A, the marginal benefits factor describes how much Reg A equivalent regulation can be provided by the next increment of a resource following Reg D, given current levels of Reg A and Reg D employed. In other words, the benefits factor describes the substitutability of Reg D miles for Reg A miles at any given ratio of dispatched resources following Reg A or Reg D. The benefits factor, therefore, provides a direct means by which to compare the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement.

Once directly comparable, the single market solution involving Reg A and Reg D resources is a tractable optimization problem that allows a single price and quantity for the market solution, in terms of the normalized good (Reg A capability and associated miles). So long as resources are paid on a per equivalent unit basis, based on the marginal value of an equivalent unit basis on the margin, the results are consistent with a least cost, non-discriminatory result, whether the valuation is based on MW or miles. This means that for a market with single clearing price for a specified unit of work to be efficient and non-discriminatory, every specified unit of work supplied in that market must be paid the same price per unit of work. This price per unit of work must reflect the marginal price of the marginal resource that clears the market such that every resource that cleared in the market solution must have an incurred marginal cost of deployment equal to or less than the

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[18]   The November 16th Order states (at P 85), "in Order No. 755, the Commission required that resources that are asked to, and do, provide the same regulation service be paid the same, and that resources that are asked to, and do, perform different amounts of service be paid differently."

market price. A market that results in different prices being paid for the same amount of work is inefficient and discriminatory.

Removing the marginal benefits factor from the market solution, either in the optimization or the pricing determination, eliminates the direct means by which to compare the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement. Using the benefits factor in the optimization but removing the benefits factor from the settlement eliminates the ability of the market to pay Reg A and Reg D resources on a per equivalent unit basis, based on the marginal value of an equivalent unit basis on the margin. As a result a regulation market design that optimizes (clears) Reg A and Reg D based on an equivalent unit of work basis but prices and settles on a non-equivalent basis will provide market results that are not consistent with a least cost, non-discriminatory result, whether the valuation is based on MW or miles.

In the absence of a price based on an equivalent unit of work for Reg A and Reg D a regulation market with single clearing price for capability and miles will be inefficient and discriminatory, as every equivalent unit of work supplied by Reg D will be paid a different price per equivalent unit of work than every equivalent unit of work provided by Reg A. The price per unit of work in such a market will therefore not reflect the marginal price of the marginal resource that clears the market and there will be no guarantee that that every resource that cleared in the market solution will have an incurred marginal cost of deployment equal to or less than the market price. There will be no guarantee that the price used for settlement will be sufficient to cover the costs of cleared resources. The removal of the marginal benefits factor from settlement portion of the market will result in different prices being paid to Reg D and Reg A resources for the same amount of work. Removing the marginal benefits factor from the settlement portion of the market design will thereby cause the PJM regulation market design to be in inefficient and discriminatory.

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For a product market to function efficiently, the product in question, and the unit of measure for the product, must be defined and consistent. In a market with two distinct sources of supply (Reg A and Reg D resources), the sources of supply must be broken down into comparable units of value for a price per unit to be meaningful. The following set of examples will illustrate the issue created by an inconsistent application of the marginal benefits factor to the two input market for regulation for the purpose of forcing a uniform per mile rather than a uniform price per normalized unit of work (Reg A equivalent regulation service). There are two sets of examples. Each example set compares three approaches to the regulation market optimization and settlement under each example's set of assumptions regarding the benefits factor, offer prices and signal (miles/MW).

The first approach will show the results of using the market design proposed in PJM's August 15 compliance filing. In the August 15th Compliance Filing the benefits factor was consistently used throughout optimization and settlement. In the August 15th Compliance Filing the benefits factor is used to provide a direct means to consistently compare, in comparable units of value, the marginal benefit and the marginal cost of using an additional Reg D or an additional Reg A resource in meeting the regulation requirement. By using the benefits factor throughout the optimization and settlement process, PJM's August 15 approach results in uniform prices per normalized unit of work (Reg A equivalent regulation service) in terms of MW and miles for both Reg A and Reg D provided regulation.

The second approach in each example will illustrate a possible interpretation of the Commission's directive, under PJM's two part pricing approach, to use the benefits factor in the optimization, but not settlement, and to pay Reg A and Reg D the same $/mile rate regardless of the actual benefits factor or signal ratio. Under this modeled approach, the $/mile rate for all resources is determined by taking the marginal performance price (the highest performance offer that clears the market) and dividing it by the unadjusted (not normalized) miles of the resource that sets the non-normalized performance clearing price. This approach results in realized payment (price) per unit of equivalent effective work for

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Reg A and Reg D to vary from one another, thereby causing inefficient market results and prices that are inconsistent with the optimization.

The third approach in each example illustrates PJM's revised proposal as presented in the January 15 Compliance Filing in response to the Commission's directives. Under PJM's January 15 Compliance Filing, the benefits factor is eliminated in settlement, but the performance payment ($/MW) to Reg D resources is multiplied by the ratio of the Reg D to Reg A (Reg D miles/Reg A miles) to provide a non-normalized and uniform $/mile price payment to Reg D and Reg A resources. This approach results in realized payment (price) per unit of equivalent effective work for Reg A and Reg D to vary from one another, thereby causing inefficient market results and prices that are inconsistent with the optimization.

1. **Example Set 1: Benefit Factor of 1, 10 to 1 Reg D and 5 to 1 signals Reg A.**

This first set of example outlines a situation where the marginal benefits factor is one (1), the Reg D signal calls for 10 miles per MW of movement in the hour and the Reg A signal calls for 5 miles of movement per MW in the hour. The example focuses on two resources for simplicity. A 1 MW Reg A following resource with a $1/MW offer for capacity and $0.50 per mile offer for performance and a 1 MW Reg D following resource with a $5/MW offer for capacity and a $0.20 per mile offer for performance. Table 1 shows the full assumption set for Example 1. This example assumes that two (2) total MW of Reg A equivalent regulation is required to meet the regulation requirement.

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Table 1 Example 1 Assumption Set

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0		Fast Signal/Slow Signal
3	Slow equivalent mile per mile	2.0		Fast to Slow Ratio/BF
4	MW (Capability)	$1.00	$1.00	
5	$/MW Offer	$1.00	$5.00	
6	$/Mile Offer	$0.50	$0.20	
7	Performance Offer (No BF) $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer (No BF) $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	1.00	1.00	
10	BF Adjusted Total Offer $/MW	$6.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$5.00	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$6.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)

As shown in Table 1, with a 5 to 1 signal for Reg A (Slow) and a 10 to 1 signal for Reg D (Fast), the total $/MW performance offer of the Reg A resource would be $1/MW (Row 7, Column 2) and the total $/MW (unadjusted) performance offer cost of the Reg D resource would be $5/MW (Row 7, Column 1). The total $/MW capability offer of the Reg A resource would be $5/MW (Row 5, Column 2) and the total $/MW (unadjusted) capability offer performance offer cost of the Reg D resource would be $1/MW (Row 5, Column 1). The total $/MW offer (unadjusted) of the Reg A resource would be $6/MW (Row 8, Column 2) and the total $/MW capability offer performance offer cost of the Reg D resource would be $6/MW (Row 8, Column 1). These values are not adjusted for a benefits factor.

In this example, the benefits factor of 1 indicates that 1 MW of Reg A is doing as much work as 1 MW of Reg D, each 1 MW of Reg A is equivalent to 1 MW of Reg D in the optimization. Reg D and Reg A are directly comparable on a per MW basis and no adjustment is needed on their price per MW as the work (regulation provided) per MW is equivalent.

It is important to note that the Reg A and Reg D resources, even with a benefits factor of one, are not performing the same amount of work (in terms of regulation provided) per mile. The marginal benefits factor, combined with the ratio of the Reg D to

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Reg A signal, is indicating that 1 MW of Reg D, following the 10 to 1 Reg D signal, is providing as much regulation (work) as 1 MW of Reg A, following the 5 to 1 Reg A signal. This means that 10 miles of Reg D work is doing the equivalent of 5 miles of Reg A work in terms of regulation provided. Stated another way, every 2 miles of Reg D work is equal to 1 mile of Reg A work for purposes of providing regulation in the hour (Row 3), or 1 miles of Reg D is equal to 0.5 miles of Reg A. This means that on a non-normalized per mile basis, Reg D is doing half the work of Reg A per mile. This ratio of miles to MW is implicitly contained in the marginal benefits conversion of Reg D MW into equivalent units of Reg A MW, and in the resulting relative valuation in the optimization.

If the performance clearing price is $5 per Reg A equivalent MW (max performance price among cleared resources), the price per Reg A *equivalent mile* is $1 per mile ($5/5 miles). If every resource gets the equivalent of $1/mile of Reg A equivalent work provided, the market price will be consistent with the optimization solution. This would mean that both the Reg A and Reg D resource should get $5 per Reg A equivalent MW for performance, as each is provided the equivalent of 5 miles per MW of Reg A service. Any deviation from this result in settlement is evidence of a market failure, as this would indicate that Reg A and Reg D resources were being paid different amounts per unit of equivalent work.

Within the optimization the Reg A MW and the Reg D MW both cost $6 per unit of Reg A MW (Row 10). The optimization requires a total of two MW of Reg A, or Reg A equivalent MW to meet the regulation requirement, so any market solution will require the use of both resources. The marginal resource cost in the market solution (in the optimization) is $6/MW (Row 13). A market clearing price result of $6/MW per MW of slow, or slow equivalent MW, would be consistent with the marginal valuation of resources in the optimization. A market model that paid both the Reg D resource and the Reg A resource $6 per Reg A equivalent MW would be consistent with the optimal solution. This is true regardless of how the $6 per Reg A equivalent MW is subdivided between capability and performance. Any deviation from this result in settlement is evidence of a market

failure, as this would indicate that Reg A and Reg D resources were being paid different amounts per unit of equivalent work.

> ### a. Approach 1: Consistent use of the benefits factor to make optimization, pricing and settlement consistent with the value of the normalized good.

This approach shows the results of using PJM's August 15th application of the benefit factor. In the August 15 approach, the benefits factor is consistently used throughout the optimization and settlement process. The benefits factor therefore provides a direct means by which to compare the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement. This means that the optimization solution will be consistent with the market signals that appear in the marketplace. The August 15 approach results in a uniform price per units of the normalized good (Reg A), whether measured in terms of normalized MW or normalized miles. Table 2 provides the shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

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Table 2 PJM's August 15ᵗʰ Approach: Consistent Application of the Benefits Factor with uniform pricing on a normalized unit basis

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2	1.0	Fast Signal/Slow Signal
3	Slow equiavlant mile per mile	2		Fast to Slow Ratio/BF
4	MW	1	1	
5	$/MW	$1.00	$5.00	
6	$/Mile	$0.50	$0.20	
7	Performance Offer $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	1.00	1.00	
10	BF Adjusted Total Offer $/MW	$6.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$5.00	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$6.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)
	PJM Approach (August)			
14	Settlement Prices $/MW			
15	Clearing Price $/MW	$6.00		Max (Row 8)
16	Performance Clearing Price $/MW	$5.00		Max (Row 7)
17	Capability Price $/MW	$1.00		Row 15- Row 16
18	$/ Slow Equivalent Mile	$1.00	$1.00	$/Mile
19	Slow Equivalent Miles	$5.00	$5.00	MW X BF X Slow Signal
20	Total Payment Capability	$1.00	$1.00	Per Slow MW
21	Total Payment Performance (miles)	$5.00	$5.00	Per Slow MW
22	Total Payment	$6.00	$6.00	Per Slow MW
23	Total Payment with BF Adjustment	$6.00	$6.00	
24	Net Revenue	$0.00	$0.00	Per Actual MW

Under PJM's two part pricing approach the total clearing price in the optimization and the market per MW is $6/MW (Row 13 and Row 15). The base performance clearing price (equal to the highest cleared performance offer) is $5/MW and it set by the Reg D fast resource (Row 16). The base capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16). A benefits factor of one indicates that one MW of fast equals one MW of slow in the optimization and settlement process. This means the prices for capability and performance, given in terms of $/slow MW are directly applicable to any fast resources that clears.

Under PJM's August 15 compliance filing, the Reg D resource is paid its Reg A equivalent (benefit factor adjusted) capability MW times the clearing capability price (Row 27) given in dollars per Reg A equivalent MW for capability. Total capability payment per Reg A equivalent MW is $1.00/MW (Row 20).

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The Reg D resource is also paid its Reg A equivalent capability MW times the performance clearing price (Row 16) given in dollars per Reg A MW equivalent performance, for a total performance payment of $5.00 per Reg A MW equivalent performance (Row 21). The realized performance payment on per *Reg A equivalent mile* is $1 per mile (Row 18). The Reg D resource provides a total of five Reg A equivalent miles. At a $1 per Reg A equivalent mile, this also results, as it should, in a total performance payment of $5.00 per Reg A equivalent MW (Row 21).

The total payment to the 1 MW of Reg D resource is $6 per Reg A equivalent MW (Row 22), which modified by a benefit factor of one, results in total payment of $6 per MW of Reg D (Row 23). The benefit factor of one (1) indicates that each MW of Reg D is providing as much regulation (work) a MW of Reg A. Each MW of a Reg D resource should then get the same payment per equivalent unit of regulation provided as a MW of Reg A resource.

The realized cost per MW of the Reg D resource (Row 22) equals the marginal resource offer per MW used in the optimization (Row 8). The marginal value of the resource in the optimization is equal to its marginal valuation in the market. The market result is efficient, and all incremental resource costs are equal to or less than the market clearing price.

Reg A resource is paid the performance clearing price per Reg A MW (Row 16) for each MW of Reg A capability. Total performance related payments to the Reg A resource is $5.00, which is equivalent to $1 per Reg A mile (Row 18), which the identical realized payment per mile, on an equivalent mile basis, as the Reg D resource. The Reg A resource is paid Reg A capability MW (Row 4) times capability price (Row 17) for a total of $1 (Row 20). The total payment to the Reg A resource, which cleared in the optimization step, is $6.00 per MW of Reg A equivalent MW. The net revenue (Row 22) of the Reg A resource is $0.

The resulting payment to the Reg A and Reg D resource is non-discriminatory, with each resource paid the same amount per mile of Reg A work provided. As noted earlier, a

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benefits factor of one indicates that 1 MW of Reg A is doing as much work as 1 MW of Reg D, each 1 MW of Reg A is equivalent to 1 MW of Reg D in the optimization. Reg D and Reg A are directly comparable on a per MW basis and no adjustment is needed on their price per MW as the work (regulation provided) per MW is equivalent. The resulting realized market solution is efficient and non-discriminatory.

Total cost to meet the regulation requirement under the optimization solution is $12. Total cost to meet the regulation requirement after-market settlement is $12.

> b. *Possible Compliance Approach: No benefit factor in settlement, marginal performance resource determines uniform $/mile on a non-normalized basis*

This example will illustrate a possible interpretation of the Commission's directive, under PJM's two part pricing approach, to use the benefits factor in the optimization, but not settlement, and to pay Reg A and Reg D the same $/mile rate regardless of the actual benefits factor or signal ratio. Under this modeled approach, the $/mile rate for all resources is determined by taking the marginal performance price (the highest performance offer that clears the market) and dividing it by the unadjusted (not normalized) miles of the resource that sets the non-normalized performance clearing price. This approach results in realized payment (price) per unit of equivalent effective work for Reg A and Reg D to vary from one another, thereby causing inefficient market results and prices that are inconsistent with the optimization. Table 3 shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

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Table 3 Possible Compliance Approach 1: Marginal Resource Determines $/Mile

Row	Category	Column 1 Fast	Column 2 Slow	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0		Fast Signal/Slow Signal
3	Slow equivalent mile per mile	2.0		Fast to Slow Ratio/BF
4	MW (Capability)	$1.00	$1.00	
5	$/MW Offer	$1.00	$5.00	
6	$/Mile Offer	$0.50	$0.20	
7	Performance Offer (No BF) $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer (No BF) $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	1.00	1.00	
10	BF Adjusted Total Offer $/MW	$6.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$5.00	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$6.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)
	Approach 1, Marginal Resource Determines $/Mile	**Fast**	**Slow**	**Notes**
14	Settlement Prices (No BF)			
15	Clearing Price	$6.00		Max (Row 8)
16	Performance Clearing Price	$5.00		Max (Row 7)
17	Capability Clearing Price	$1.00		Row 15- Row 16
18	$/Mile Price	$0.50		Row 16/Row 1
19	Total Payment Capability	$1.00	$1.00	Row 4 x Row 17
20	Total Payment Performance (miles)	$5.00	$2.50	Row 18 x Row 1
21	Total Payment	$6.00	$3.50	Row 19 + Row 20
22	Net Revenue	$0.00	($2.50)	Row 21 - Row 7

Since the benefits factor is used in the optimization, the optimization solution in this example is the same as it is under the August 15 proposal. In addition, the benefits factor of one results in the same posted total clearing price per MW of $6/MW (Row 15). The performance clearing price (equal to the highest cleared performance offer) is $5/MW and it set by the Reg D fast resource (Row 16).

As before, the Reg D resource is marginal for performance, so under this construct, the Reg D actual miles (Row 1) in the hour are used to determine the uniform performance price per mile. The performance clearing price (Row 16) divided by actual Reg D miles (Row 1) provides a price per mile (Row 18) of $0.50/mile. The capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16).

The Reg D resource is paid Reg D capability MW times capability price (Row 19) plus Reg D capability MW times Reg D actual miles times $/mile (Row 20) for a total of

$6.00. Marginal price equals the marginal resource offer per MW for the Reg D resource. The net revenue (Row 22) of the Reg D resource is $0.

The Reg A resource is inframarginal for performance, so the Reg A actual miles (Row 1) in the hour (miles/MW signal) are not used to determine the performance price per mile. The Reg D resource has set the price per mile at $0.50/mile (Row 18). The capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the highest performance clearing price (Row 16), set by the Reg D resource. The Reg A resource is paid Reg A capability MW times capability price for a total of $1 (Row 19) The Reg A resource is also paid for each of its five miles at the rate of $0.50 a mile, for a total of $2.50 (Row 20).

The total payment to the Reg A under this construct of uniform payment per mile is only $3.50 per MW. This is $2.50 per MW less than the Reg A total offer ($6.00 per MW) which set the optimization clearing price. The net revenue (Row 22) of the Reg A resource is -$2.50. Without an uplift payment, the Reg A resource loses money from participating in the market and the marginal payments to resources does no match up with the marginal offers or the marginal price. Relative to the Reg A MW per unit value in the optimization, this approach undervalues and under pays the Reg A resource.

This market approach results in a discriminatory and inefficient market result. Under this approach Reg A and Reg D resources would, in the absence of uplift correction, be paid different amounts per unit of regulation service provided. As noted earlier, a benefits factor of one indicates that 1 MW of Reg A is doing as much work as 1 MW of Reg D, each 1 MW of Reg A is equivalent to 1 MW of Reg D in the optimization. Reg D and Reg A are directly comparable on a per MW basis and no adjustment is needed on their price per MW as the work (regulation provided) per MW is equivalent. Yet, this approach would provide $6.00 per MW of Reg D and only $3.50 per MW of Reg A, despite each supply the same amount of regulation per MW.

Total cost to meet the regulation requirement under the optimization solution is $12. The market settlement result requires that the Reg A resource be subsidized with out of

market payments (uplift). Total cost to meet the regulation requirement, including the $2.50 of needed uplift, is $12.

> c. *PJM's January Compliance Approach with no benefit factor in settlement and a uniform Mileage rate based on a signal ratio modified performance price.*

This example illustrates PJM's revised compliance proposal as presented in the January 15th filing in response to the Commission's directives. Under PJM's new compliance proposal, the benefits factor is eliminated in settlement, but the performance payment ($/MW) to Reg D resources is multiplied by the ratio of the Reg D to Reg A (Reg D miles/Reg A miles) to provide a ratio modified, uniform $/mile price payment to Reg D and Reg A resources.

The PJM approach is intended to provide a uniform, non-normalized price/mile for compensation of performance. However, as noted in PJM's January compliance filing, this approach will tend to undercompensate fast resources when few fast resources are available (when the benefits factor would increase the value of fast resources in the optimization and settlement) and will overcompensate fast resources as the market becomes saturates with fast resources (when the benefits factor would reflect decreased value of fast resources in the optimization and settlement).

In the set of assumptions modeled here, the PJM approach, as outlined in the PJM January 15 compliance filing, results in the fast resource being overcompensated relative to its marginal value in the optimization, resulting in marginal costs of the fast resource exceeding valuation in the optimization. Table 4 shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

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Table 4 PJM's January Compliance Proposal: No BF in settlement and mileage ratio used to partially adjust performance payments to fast (Reg D) resources

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0	1.0	Fast Signal/Slow Signal
3	Slow equiavlant mile per mile	2.0		Fast to Slow Ratio/BF
4	MW	$1.00	$1.00	
5	$/MW	$1.00	$5.00	
6	$/Mile	$0.50	$0.20	
7	Performance Offer	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	1.00	1.00	
10	BF Adjusted Total Offer	$6.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer	$5.00	$1.00	Row 8/Row 9
12	Optimization Price (BF included)	$6.00	$6.00	BF Adjusted Total Offer
13	Clearing Price	$6.00		Max (BF Adjusted Total Offer)
	PJM Approach (New)			**Notes**
14	Settlement Prices (No BF)			
15	Clearing Price $/MW	$6.00		Max (Row 8)
16	Performance Clearing Price $/MW	$5.00		Max (Row 7)
17	Capability Price $/MW	$1.00		Row 15- Row 16
18	Miles Ratio Adjusted Performance Price $/MW	$10.00	$5.00	Row 16 x Row 2
19	$/Mile	$1.00	$1.00	Row 18/Row 1
20	Total Payment Capability $/MW	$1.00	$1.00	Row 17 x Row 2
21	Total Payment Performance (miles)	$10.00	$5.00	Row 19 x Row 1
22	Total Payment	$11.00	$6.00	Row 20 + Row 21
23	Net Revenue	$5.00	$0.00	Row 21 - Row 7

Under PJM's two part pricing approach the total clearing price per MW is $6/MW (Row 15). The base performance clearing price (equal to the highest cleared performance offer) is $5/MW and it set by the Reg D fast resource (Row 16). The base capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16).

Under PJM's January Compliance Filing Proposal, the benefits factor is eliminated in settlement, but the performance payment ($/MW) to Reg D resources is multiplied by the ratio (Row 2) of the Reg D to Reg A (Reg D miles/Reg A miles) to provide a ratio modified, uniform dollar per mile payment to Reg D and Reg A resources. The adjustment is made to the performance price per MW paid to Reg D resources. The performance price paid per

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MW to Reg A resources is not affected. Taking the performance price (Row 16) times the ratio of fast miles to slow miles (Row 2) provides a fast only performance price of $10/MW (Row 18, Column 1). The performance price to Reg A remains at $5/MW (Row 18, Column 2). In terms of a price per mile, this pays Reg A resources and Reg D resources a $1 per mile (Row 19), but it introduces different payments for the same amount of work.

The Reg D resource is paid Reg D capability MW times capability price (Row 20) plus Reg D capability MW times Reg D only performance clearing price/MW (Row 18) for a total of $11.00 per MW of Reg D (Row 22). The realized cost per MW of the Reg D resource (Row 22) exceeds the marginal value per of Reg D MW used in the optimization (Row 8).This disconnect is a market failure, and indicates that, in terms of realized marginal cost in the market (Row 22), the Reg D resource is more expensive per MW than it appeared to be in the optimization (Row 8). Although marginal in the optimization (along with the Reg A resource), the net revenue (Row 23) of the Reg D resource is $5.00. The resulting realized market solution is suboptimal and the market would be more efficient if it can substitute away from the use of Reg D resources.

The Reg A resource is paid the unadjusted performance clearing price/MW (Row 16) per MW of capability. Total performance related payments to the Reg A resource is $5.00, which is equivalent to $1/mile (Row 19), the same realized payment per mile as the Reg D resource. The Reg A resource is paid its MW (Row 4) times capability price (Row 17) for a total of $1 (Row 20) for capability. The total payment to the Reg A resource, which cleared in the optimization step, is $6.00, equal to its total offer. The net revenue (Row 22) of the Reg A resource is $0.

This market approach results in a discriminatory and inefficient market result. Under PJM's January Compliance filing Reg A and Reg D resources would be paid different amounts per unit of regulation service provided. As noted earlier, a benefits factor of one indicates that 1 MW of Reg A is doing as much work as 1 MW of Reg D, each 1 MW of Reg A is equivalent to 1 MW of Reg D in the optimization. Reg D and Reg A are directly comparable on a per MW basis and no adjustment is needed on their price per MW as the

work (regulation provided) per MW is equivalent. Yet, PJM's January proposal would provide $11.00 per MW of Reg D and only $6.00 per MW of Reg A, despite each supplying the same amount of regulation per MW.

The total cost to meet the regulation requirement according to the optimization solution is $12. However, the market settlement solution shows a higher cost incurred by regulation buyers due to the overpayment to the Reg D resource, with total cost to meet the regulation requirement of $17. The resulting realized market solution is suboptimal and discriminatory.

2. **Example Set 2: Benefit Factor of 2, 10 to 1 Reg D and 5 to 1 signals Reg A.**

This second set of examples outlines a situation where the marginal benefits factor is two (2), the Reg D signal calls for 10 miles per MW of movement in the hour and the Reg A signal calls for 5 miles of movement per MW in the hour. The example focuses on two resources for simplicity. A 1 MW Reg A following resource with a $1/MW offer for capacity and $0.50 per mile offer for performance and a 1 MW Reg D following resource with a $5/MW offer for capacity and a $0.20 per mile offer for performance. Table 5 shows the full assumption set for Example 2. This example assumes that three (3) total MW of Reg A equivalent regulation is required to meet the regulation requirement.

Table 5 Example 2 Assumption Set

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0		Fast Signal/Slow Signal
3	Slow equivalent mile per mile	1.0		Fast to Slow Ratio/BF
4	MW (Capability)	$1.00	$1.00	
5	$/MW Offer	$1.00	$5.00	
6	$/Mile Offer	$0.50	$0.20	
7	Performance Offer (No BF) $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer (No BF) $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	2.00	1.00	
10	BF Adjusted Total Offer $/MW	$3.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$2.50	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$3.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)

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In this example, the benefits factor of two (2) indicates that 1 MW of Reg D is doing as much work (regulation service) as 2 MW of Reg A. As a result, Reg D and Reg A are not directly comparable on a per MW basis without normalization to common units. In order to directly compare Reg D and Reg A, Reg D MW must be converted into equivalent Reg A MW. This is done by dividing the Reg D offer by the Reg D benefits factor.

As shown in Table 5, with a 5 to 1 signal for Reg A (Slow) and a 10 to 1 signal for Reg D (Fast), the total $/MW performance offer of the Reg A resource would be $1/MW (Row 11, Column 2) and the total $/MW performance offer cost of the Reg D resource would be $2.50/MW (Row 11, Column 1). The total $/MW capability offer of the Reg A resource would be $5/MW (Row 5, Column 2) and the total $/MW capability offer performance offer cost of the Reg D resource would be $0.50/MW (Row 5, Column 1 divided by Row 9, Column 1). The total $/MW offer of the Reg A resource would be $6/MW (Row 8, Column 2) and the total $/MW offer of the Reg D resource would be $3.00/MW (Row 8, Column 1).

With a benefits factor of two (2) Reg A and Reg D resources are performing the same amount of work (in terms of regulation provided) per non-normalized mile. The marginal benefits factor, combined with the ratio of the Reg D to Reg A signal, is indicating that 1 MW of Reg D, following the 10 to 1 Reg D signal, is providing as much regulation (work) as 2 MW of Reg A, following the 5 to 1 Reg A signal. This means that 10 miles of Reg D work is doing the equivalent of 10 miles of Reg A work in terms of regulation provided. Stated another way, every 1 mile of Reg D work is equal to 1 mile of Reg A work for purposes of providing regulation in the hour (Row 3). This ratio of miles to MW is implicitly contained in the marginal benefits conversion of Reg D MW into equivalent units of Reg A MW, and in the resulting relative valuation in the optimization.

Within the optimization, the Reg A MW costs $6 per MW and Reg D MW costs $3 per equivalent unit of Reg A MW (Row 10). This example is assuming that the regulation requirement requires 3 MW of Reg A or Reg A equivalent MW. The marginal resource cost in the market solution (in the optimization) is $6/MW (Row 13). A market clearing price

result of $6/MW per MW of slow would be consistent with the marginal valuation of resources in the optimization. Therefore, a market model that paid the Reg D resource and the Reg A resource $6 per equivalent MW of slow would be consistent with the optimal solution. This is true regardless of how the $6 per MW is subdivided between capability and performance.

If the performance price portion of the clearing price is $2.50 per Reg A equivalent MW (max normalized performance price among cleared resources, Row 11), the price per Reg A equivalent mile is $0.50 *per Reg A equivalent mile* ($2.50/5 miles). If every resource gets the equivalent of $0.50/mile of Reg A equivalent work provided, the market price will be consistent with the optimization solution. This would mean that both the Reg A and Reg D resource should get $2.50 per Reg A equivalent MW for performance, as each is provided the equivalent of 5 miles per MW of Reg A service.

With a benefit factor of two, each one MW of Reg D is providing the equivalent of two MW of Reg A. If total regulation is met with one MW of Reg A and one MW of Reg D, the regulation requirement of three Reg A equivalent MW is met. So long as Reg A and Reg D MW are paid on an equivalent $6 a Reg A MW basis, the market result will be efficient. Total payment to the Reg A resource should be $6 (it provides one MW of Reg A) and the total payment to the Reg D resource should be $12 (it provides two MW of Reg A service at $6 per Reg A MW equivalent). Any deviation from this result in settlement is evidence of a market failure.

>   a. **PJM's August 15th Compliance Proposal: Consistent use of the benefits factor to make optimization, pricing and settlement consistent with the value of the normalized good.**

This approach shows the results of using PJM's August 15th application of the benefit factor. In the August 15 approach, the benefits factor is consistently used throughout the optimization and settlement process. The benefits factor therefore provides a direct means by which to compare the marginal benefit and the marginal cost of using an additional Reg D resource relative to using an additional Reg A in meeting the regulation requirement. This means that the optimization solution will be consistent with the market signals that

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appear in the marketplace. The August 15 approach results in a uniform price per unit of the normalized good (Reg A), whether measured in terms of normalized MW or normalized miles. Table 6 provides the shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

Table 6 PJM's August 15ᵗʰ Approach: Consistent Application of the Benefits Factor with uniform pricing on a normalized unit basis

Row	Marginal Performance Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2	1.0	Fast Signal/Slow Signal
3	Slow equiavlant mile per mile	1		Fast to Slow Ratio/BF
4	MW	1	1	
5	$/MW	$1.00	$5.00	
6	$/Mile	$0.50	$0.20	
7	Performance Offer $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	2.00	1.00	
10	BF Adjusted Total Offer $/MW	$3.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$2.50	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$3.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)
	PJM Approach (August)			
14	Settlement Prices $/MW			
15	Clearing Price $/MW	$6.00		Max (Row 8)
16	Performance Clearing Price $/MW	$2.50		Max (Row 7)
17	Capability Price $/MW	$3.50		Row 15- Row 16
18	$/ Slow Equivalent Mile	$0.50	$0.50	$/Mile
19	Slow Equivalent Miles	10.00	5.00	MW X BF X Slow Signal
20	Total Payment Capability per Slow MW	$3.50	$3.50	Per Slow MW
21	Total Payment Performance (miles) per Slow MW	$2.50	$2.50	Per Slow MW
22	Total Payment per Slow MW	$6.00	$6.00	Per Slow MW
23	Total Payment with BF Adjustment	$12.00	$6.00	
24	Net Revenue	$6.00	$0.00	Per Actual MW

Under PJM's two part pricing approach the total clearing price in both the optimization and the market is $6/MW (Row 13 and Row 15). The base performance clearing price (equal to the highest cleared performance offer) is $2.50/MW and it set by the Reg D fast resource (Row 16). The base capability clearing price, $3.50/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16). A benefits factor of two indicates that one MW of Reg D (fast) equals two MW of Reg A (slow) in the optimization and settlement process.

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Under PJM's August 15th compliance filing, the Reg D resource is paid its Reg A equivalent (benefit factor adjusted) capability MW times the clearing capability price (Row 27) given in dollars per Reg A equivalent MW for capability. Total capability payment *per* Reg A equivalent MW is $3.50 (Row 20). The Reg D resource is providing *two* MW of Reg A service. It is therefore paid a total of $7.00 ($3.50 for each Reg A equivalent MW) for the two MW of capability provided.

The Reg D resource is also paid its Reg A equivalent capability MW times the performance clearing price/MW (Row 16) given in dollars per Reg A MW equivalent performance, for a total performance payment of $2.50 per Reg A MW equivalent performance (Row 21). The realized performance payment per mile is $0.50 per Reg A equivalent mile (Row 18). The Reg D resource provides five Reg A equivalent miles per Reg A equivalent MW. At a $0.50 per Reg A equivalent mile, the Reg D resource is paid $2.50 per Reg A equivalent MW. Since the Reg D resource is providing two (2) Reg A equivalent MW, this results in a total performance payment of $5.00 ($2.50 per Reg A equivalent MW).

The total payment to the Reg D resource is $6 *per Reg A equivalent MW* (Row 22), which modified by a benefit factor of two, results in total payment of $12 ($6 per Reg A equivalent MW) (Row 23). Note, with a benefits factor of two (2), the Reg D resource is inframarginal in the optimization and market solution. The Reg D resource nets $6 in revenue (Row 24). This total payment recognizes that the Reg D resource is providing 2 MW equivalent of Reg A produced regulation.

The Reg A resource is paid the performance clearing price/MW (Row 16) per MW of Reg A capability. Total performance related payments to the Reg A resource is $2.50, which is equivalent to $0.50/mile (Row 18), the same realized payment per mile as the Reg D resource on a Reg A equivalent mile basis. The Reg A resource is paid Reg A capability MW (Row 4) times capability price (Row 17) for a total of $3.50 (Row 20). The total payment to the Reg A resource, which cleared in the optimization step, is $6.00 (Row 22), equal to its total offer per MW. The net revenue (Row 24) of the Reg A resource is $0.

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With a benefit factor of two, each one MW of Reg D is providing the equivalent of two MW of Reg A. If total regulation is met with one MW of Reg A and one MW of Reg D, the regulation requirement of three Reg A equivalent MW is met. Total payment to the Reg A resource is $6 (it provides one MW of Reg A) and the total payment to the Reg D resource is $12 (it provides two MW of Reg A service at $6 per Reg A MW equivalent). The resulting payment would be non-discriminatory, with each resource paid the same amount per mile of Reg A work provided.

Total cost to meet the regulation requirement under the optimization solution is $18. Total cost to meet the regulation requirement after-market settlement is $18. The Reg D resource earns inframarginal rents of $6.

> **b. *Possible Compliance Approach: No benefit factor in settlement, marginal performance resource determines uniform $/mile on a non-normalized basis***

This approach illustrates a possible interpretation of the Commission's directive, under PJM's two part pricing approach, to use the benefits factor in the optimization, but not settlement, and to pay Reg A and Reg D the same $/mile rate regardless of the actual benefits factor or signal ratio. Under this modeled approach, the $/mile rate for all resources is determined by taking the marginal performance price (the highest performance offer that clears the market) and dividing it by the unadjusted (not normalized) miles of the resource that sets the non-normalized performance clearing price. This approach results in realized payment (price) per unit of equivalent effective work for Reg A and Reg D to vary from one another, thereby causing inefficient market results and prices that are inconsistent with the optimization. Table 7 shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

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Table 7 Possible Compliance Approach 1: Marginal Resource Determines $/Mile

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0		Fast Signal/Slow Signal
3	Slow equivalent mile per mile	1.0		Fast to Slow Ratio/BF
4	MW (Capability)	$1.00	$1.00	
5	$/MW Offer	$1.00	$5.00	
6	$/Mile Offer	$0.50	$0.20	
7	Performance Offer (No BF) $/MW	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer (No BF) $/MW	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	2.00	1.00	
10	BF Adjusted Total Offer $/MW	$3.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer $/MW	$2.50	$1.00	Row 8/Row 9
12	Optimization Price (BF included) $/MW	$3.00	$6.00	BF Adjusted Total Offer
13	Clearing Price $/MW	$6.00		Max (BF Adjusted Total Offer)
	Approach 1, Marginal Resource Determines $/Mile	**Fast**	**Slow**	**Notes**
14	Settlement Prices (No BF)			
15	Clearing Price	$6.00		Max (Row 8)
16	Performance Clearing Price	$5.00		Max (Row 7)
17	Capability Clearing Price	$1.00		Row 15- Row 16
18	$/Mile Price	$0.50		Row 16/Row 1
19	Total Payment Capability	$1.00	$1.00	Row 4 x Row 17
20	Total Payment Performance (miles)	$5.00	$2.50	Row 18 x Row 1
21	Total Payment	$6.00	$3.50	Row 19 + Row 20
22	Net Revenue	$0.00	($2.50)	Row 21 - Row 7

Under this approach, and the scenario assumptions, the optimization solution is the same as under the August 15th proposal outlined above. Under this approach the posted total clearing price per MW is also $6/MW (Row 15). Due to the absence of the benefit factor in the pricing and settlement, the posted performance clearing price is, however, $5.00 (Row 16) (equal to the highest cleared performance offer) instead of the $2.50 in the optimization (Row 11).

In the pricing and settlement, the Reg D resource is marginal for performance, so the Reg D actual miles (Row 1) in the hour (miles/MW signal) are used to determine the performance price per mile. Performance clearing price (Row 16) divided by actual Reg D miles (Row 1) provides a price per mile (Row 18) of $0.50/mile. The capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16).

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The Reg D resource is paid the normalized capability price (Row 19) plus its' Reg D miles times the uniform $0.50 per mile rate (Row 20) for a total of $6.00. In this case, this is an inefficient result. The marginal value of the resource, in the context of the optimization, is greater than the market is recognizing. In the optimization each Reg D resource MW is doing the work of two Reg A MW for purposes of meeting the total regulation requirement. If properly recognized, as it is under PJM's August 15th filing proposal, the resource would be paid $12 ($6 for each MW provided), with net revenue of $6. Absent the uniform application of the benefits factor, however, the net revenue (Row 22) of the Reg D resource is $0.

The Reg A resource is inframarginal for performance, so the Reg A actual miles (Row 1) in the hour (miles/MW signal) are not used to determine the performance price per mile. The Reg D resource has set the price per mile at $0.50/mile (Row 18). The capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the highest performance clearing price (Row 16), set by the Reg D resource. The Reg A resource is paid Reg A capability MW times capability price for a total of $1 (Row 19) The Reg A resource is also paid for its miles, capability MW times Reg A miles times $/mile (Row 20) for a total of $2.50.

The total payment to the Reg A resource, which cleared in the optimization step, is $3.50/MW, $2.50 less than its total offer, which set the optimization clearing price. The net revenue (Row 22) of the Reg A resource is -$2.50. Without an uplift payment, the Reg A resource loses money from participating in the market, and the marginal payments to resources does no match up with the marginal offers. Relative to the per unit value in the optimization, this approach undervalues and under pays the Reg A resource.

As before, this market approach results in a discriminatory and inefficient market result. Under this approach Reg A and Reg D resources are paid different amounts per equivalent units of regulation service provided. In the optimization, each MW of Reg A equivalent at the market solution costs $6 per MW. This means that the Reg D resource, with a total payment of $6 is underpaid relative to its contributed value, as it is providing

the equivalent of two Reg A MW of regulation for each of Reg D MW provided on the margin. The Reg A resource, with a total payment of $3.50 is also underpaid relative to its marginal contribution to regulation, as it is providing one Reg A equivalent MW of regulation. The market results in inefficient and discriminatory.

Total cost to meet the regulation requirement under the optimization solution is $18 (the optimization is purchasing three slow equivalent MW of regulation, two from Reg D and one from Reg A). Total cost to the market to meet the regulation requirement, including the $2.50 of needed uplift, is $12. The discrepancy is generated by the fact that the market only recognizes two MW of purchased regulation instead of three, and does not have realized prices set equal to the marginal cost of the marginal resource.

> c. *PJM's January Compliance Approach with no benefit factor in settlement and a uniform Mileage rate based on a signal ratio modified performance price.*

This example illustrates PJM's revised compliance proposal as presented in the January 15 filing in response to the Commission's directives. Under PJM's new compliance proposal, the benefits factor is eliminated in settlement, but the performance payment ($/MW) to Reg D resources is multiplied by the ratio of the Reg D to Reg A (Reg D miles/Reg A miles) to provide a ratio modified, uniform $/mile price payment to Reg D and Reg A resources.

In the set of assumptions modeled here, the PJM approach results in the fast resource being undercompensated relative to its marginal value in the optimization. Table 8 shows the result of this approach in terms price results, payments and net revenues for the Reg A and Reg D resources.

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Table 8 PJM's January Compliance Proposal: No BF in settlement and mileage ratio used to partially adjust performance payments to fast (Reg D) resources

Row	Category	Column 1 Reg D (Fast)	Column 2 Reg A (Slow)	Notes
1	Signal (miles/MW)	10	5	
2	Fast to Slow Mile Ratio	2.0	1.0	Fast Signal/Slow Signal
3	Slow equiavlant mile per mile	1.0		Fast to Slow Ratio/BF
4	MW	$1.00	$1.00	
5	$/MW	$1.00	$5.00	
6	$/Mile	$0.50	$0.20	
7	Performance Offer	$5.00	$1.00	Row 1 x Row 4 x Row 6
8	Total Offer	$6.00	$6.00	Row 5 + Row 7
9	Benefit Factor (BF)	2.00	1.00	
10	BF Adjusted Total Offer	$3.00	$6.00	Row 7/Row 9
11	BF Adjusted Performance Offer	$2.50	$1.00	Row 8/Row 9
12	Optimization Price (BF included)	$3.00	$6.00	BF Adjusted Total Offer
13	Clearing Price	$6.00		Max (BF Adjusted Total Offer)
	PJM Approach (New)			**Notes**
14	Settlement Prices (No BF)			
15	Clearing Price $/MW	$6.00		Max (Row 8)
16	Performance Clearing Price $/MW	$5.00		Max (Row 7)
17	Capability Price $/MW	$1.00		Row 15- Row 16
18	Miles Ratio Adjusted Performance Price $/MW	$10.00	$5.00	Row 16 x Row 2
19	$/Mile	$1.00	$1.00	Row 18/Row 1
20	Total Payment Capability $/MW	$1.00	$1.00	Row 17 x Row 2
21	Total Payment Performance (miles)	$10.00	$5.00	Row 19 x Row 1
22	Total Payment	$11.00	$6.00	Row 20 + Row 21
23	Net Revenue	$5.00	$0.00	Row 21 - Row 7

Under PJM's two part pricing approach the total clearing price per MW is $6/MW (Row 15). The base performance clearing price (equal to the highest cleared performance offer) is $5/MW and it set by the Reg D fast resource (Row 16). The base capability clearing price, $1/MW is the difference between the total clearing price (Row 15) and the performance clearing price (Row 16).

Under PJM's January Compliance Proposal, the benefits factor is eliminated in settlement, but the performance payment ($/MW) to Reg D resources is multiplied by the ratio of the Reg D to Reg A (Reg D miles/Reg A miles) to provide a ratio modified, uniform dollar per mile payment to Reg D and Reg A resources. The adjustment is made to the performance price per MW paid to Reg D resources. The performance price paid per MW to

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Reg A resources is not affected. Taking the performance price (Row 16) times the ratio of fast miles to slow miles (Row 2) provides a fast only performance price of $10/MW (Row 18, Column 1). The performance price to Reg A is $5/MW (Row 18, Column 2). In terms of a price per mile, this pays Reg A resources and Reg D resources a $1 per mile (Row 19), but it introduces different payments per unit of work when miles are measured in equivalent work units under the optimization.

The Reg D resource is paid Reg D capability MW times capability price (Row 20) plus Reg D capability MW times Reg D only performance clearing price/MW (Row 18) for a total of $11.00 per MW of Reg D (Row 22). Note that under the PJM January 15 proposal, the payments to the Reg D resource in example 1, with a benefits factor of one, and the payments in this example are the same, despite the change in the benefits factor associated with the Reg D resource. In the first example, this resulted in the Reg D resource being overcompensated. In this case, PJM January 15th Compliance Filing results in under compensation relative to the optimal market solution available under the August 15 proposal. Correctly valued, the Reg D resources should be paid $12, not $11, with $6 paid per each Reg A equivalent MW provided. The disconnect between the marginal valuation in the optimization and the marginal valuation in the market result under the PJM January 15th proposal is caused by the absence of the benefits factor in the determination of pricing and settlement. The market results under the January 15 proposal fails to recognize the fact that the Reg D resource, due to the benefit factor of 2, is providing two MW of Reg A equivalent work.

The January 15th Compliance Filing does not account for the fact each MW of Reg D will, depending on the benefits factor in the optimization solution, be providing varying amount of Reg A equivalent MW. Instead, the January 15th proposal is merely paying a margin for Reg D MW, through the scalar adjustment of the Reg D performance payment, which will either be too little or two low, depending on actual realized market conditions. This disconnect results in a market failure. In terms of realized compensation in the market

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(Row 22), the Reg D resource is less valuable per Reg A equivalent MW than it appeared to be in the optimization (Row 8).

Reg A resource is paid the unadjusted performance clearing price/MW (Row 16) per MW of capability. Total performance related payments to the Reg A resource is $5.00, which is equivalent to $1/mile (Row 19), the same realized payment per mile as the Reg D resource. The Reg A resource is paid its MW (Row 4) times capability price (Row 17) for a total of $1 (Row 20) for capability. The total payment to the Reg A resource, which cleared in the optimization step, is $6.00, equal to its total offer. The net revenue (Row 22) of the Reg A resource is $0.

This market approach results in a discriminatory and inefficient market result. Under PJM's January Compliance filing Reg A and Reg D resources would be paid different amounts per equivalent unit of regulation service provided. As noted earlier, a benefits factor of two indicates that 1 MW of Reg D is doing as much work as 2 MW of Reg A. Yet, PJM's January 15th proposal would pay the Reg D resource $5.50 per Reg A MW equivalent ($11/ 2 MW of equivalent Reg A) and pay the Reg A resource $6.00 per Reg A MW equivalent. Total cost to meet the regulation requirement under the optimization solution is $18 (the optimization is purchasing three slow equivalent MW of regulation, two from Reg D and one from Reg A). Total cost to the market is $17. The discrepancy is generated by the fact that the market only recognizes two MW of purchased regulation instead of three, and does not have realized prices set equal to the marginal cost of the marginal resource.