UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

ANSWER AND MOTION FOR LEAVE TO ANSWER
OF THE INDEPENDENT MARKET MONITOR FOR PJM

Pursuant to Rules 212 and 213 of the Commission's Rules and Regulations,[1] Monitoring Analytics, LLC, acting in its capacity as the Independent Market Monitor for PJM Interconnection, L.L.C. ("PJM")[2] ("Market Monitor"), submits this answer to the protests submitted on November 15, 2017 by AES Corporation ("AES"), Beacon Power, LLC ("Beacon"), EDF Renewable Energy ("EDF"), the Energy Storage Association ("ESA"), Invenergy Storage Development LLC ("Invenergy") and NextEra Energy Resources ("NextEra").

I. ANSWER

A. The Revised Regulation Signals Are Consistent with the Physical Limits of RegD Resources.

AES claims (at 3) that "the drastic increase in throughput and intensity for a battery storage facility drives the equipment past its design specifications and physically harms the equipment and shortens its life."

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1 18 CFR §§ 385.212 & 385.213 (2017).

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

This assertion is incorrect. The new regulation signals do not require resources to exceed their physical limits. In general, RegD resources have either adapted to the changes in the market by modifying their offer parameters (reductions in bid in capability to support longer duration injections and withdrawals) to improve their performance and/or have proven capable of longer duration operation.[3] In either case, RegD resources continue to successfully participate in the market.

B. RegD Resources Are Never Forced to Exceed Their Physical Capability.

AES claims (at 3–4) that "the longer duration demand and the higher throughput and intensity have been causing more equipment failures consequently increasing O&M expenses."

AES's argument has no merit. PJM dispatch decisions cannot damage resources. Resources are not forced or required to operate outside of their actual capability. Participation in the regulation market is voluntary on an hourly basis. The MW offered, the parameters offered and the response of a resource to a regulation signal are all under the control of the resource owner. Resource owners have the responsibility to offer their units in an economic manner and in a manner consistent with the way in which the resource can actually respond.

C. PJM's Proposed Market Design Supports Competitive and Useful Resources.

AES states (at 5) that "PJM's description of its proposal leaves no doubt that its proposal is deliberately designed to make existing battery storage facilities uneconomic and drive them out of the market." AES argues (at 7) that "[i]nstead of benefiting from the

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[3] RegD resources are at times incorrectly referred to as energy limited resources. The amount of energy that can be produced before recharging is a function of the offered capability relative to the capacity of the resource, e.g. a battery. The energy capability (the amount it can discharge or charge) of a storage resource within a given period of time is a function of the offered capability relative to the resources total storage capacity, which is a choice of the resource owner. The lower the offered capability relative to the total storage capacity of the resource the greater the length of time that the resource can provide that capability to the system.

nearly instantaneous response to changes offered by lithium ion batteries; PJM has designed and proposed a pseudo ramp product designed only to accommodate synchronous generation." AES argues (*id*.) that "this design is unjustifiably preferential" and "[t]here is nothing resource neutral about the proposed plan."

There is no basis for AES' hyperbolic and unsupported assertions. PJM's proposal is designed to procure the resources it needs to provide regulation service using two different signals at least cost.

The AES complaint is that it believes the proposed market design will cause its lithium ion storage resources to be less economic relative to new battery technology and make less money under the new rules. If the result of an efficient market design were reduced payments for AES resources, AES appears to suggest that the outcome should be modified to favor its resources. That is not the way markets work. PJM's proposal is for an efficient market design that results in least cost, efficient provision of regulation service.

Contrary to AES's assertions, PJM's proposed market design does not discriminate against RegD resources in general, or lithium ion batteries in particular. PJM's proposed market is designed to explicitly value, based on engineering studies and operational experience, the operational characteristics of resources following PJM's RegA and RegD signals. The objective of PJM's regulation market design is to minimize the cost to provide regulation via a combination of resources following two different signals (RegA signal and RegD signal) in a single, competitive and efficient market, based on the relative value and relative costs of resources following the RegA and RegD signal. For a given signal design and resource mix, that is the purpose of the RRTS curve(s) within the optimization, clearing and settlement in PJM's proposal.

PJM's recently adopted RegA and RegD signals do not discriminate against RegD resources. PJM redesigned the RegD signal to address a significant operational issue that resulted from the old signal. Rather than discriminate against RegD, the new signal requires RegA to support RegD. RegD as a class of resources is not being disadvantaged or

discriminated against. RegD as a class is being accommodated, supported and subsidized. This is true for the specific subgroup of RegD resources that includes AES.

D. Energy Limited Resources Will Have Positive Value Under PJM's Proposed Market Design

AES asserts (at 7) that "[u]nder PJM's proposed market design, virtually no value is accorded to battery storage resources because the resources are given a valuation score based on its net output or input over the course of a full hour – and for fast-discharge batteries, that score will be near zero."

AES' assertion is incorrect and unsupported. Every representation of the RRTS curve based on the current regulation signal designs have indicated a positive value for RegD resources, including Figure 3 in PJM's comments (at 18). The relative values of RegD and RegA vary with the amount of RegD that clears in a market clearing solution.

E. The Mileage Ratio Does Not Indicate the Relative Amount of Work or ACE Control Provided by RegD and RegA.

Beacon claims (at 10 n.6) "[t]he greater amount of ACE correction provided by RegD resources is evident in the mileage ratio, which has averaged 6.2x over the February 2017 through September 2017 period." Beacon then claims (at 13) that "the RMRTS does not provide an accurate measure of the actual amount of ACE correction provided by a resource in a particular interval – instead, it merely reflects the effective MWs being provided by the marginal resource." Based on these assertions, Beacon states (at 8) that PJM's proposal "to replace the mileage ratio with the RMRTS…will result in resource compensation that is no longer tied to the amount of work (*i.e.*, ACE correction) provided by each resource as required by Order No. 755." Beacon argues (at 10) that under PJM's proposal "RegD resources would frequently be paid less than RegA resources based on the amount of ACE correction provided."

These assertions are incorrect and unsupported.

Neither Beacon nor ESA assert that the mileage ratio should replace the marginal RRTS in the optimization, clearing or price setting in the PJM proposal. Beacon and ESA

apparently recognize that the mileage ratio is not an indication of the relative value of work done by RegD MW and RegA MW in providing effective ACE control. Beacon and ESA instead attempt to make a false distinction between marginal effective work done by RegA and RegD MW in the market clearing and marginal effective work done in operation, with the purpose of maintaining the current inflated compensation of RegD resources relative to RegA resources.

The mileage of RegD relative to the mileage of RegA in any instance, or averaged over any period, is not an indication of the relative work done by RegD or RegA in providing ACE correction. The mileage ratio has nothing to do with the relative or direct valuation of the amount of ACE control provided by RegD or RegA. The relative value of the RegA and RegD, for any given combination of RegA and RegD, in providing an expected level of ACE control is measured by the RMRTS. If the mileage ratio was the determinant of the relative contribution of RegD and RegA to ACE control, the mileage ratio would be the basis for the marginal RRTS (the marginal rate of technical substitution) function and the mileage ratio would be used as the marginal RRTS between RegD and RegA in the optimization, clearing, pricing and settlement in PJM's proposal. This is not the case. The mileage ratio does not result from an engineering study or operational experience that describes the combinations of RegA and RegD that can provide an expected level of ACE control. The mileage ratio is merely an outcome of the regulation signal design, the proportion of the RegA MW and RegD MW operating at the direction of PJM in a given period and system conditions.

PJM's signal design results in mileage and mileage ratios that have no relationship to theactual amount of ACE correction provided by a particular resource type. There are system conditions where extreme mileage ratios result when the RegA signal is fixed at a single value for an extended period ("pegged") to control ACE and the RegD signal is not. If RegA is held at a constant MW output, mileage is zero for RegA. In this circumstance, RegA is providing ACE control and may be, due to the conditional neutrality signal design, supporting a recharge of RegD, which involve RegD moving to hurt ACE. In such an event,

RegA is controlling for ACE and contributing the future ability of RegD to provide ACE control in a later interval. The result of a fixed RegA signal is that RegA mileage is very small and therefore the mileage ratio is very large but the contribution of RegA to ACE control is critical.

The extreme mileage ratios that result from the interaction between the RegA and RegD signal in the conditional signal design are an example of why it is not appropriate to use the mileage ratio, rather than the marginal RRTS, to measure the relative value of RegA and RegD resources. In these events, RegA resources are providing ACE control by providing a fixed level of MW output which means zero mileage, while RegD resources alternate between helping and hurting ACE control, both of which result in positive mileage.

F. The Use of the marginal RRTS in Settlement Would Create Consistency Between Market Clearing, Valuation and Settlement

ESA claims (at 9) that using the marginal RRTS in settlement calculation would "fail to appropriately compensate Regulation resources since they do not settle resources consistent with their clearing or operation, despite PJM's claims to the contrary." Due to the downward sloping (relative to increasing RegD MW) RRTS curve, ESA claims that the "RMRTS value used in settlement is always lower than the RegD effective MW used in market clearing." Beacon similarly asserts (at 20) that "[t]his approach would significantly misrepresent the effective capacity of all but the last RegD resource cleared, would not compensate RegD resources for the actual amount of ACE correction provided, and would maintain a significant inconsistency between clearing and settlements."

ESA and Beacon are arguing that using the marginal resource's marginal RRTS from the downward sloping RRTS function in settlement will cause an undervaluing of all RegD MW relative to the effective MW contributed by RegD in that market solution. There is no basis to these assertions or the resulting conclusion.

These arguments are based on a misunderstanding of the interaction between a function (a mathematical expression involving one or more variables) and a derivative of

that function (a mathematical expression representing the rate of change of a function with respect to an independent variable). More specifically, ESA's argument is based on a misunderstanding of an isoquant with a diminishing marginal rate of technical substitution between the two inputs, where adding more and more of a particular input is less and less effective as a substitute for another input, holding output constant. The KEMA study and the PJM studies have provided isoquants indicating diminishing returns to RegD as a substitute for RegA. This relationship is not unusual in production models.[4]

An isoquant is a mathematical function that describes the combinations of two or more input variables that provide the same output.[5] More specifically, the isoquant describes the amount of one input that is needed given a specified amount of another input to produce a fixed amount of output. In PJM's case, the isoquant function is described in terms of RegA MW (vertical axis) needed for a given amount of RegD MW (horizontal axis) to produce the target level of ACE control.[6] Any combination of RegA MW and RegD MW on the isoquant will provide the same level of ACE control.

The derivative of the isoquant defines the marginal rate of technical substitution (MRTS) between the two inputs, holding output constant.[7] The MRTS is the point specific slope (rate of change) between the two inputs at every point on the isoquant. In PJM's

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4 *See* Michael Katz and Harvey Rosen, *Microeconomics* (Irwin 1991) ("Katz/Rosen") at 265 ("Most technologies exhibit a diminishing marginal rate of technical substitution.").

5 An isoquant is a common term of art in the economics literature that refers to a curve that defines all of the input combinations that yield a fixed level of output. *See* Katz/Rosen at 253–254.

6 The isoquant could also be expressed in terms of RegD MW needed for any given amount of RegA. This would change the MRTS (point specific slope) to describe a change in RegD MW for a change in RegA MW. This would not change the outcome of the market solution or pricing, so long as the functional form was consistently applied through the regulation market design.

7 The marginal rate of technical substitution (MRTS) is a common term of art in the economics literature that refers to a slope of the isoquant. The slope of the isoquant is the rate at which the production function (available technology) allows the substitution of one input for another while holding output constant. *See* Katz/Rosen at 264–272.

application, the derivative of the isoquant (the change in RegA for a change in RegD) defines the marginal rate of technical substitution function (MRTS) between RegA and RegD. PJM has termed this to be the RRTS function. The RRTS function describes the rate of change in RegA MW for a change in RegD MW at every point along the isoquant, holding ACE control constant.

The cumulative marginal RRTS values (which can be calculated as the area under the RRTS curve) at any given amount of one input (RegD MW) provides the total change in the second input (RegA MW) relative to the vertical intercept point of the isoquant curve. This is not a surprise, as the RRTS is the derivative of the isoquant, and describes the point specific changes in the one input (RegA) for changes in the second input (RegD MW) along the isoquant. For any given level of the one input, the isoquant provides the corresponding level of the second input needed to maintain fixed output by definition.

The area under the RRTS curve is therefore not providing the relative value of RegA and RegD for any level of RegD for purposes of meeting the ACE control target. All the area under the RRTS curve is providing is assurance that the resulting combination of RegA and RegD that is clearing, is consistent with the isoquant that defines the desired target level of ACE control.

While all the points on the isoquant are equally good for purposes of providing ACE control, the purpose of a market (or a cost minimization function) is to determine the least cost combination of inputs on that isoquant.

Determining the least cost combination requires an examination of marginal relative prices of the inputs and the marginal relative values of output along the isoquant. In an optimization, inputs are used until the incremental value for doing so is equal to the incremental cost (the price of the marginal unit of an input) of doing so. This requires a direct comparison of the marginal value and marginal prices of the two inputs. At the least cost market solution, the slope of the isoquant (the MRTS which shows the relative value of the inputs in the production function) will equal the ratio of the input prices. At this solution the effective marginal value of each resource in terms of contributing to the fixed

output is equal to the marginal price of input and all inputs are paid the same in terms of this marginal value. This means that each input is paid the same marginal price in a common unit, the marginal contribution to output. At the same time, at the least cost market solution, the marginal price for each input is paid to every unit of that input, and this is equal to the marginal price of the marginal contribution to output. That is how single price markets work, where the marginal resource sets the price for the market for that resource. This result is dependent on consistent marginal valuation in the market solution, pricing and settlement.

In the PJM proposal, RegD will be used until the marginal value of RegD as a substitute for RegA is equal to the marginal price of RegD (the price of the most expensive RegD resource cleared). Conversely, and at the same market solution, RegA will be used until the marginal value of RegA as a substitute for RegD is equal to the marginal price of RegA (the price of the most expensive RegA resource cleared). At this solution the effective marginal value of each resource in terms of contribution to the fixed output (in terms of marginal effective MW) is equal to the marginal price of that input and all inputs are paid the same in terms of this marginal effective MW value. Under these conditions, no resource is underpaid. Every resource is correctly paid it respective market clearing price and, at the same time, every resource is correctly paid the single marginal clearing price for marginal effective MW.

G. Failure to Use the MBF Instead of the Mileage Ratio in Settlement Has Contributed to Over Procurement, Over Valuation and Overinvestment of RegD in the Current PJM Regulation Market

Beacon cites PJM stating (at 16) that the "implementation of [a] mileage ratio into Regulation settlements, as directed by Commission order, drove a higher financial signal for new market entry of RegD resources and contributed to an over-supply and over-procurement of RegD resources." Beacon asserts (*id*.) "PJM does not provide any supporting evidence that the mileage ratio has resulted in the over-supply and over-procurement of RegD resources, but simply asserts this conclusion as fact."

The Market Monitor disagrees with Beacon's assertion. The inclusion of the mileage ratio in settlements rather than the MBF has directly contributed to over procurement and over supply of RegD MW in the PJM market.

The inclusion of the mileage ratio in settlements rather than the MBF has inflated the realized price of RegD relative to its actual market value and market usefulness.[8] This caused uneconomic entry into the Regulation Market. This resulted in a saturated market where resources are forced to bid at a price of zero or self schedule in order in order for a chance to clear the market and earn extra normal rents

While prices are set on the basis of dollars per effective MW, only RegA resources receive payments based on this price per effective MW.[9] RegA resources are paid the RMCCP times MW times the performance factor times the MBF, plus the RMPCP times MW times the performance factor times the MBF. (The RegA MBF is 1.0.) RegD resources are not paid in terms of dollars per effective MW of RegA because the MBF is not used in settlements for RegD. RegD resources are paid the RMCCP times MW times the performance factor, plus the RMPCP times MW times the performance factor times the mileage ratio.[10]

When the MBF is above one, RegD resources are underpaid on a per effective MW basis, although this could be offset by a high mileage ratio. When the MBF is less than one, RegD resources are overpaid on a per effective MW basis, a result that is exacerbated by the mileage ratio multiplier. The average MBF was less than 1.0 in 2016 (0.60) and in the first

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8 *See* 2017 Q3 State of the Market Report for PJM at 460–470.

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

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

nine months of 2017 (0.95), resulting in an average overpayment of RegD resources.[11] The current settlement process does not, therefore, result in paying RegA and RegD resources the same price per effective MW. As a result, the current market design does not send the correct price signal to the RegD resources.

Competition from the RegD resources attempting to be rewarded the inflated price has reached the point where most resources in the market bid at a price of zero, or self-supply in an effort to clear the market. All RegD MW clearing the market in the period between January 1, 2016, and April 30, 2017, had an effective offer of $0.00. From May 1, 2017 through September 30, 2017, an average of 98.2 percent of cleared RegD MW had an effective cost of $0.00.[12] Since all nearly all resources are offering at effective price of zero, PJM was forced to clear the market on the basis of rank ordered performance scores, rather than relative offers. The result is a lottery by performance score, with small changes in a performance score making the difference between clearing or not clearing the market.

The Regulation Market clearing engine, as currently implemented, does not recognize the actual, inflated marginal cost of using RegD in the market caused by the use of the mileage ratio instead of the MBF in settlement. Instead, the market clearing engine only sees the MBF adjusted prices of RegD resources (which are offering at zero) and acquires too much RegD. This disconnect between the marginal resource cost in the optimization and the realized marginal costs in the market settlement, due to the failure to consistently apply the MBF/MRTS throughout the construct, has resulted in over procurement, over supply and excessive costs to provide regulation service. It has also contributed to wasteful investment in a saturated market.

These issues would be self-corrected if the MBF were consistently applied throughout the Regulation Market. If the MBF were properly defined and consistently

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11 *See* 2017 Q3 State of the Market Report for PJM at 460–470

12 *See* 2017 Q3 State of the Market Report for PJM at 460–470

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

The incorrect and inflated market signals for RegD resources has led to a continuing stream of storage projects entering PJM's interconnection queue, despite clear evidence that the current market design is flawed, that the current market construct was overpaying RegD and despite the ongoing operational evidence that the RegD market was (and is) saturated.

H. Under PJM's Proposal Resources are Paid the Same $/Effective MW and the $/Effective Mile

Beacon provides (at 10–11) an example that it asserts shows that under PJM's proposal RegD resources "will not be compensated for the actual amount of work (i.e., a greater amount of ACE correction) provided to the system."

There is no basis for Beacon's assertions. Beacon's assertions are based on a flawed example that does not reflect PJM's proposal.

In their example, Beacon shows two resources clearing in a market, a RegA and RegD. Both resources have 100 percent performance scores and 20 MW of capability. Both resources have a $/MW capability offer of $20/MW and a $/MW performance offer of $3.00/MW. The mileage of RegA is assumed to be 5.00 and the mileage of RegD is 30. Beacon assumes an MRTS of .70. The total offer for the RegA resource is $23/MW and the total offer for the RegD resource is $23/MW, prior to any adjustments. The CCP (capability clearing price) is assumed to be $20/MW and the PCP (performance clearing price) is assumed to be $3.00/MW.

Beacon shows that the RegA resource is paid $400 for capability ($20/MW times 20 MW), $60 for performance ($3/MW times 20 MW) under PJM's proposed construct, for a total payment of $460. Beacon then claims that under PJM's proposal, the RegD resource is paid only $280 for its capability (CCP) and $42 for its performance (PCP), for a total of $322. Based on this, Beacon claims that RegA will receive $23/MW, but the RegD resource would

only receive $16.10/MW due to an adjustment by the 0.70 marginal RRTS. Based on this result, Beacon concludes that the RegD resource is undercompensated relative to the market clearing price.

Beacon's example does not illustrate how PJM's proposal would set price and how it would determine settlement. This example fails to consistently apply the concept of the MRTS throughout the market clearing, price determination in settlement, and illustrates a fundamental misunderstanding by Beacon and other protestors about how the PJM proposal will work. The example illustrates why Beacon and other protestors incorrectly believe that the proposed market construct will undercompensate RegD resources when the MRTS is less than one.

The example provided by Beacon indicates that the total offer ($/MW) of both the RegA and RegD resource is $23/MW. Beacon assumes that the total clearing price is $23 per effective MW. For this result to be true, the marginal RRTS cannot be 0.70. Under PJM's proposal, for both of these resources to clear when the clearing price is $23 per effective MW, the marginal RRTS would have to be 1.0. Only in that case would the offer for RegA and RegD both be equal to $23 per effective MW. This is because in the optimization, the RegD MW and RegD MW are converted to marginal effective MW equivalent for purposes of the market clearing. The least cost solution occurs where the marginal relative value of the contribution of RegD and RegA to system control (the Marginal RRTS value = 1) is equal to the ratio of the prices ($23/23 = 1). If the marginal RRTS is 1, RegA is paid $23 per effective MW and RegD is paid $23 per effective MW. There is no underpayment of RegD.

This market clearing, with a marginal RRTS of 1.0, will also result in the same payment for RegA and RegD in terms of $/effective MW mile. With a marginal RRTS of 1, each MW of RegD following the RegD signal is providing the same effective ACE control as each MW of RegA following the RegA signal. In this example, with a marginal RRTS of 1.0, 1 MW of RegD providing 30 miles/MW is providing the same amount of ACE control (effective, functional work) as 1 MW of RegA providing 5 miles/MW. This means that every 6 miles from a RegD MW provides 1.0 effective MW mile. With a PCP of $3.00/MW, RegA

resources are being paid $0.60 per effective MW mile and RegD resources are being paid $0.60 per effective MW mile. There is no underpayment of RegD.

Under PJM's proposal, if the market clearing price is $23 per effective MW and the MRTS is 0.70 in equilibrium, as Beacon asserts, then the RegD resource with an unadjusted offer of $23 per MW would not clear the market. This is because the RegD offer in effective MW terms is $32.86 per effective MW, well above the clearing price of the market.

Under PJM's proposal, for the RegD resource to clear with an offer of $23/MW and a marginal RRTS of 0.7, the market clearing price would have to be equal to or greater than $32.86 ($23/0.7 = $32.86) per effective MW. If the market cleared at $32.86/MW, the RegD resource would be marginal. If the market cleared at $32.86/MW the RegD resource would be paid $32.86 per effective MW, which the same as $23 per unadjusted RegD MW. In a single price clearing market, resources that clear the market always receive at least their marginal offer price.

II. MOTION FOR LEAVE TO ANSWER

The Commission's Rules of Practice and Procedure, 18 CFR § 385.213(a)(2), do not permit answers to answers or protests unless otherwise ordered by the decisional authority. The Commission has made exceptions, however, where an answer clarifies the issues or assists in creating a complete record.[13] In this answer, the Market Monitor provides the Commission with information useful to the Commission's decision-making process and

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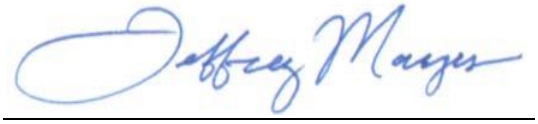
[13] *See, e.g., PJM Interconnection, L.L.C., 119 FERC ¶61,318 at P 36 (2007) (*accepted answer to answer that "provided information that assisted … decision-making process*"); California Independent System Operator Corporation*, 110 FERC ¶ 61,007 (2005) (answer to answer permitted to assist Commission in decision-making process); *New Power Company v. PJM Interconnection, L.L.C.*, 98 FERC ¶ 61,208 (2002) (answer accepted to provide new factual and legal material to assist the Commission in decision-making process); *N.Y. Independent System Operator, Inc.*, 121 FERC ¶61,112 at P 4 (2007) (answer to protest accepted because it provided information that assisted the Commission in its decision-making process).

which provides a more complete record. Accordingly, the Market Monitor respectfully requests that this answer be permitted.

III. CONCLUSION

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

Respectfully submitted,



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Dated: November 30, 2017

CERTIFICATE OF SERVICE

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

Dated at Eagleville, Pennsylvania,
this 30th day of November, 2017.

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