162 FERC ¶ 61,295
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Cheryl A. LaFleur, Neil Chatterjee,
Robert F. Powelson, and Richard Glick.

PJM Interconnection, L.L.C. Docket Nos. ER18-87-000
ER18-87-001

ORDER REJECTING TARIFF REVISIONS

(Issued March 30, 2018)

1. On October 17, 2017, as amended on October 25, 2017, PJM Interconnection, L.L.C. (PJM), pursuant to section 205 of the Federal Power Act[1] and section 35.13 of the Commission's regulations,[2] filed proposed revisions to the PJM Amended and Restated Operating Agreement (Operating Agreement) and the parallel provisions of the PJM Open Access Transmission Tariff (Tariff) to improve the performance of the PJM frequency regulation (Regulation) market (Regulation Proposal). PJM requests an April 1, 2018 effective date for the proposed revisions.

2. As discussed below, we reject PJM's Regulation Proposal because it is inconsistent with the Commission's directives in Order No. 755 and the Commission's regulations.

I. Background

A. Overview of the PJM Regulation Market

3. PJM explains that as a balancing authority, it manages the supply and demand of electricity by economically dispatching generation to meet real-time load and interchange on the PJM bulk power system. PJM asserts that because changes in supply and demand are not precisely predictable, real-time mismatches between supply and demand will

[1] 16 U.S.C. § 824d (2012).

[2] 18 C.F.R. § 35.13 (2017).

occur, resulting in non-zero Area Control Error (ACE).[3] PJM states that the Tariff defines Regulation as "the capability of a [resource] with appropriate telecommunications, control and response capability to *separately* increase *and* decrease its output or adjust load in response to a regulating control signal, in accordance with the specifications in the PJM Manuals."[4] PJM explains that Regulation is an ancillary service and essential reliability product that PJM relies upon to aid in the continuous balancing of generation and load by helping to maintain interconnection frequency and manage ACE. PJM further explains that to accomplish this, its Regulation controller sends Regulation resources an automatic generation control (AGC) signal to raise or lower output to correct for instantaneous changes in load and generation every few seconds when PJM's ACE calculation indicates an imbalance between supply and demand. PJM states the Regulation controller will send a signal for Regulation resources to move in the opposite direction of ACE to correct the imbalance.[5]

4. In 2011, the Commission issued Order No. 755[6] to "remedy undue discrimination in the procurement of Regulation in the organized wholesale electric markets and ensure that providers of frequency regulation service receive just and reasonable and not unduly discriminatory or preferential rates," and noted that "the ability to provide more accurate frequency regulation service means to follow the system operator's dispatch signal more closely."[7] In light of these findings, the Commission revised its regulations in Order No. 755 to require each independent system operator (ISO) or regional transmission organization (RTO) that compensated for Regulation service to adopt a two-part compensation system:

> Each 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

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[3] PJM Transmittal at 2-3 (citing North American Electric Reliability Corp., *Balancing and Frequency Control* at 15 (Jan. 26, 2011), *available at* http://www.nerc.com/docs/oc/rs/NERC%20Balancing%20and%20Frequency%20Control%20040520111.pdf).

[4] *Id.* at 3 (quoting PJM Tariff, Part I, § 1).

[5] *Id.* at 3.

[6] *Frequency Regulation Compensation in the Organized Wholesale Power Markets*, Order No. 755, FERC Stats. & Regs. ¶ 31,324 (2011), *reh'g denied*, Order No. 755-A, 138 FERC ¶ 61,123 (2012).

[7] PJM Transmittal at 3-4 (citing Order No. 755, FERC Stats. & Regs. ¶ 31,324 at P 1).

> compensation based on the actual service provided, including a capacity payment that includes the marginal unit's opportunity costs and 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.[8]

5. In 2012, PJM introduced a performance-based Regulation market design in conjunction with a series of Order No. 755 compliance filings. As PJM explained in its Order No. 755 compliance filings, PJM employs two different types of Regulation signals.[9] PJM uses a traditional signal, called RegA, to dispatch slower, sustained-output resources such as steam and combustion resources. PJM uses a faster signal, called RegD, to dispatch faster, dynamic resources, such as battery storage.[10] PJM originally designed its RegD signal to be unconditionally energy neutral, meaning that the amount of RegUp provided by a RegD resource would match the amount of RegDown provided by the same resource, converging to neutrality within 15 minutes.[11]

6. PJM also uses a "benefits factor" curve in the Regulation market-clearing process to reflect the operational relationship between the RegA and RegD signal.[12] The purpose of the benefits factor curve is to establish the tradeoff between RegA and RegD resources at various combinations so that the Regulation market's clearing engine can consider them on a comparable basis. PJM calculates a unit-specific benefits factor for each RegD resource in the Regulation bid stack based on the benefits factor curve.[13] The values on the benefits factor curve range from 2.9 to 0.0, with a benefits factor of 1.0 representing the point where one megawatt of RegD resources is treated as providing the same value as one megawatt of RegA resources. RegD resources assigned a unit-specific benefits

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[8] 18 C.F.R. § 35.28(g)(8) (2017).

[9] PJM, Compliance Filing Transmittal at 7, Docket No. ER12-1204-000 (Mar. 5, 2012).

[10] The RegA and RegD signals are not resource-type dependent, as any resource that can follow a given signal can qualify to provide Regulation service using that signal. PJM Transmittal at 4-5.

[11] *See* PJM Transmittal at 9.

[12] *See PJM Interconnection, L.L.C.*, 139 FERC ¶ 61,130, at P 12 (2012) (May 2012 Order); *see also PJM Interconnection, L.L.C.*, 141 FERC ¶ 61,134, at PP 27-30 (2012) (November 2012 Order).

[13] PJM, Compliance Filing Transmittal at 11, Docket No. ER12-1204-001 (Aug. 15, 2012); *see* PJM Tariff Attachment K-Appendix and Operating Agreement, Schedule 1, § 3.2.2(j).

factor of greater than 1.0 provide more benefit than a RegA resource, and thus are more likely to clear, whereas RegD resources assigned a unit-specific benefits factor of less than 1.0 provide less benefit and are less likely to clear. Traditional RegA resources have a unit-specific benefits factor equal to 1.0.[14]

B. PJM Regulation Market Clearing and Settlement

7. Consistent with Order No. 755, PJM requires Regulation resources to submit a two-part offer, consisting of a capability (i.e., capacity) offer, and a performance offer, which is a price associated with the amount of work provided by each unit (sometimes referred to as "movement" or "mileage"). PJM adjusts both the capability offer and the performance offer by the benefits factor, discussed above, and a historic performance score. PJM also adjusts the performance offer to estimate the amount of mileage each resource will provide if selected.[15] Following these adjustments, PJM combines each two-part offer into a single combined offer that reflects both capability and performance. To determine which resources will clear the market, PJM ranks all available offers in ascending order by this combined price, and selects the lowest-cost set of resources necessary to simultaneously meet the Regulation requirement and the PJM synchronized reserve requirement.[16]

8. Though PJM clears its Regulation market based on one combined offer price, PJM settles its Regulation market through a two-part payment structure: a capability payment and a performance payment.[17] The capability payment equals the amount of capability a resource cleared multiplied by its performance score and the Capability Market Clearing Price; the performance payment equals the cleared quantity multiplied by a resource's performance score, the mileage ratio, and the Performance Market Clearing Price.

9. In the course of its Order No. 755 compliance process, however, PJM sought a different approach to complying with Order No. 755. In its initial Order No. 755 compliance filing, PJM explained that it planned to adopt language in its manuals providing that, for settlement purposes, Regulation performance would be measured

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[14] PJM Tariff Attachment K-Appendix and Operating Agreement, Schedule 1, § 3.2.2(j).

[15] *Id.* § 3.2.2(g).

[16] *Id.* § 3.2.2(c).

[17] PJM identifies a Performance Market Clearing Price (the highest adjusted performance offer of the resources that cleared the market) and Capability Market Clearing Price (the difference between the combined clearing price and the Performance Regulation Market Clearing Price) to enable PJM to provide two-part compensation in settlement. *Id.* § 3.2.2 (c), (h).

by the actual mileage the resource is dispatched to provide.[18] In a May 2012 Order, the Commission directed PJM to file this provision in the PJM Tariff, given the effect of this manual provision on rates, terms and conditions of PJM's jurisdictional services.[19] In response, PJM proposed tariff revisions and separately filed a compliance proposal, under which PJM proposed to eliminate actual mileage from the performance payment settlement and, instead, to adjust the capability and performance payments in settlement by the marginal benefits factor.[20]

10. In the November 2012 Order, the Commission found that PJM's proposal failed to comply with the Commission's directives.[21] Relying on the regulatory text adopted in Order No. 755, which required "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,"[22] the Commission found that "[b]y failing to include actual mileage in the settlement equation, PJM appears to be inconsistent with Order No. 755."[23] The Commission also found that "PJM has not demonstrated that the benefits factor is a substitute for including actual mileage in the settlement process," and rejected PJM's argument that its consideration of mileage in clearing the market, which was based on the ratio of control signals, eliminated the need to consider mileage in settlement. [24] The Commission found that the clearing process reflects "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."[25]

11. In response, in a January 2013 compliance filing and as reflected in the current PJM Tariff, PJM proposed to eliminate the use of the marginal benefits factor in calculating the capability and performance payments in settlement. PJM also added new tariff language stating that each Regulation resource will be compensated for its performance by multiplying the resource's megawatts by the Performance Market

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[18] PJM, Compliance Filing Transmittal at 19, Docket No. ER12-1204-000 (Mar. 5, 2012).

[19] May 2012 Order, 139 FERC ¶ 61,130 at P 72.

[20] November 2012 Order, 141 FERC ¶ 61,134 at P 46.

[21] *Id.* PP 45-46.

[22] *Id.* P 46 (citing 18 C.F.R. § 35.28 (2017)).

[23] *Id.*

[24] *Id.* P 87.

[25] *Id.* P 46.

Clearing Price, as adjusted by a mileage ratio,[26] and the resource's accuracy score.[27] However, in proposing these changes in compliance with the Commission's directives, PJM warned that removal of the marginal benefits factor from settlement would result in an unsustainable market structure.[28]

C. Operational Issues with the PJM Regulation Market

12. PJM asserts that, as it cautioned in its January 2013 compliance filing, the Regulation market design that it ultimately implemented through its Order No. 755 compliance proceeding led to operational issues. PJM explains that in April 2015, PJM and the independent market monitor (IMM) proposed a review of the Regulation signals and market design,[29] and with stakeholders began analyzing issues associated with the relative mix of RegA and RegD resources participating in the Regulation market, and the impact of the RegD signal's energy neutrality on ACE management.[30]

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[26] PJM explains that the RegD signal moves more than the RegA signal, and mileage ratio can be viewed as a measure of the relative movement (*i.e.*, the relative amount of work) of RegD resources compared to RegA resources over a time interval. PJM Transmittal at 7 n.21. The mileage ratio is calculated by dividing the hourly miles traveled by the Regulation signal the resource is following (either RegA or RegD) by the hourly miles traveled by the RegA signal. PJM Tariff Attachment K-Appendix and Operating Agreement, Schedule 1, § 3.2.2(g).

[27] The accuracy score reflects a Regulation resource's accuracy in increasing or decreasing its output to provide Regulation service in response to PJM's dispatch signal and is comprised of three measures (i.e., the Energy Score, the Delay Score and the Correlation Score). PJM Tariff Attachment K-Appendix and Operating Agreement, Schedule 1, § 3.2.2(k).

[28] PJM, Compliance Filing Transmittal at 8-12, Docket No. ER12-2391-003 (filed Jan. 15, 2013) (January 2013 Compliance Filing). PJM specifically warned that the Commission's required approach would "lead to over-compensation for fast-following resources that provide less control," and would result in a portfolio with too many fast-following resources that could ultimately result in "undesirable ACE oscillations" and the need for future mitigation proposals. *Id.* at 10-11.

[29] PJM Transmittal at 6 (citing IMM, Problem Statement and Issue Charge Overview, (Sep. 16, 2015), *available at* http://www.pjm.com/%7E/media/committees-groups/task-forces/rmistf/20150916/20150916-item-02b-problem-statement-issue-charge-overview.ashx).

[30] *Id.* at 6.

13. PJM asserts that it observed that the original benefits factor curve was producing a suboptimal mix of RegA and RegD resources, which inflated the procurement of RegD megawatts and exacerbated system control challenges. Moreover, PJM argues that inclusion of the mileage ratio in the Regulation settlement equation drove a higher financial signal for new RegD market entry and contributed to an over-supply and over-procurement of RegD resources.[31]

14. PJM also asserts that, because the RegD signal that PJM implemented in 2012 was designed to be unconditionally energy neutral over a 15-minute interval, it always would signal RegD resources to maintain power balance over the interval, through the neutrality reset, regardless of the reliability needs of the bulk power system at the time, sometimes causing the RegA and RegD signals to work against each other, thus impeding efficient Regulation control.[32] PJM explains that, initially, this did not cause major system challenges. However, as the amount of RegD resources increased substantially between 2012 and 2015, PJM states that it experienced instances when hundreds of megawatts of RegD resources were performing in a manner that was appropriate to respect their power balance (e.g., batteries charging in unison), but counter to PJM's ability to manage ACE, forcing PJM operators to manually adjust the Regulation signals. PJM asserts that, as a reliability product, Regulation should provide ACE control at all times, with no counter ACE control movement.[33]

15. PJM explains that between September 2015 and February 2017, PJM and stakeholders discussed and developed possible solutions to account for the observed operational problems. PJM explains that based on the analyses, it concluded: (1) the benefits factor did not properly reflect the correct operational or engineering relationship between RegA and RegD resources; and (2) unconditionally respecting RegD resources' power balance was at times inhibiting PJM's ability to control the system and ensure reliability. PJM states these shortcomings were no fault of any individual RegD resource or market seller, but instead resulted from flaws in the Regulation market construct and signal design that PJM implemented in 2012.[34]

D. January 2017 Signal Redesign

16. PJM explains that while working with stakeholders, it implemented changes to the Regulation signals and the hourly Regulation requirement to better promote reliability and optimize system control by minimizing ACE in January 2017 (January 2017 signal

[31] *Id.* at 7 (citing November 2012 Order, 141 FERC ¶ 61,134 at PP 45-47).

[32] *Id.* at 7-8.

[33] *Id.* at 8.

[34] *Id.* at 8-9.

redesign).[35] PJM states that changes to the Regulation signals in January 2017 included: (1) modifying the RegA and RegD signals to be interdependent and work together to manage ACE; and (2) updating the RegD signal to be conditionally neutral over 30 minutes instead of unconditionally neutral over 15 minutes. PJM explains that under the January 2017 signal redesign, the Regulation controller will try to respect the energy neutrality of RegD resources, but will dispatch resources outside of their anticipated energy capabilities when required by system conditions.[36]

17. According to PJM, by moving from unconditional neutrality to conditional neutrality, it prioritizes system control while still accommodating state-of-charge management when system conditions allow. PJM explains that, by evaluating neutrality on a 30-minute interval instead of a 15-minute interval, PJM is accounting for the fact that ACE sometimes remains on either side of zero for more than 15 minutes at a time, and thus forcing neutrality on a 15-minute interval has too great a potential to result in resources moving in the opposite direction of fixing the ACE.[37]

II. PJM's Regulation Proposal

18. PJM filed the Regulation Proposal to build upon the Regulation signal enhancements that it implemented in 2017.[38] PJM explains that its Regulation Proposal responds to concerns PJM raised when it originally filed its Order No. 755 compliance filing in 2013, when PJM cautioned that its compliance model might lead to significant operational challenges and had the potential to overcompensate certain resources. PJM asserts that its proposal here—based on its operational experience with the current Regulation market rules (e.g., inclusion of mileage in the settlements equation; and use

[35] *Id.* at 9 (citing PJM Interconnection, L.L.C., Implementation and Rationale for PJM's Conditional Neutrality Regulation Signals (Jan. 2017)).

[36] *Id.*

[37] *Id.* at 9-10. PJM also updated its hourly Regulation requirement in January 2017. Previously, PJM explains, it used a fixed hourly Regulation requirement of 700 effective megawatts during on-peak hours and 525 effective megawatts during off-peak hours, regardless of season. PJM explains with the January 2017 signal redesign, it defines the hourly Regulation requirement seasonally in ramp and non-ramp hours. PJM states it will procure more Regulation service during ramp hours (800 effective megawatts) and less during non-ramp hours (525 effective megawatts). *Id.* at 10.

[38] *Id.* at 2.

of the benefits factor to calculate the effective megawatts for resources) —attempts to better align the impact that RegA and RegD resources have on system control.[39]

19. Specifically, PJM proposes to revise the PJM Tariff at Attachment K-Appendix, sections 3.2.2 and 3.2.2A, the parallel provisions to the Operating Agreement, and to add definitions in PJM Tariff, Part I, section 1 and Operating Agreement, Schedule 1, section 1.3. PJM proposes to include in the PJM Tariff and Operating Agreement the following defined terms: Regulation Rate of Technical Substitution Curve,[40] Regulation Rate of Technical Substitution,[41] Regulation Marginal Rate of Technical Substitution,[42] Regulation Requirement,[43] and Regulation Effective Megawatts.[44]

20. PJM explains there are four components of the Regulation Proposal, to: (1) implement the Regulation Rate of Technical Substitution Curve; (2) adjust performance scoring; (3) revise the Regulation settlements equation; and (4) revise how lost

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[39] *Id.* at 1-6.

[40] *Id.* at 11. PJM proposes to define the "Regulation Rate of Technical Substitution Curve" as a function that defines the operational relationship between traditional and dynamic Regulation resources utilized to meet the Regulation Requirement. The Regulation Rate of Technical Substitution Curve is calculated in accordance with the PJM Manuals.

[41] *Id.* PJM proposes to define the "Regulation Rate of Technical Substitution" as a value along the Regulation Rate of Technical Substitution Curve that translates a dynamic Regulation resource into a traditional Regulation resource. The Regulation Rate of Technical Substitution is calculated in accordance with the PJM Manuals.

[42] *Id.* at 12. PJM proposes to define the "Regulation Marginal Rate of Technical Substitution" as the Regulation Rate of Technical Substitution assigned to the last dynamic Regulation resource committed to provide Regulation service in a given hour.

[43] *Id.* PJM proposes to define the "Regulation Requirement" as the calculated Regulation Effective Megawatts required to be maintained in a Regulation Zone, absent any increase to account for additional Regulation scheduled to address operational uncertainty. The Regulation Requirement is defined in accordance with the PJM Manuals.

[44] *Id.* PJM proposes to define the "Regulation Effective Megawatts" as equal to the product of 1) the amount of Regulation that a resource is providing in a given hour, 2) the resource's historic performance score, and 3) the resource's Regulation Rate of Technical Substitution.

opportunity costs are calculated.[45] PJM states that this proposed package of reforms is necessary because the existing Regulation market clearing and settlements processes are not operating efficiently, and the two Regulation signals are not well integrated, which creates compensation misalignments, impedes efficient price signals, and causes reliability issues.[46]

21. PJM explains that all components of the Regulation Proposal are necessarily dependent, and a change in one area will impact other areas. PJM also asserts that any modifications to its January 2017 operational changes will impact its proposed new market design.[47] We summarize each of the four interdependent components next.

A. Regulation Rate of Technical Substitution Curve

22. PJM states that the Regulation Rate of Technical Substitution Curve will replace the benefits factor curve to more accurately determine the trade-off between RegA and RegD resources in providing Regulation service. As with the benefits curve, PJM explains that the Regulation Rate of Technical Substitution Curve allows for an "apples-to-apples" comparison to: (1) ensure an appropriate balance of resources are providing Regulation service; and (2) allow uniform clearing prices for all resources, whether RegA or RegD.[48]

23. PJM explains that the assumptions and models underlying the original benefits factor curve, which were based on only four weeks of data, have proven incorrect.[49] PJM outlines the five steps it takes to define the new Regulation Rate of Technical Substitution Curve, including defining the engineering relationship between RegA and RegD resources based on their ability to control ACE, plotting isoquants (i.e., contour lines through the combination of RegA and RegD that reflect an equivalent ability to manage ACE), and ultimately deriving the substitution function—which is the Regulation Rate of Technical Substitution Curve—and using that curve to evaluate offered resources and optimize RegA and RegD resources.[50]

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[45] *Id.* at 12-14.

[46] *Id.* at 2.

[47] *Id.* at 14.

[48] *Id.* at 18.

[49] The new proposed Regulation Rate of Technical Substitution Curve was developed based on one full year of data from 2015. *Id.* at 14.

[50] *Id.* at 15-18.

24. PJM explains that to calculate effective megawatts provided by resources under the existing benefits factor curve construct, PJM uses a "block" calculation, which excludes a portion of the effective megawatts under the curve and thus undercounts the contribution of RegD resources. With the proposed Regulation Rate of Technical Substitution Curve, PJM states it will calculate the effective megawatts for a resource as the full area under the Regulation Rate of Technical Substitution Curve at the point where the resource's last megawatt falls.[51]

B. Performance Scoring

25. PJM explains that a resource's Regulation performance score is used in market clearing and settlements and reflects how well a resource follows the Regulation signal. The current Regulation performance score gives equal weight to three attributes: accuracy (the correlation between the signal and the resource's response); delay (the time delay between the signal and a resource's highest degree of correlation); and precision (the instantaneous error between the signal and response). PJM explains that under the current construct, the accuracy and delay attributes can inflate a resource's performance score in some instances, and indicate that the resource is providing more system benefit than it actually is providing.[52] Specifically, according to PJM, the accuracy measure does not take into account instances where a resource may be closely following a signal, but deviating from its set point. PJM also contends the delay measure is flawed because it allows a resource up to five minutes to respond, which PJM characterizes as too long.[53] Under the Regulation Proposal, performance scoring would be modified to measure performance scoring based on a single attribute, precision. PJM further proposes refinements to the precision calculation to evaluate resources that respond within 10 seconds and to more fairly assess large and small resources.[54]

C. Lost Opportunity Cost Calculations

26. Under the current PJM Tariff, lost opportunity cost calculations use the lesser of the available market-based or highest available cost-based energy offers from the resource, which PJM asserts fails to capture the realized lost opportunity cost in real-time, reduces the efficiency of the Regulation market solution, and can artificially increase the Regulation market clearing price. PJM proposes to change the lost opportunity cost calculations for online resources that provide Regulation service to use

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[51] *Id.* at 18-19.

[52] *Id.* at 20.

[53] *Id.* at 20-21.

[54] *Id.* at 13, 21-22.

the schedule on which the resource is committed for energy. PJM asserts that this will allow PJM to properly reflect the real-time cost of not following economic dispatch, and will align the incremental costs of Regulation and energy to ensure a least-cost solution.[55]

D. Settlements Equation & Replacement of the Mileage Ratio

27. PJM also proposes to alter the Regulation settlement equations such that RegA and RegD resources are both settled based on effective megawatts. PJM argues using effective megawatts in settlement will ensure that RegA and RegD products are defined, cleared, and settled in equivalent units. PJM proposes to do so by removing the mileage ratio from the performance component of the settlements equation and incorporating the Regulation Marginal Rate of Technical Substitution into both the capacity and performance components of the equation.[56]

28. PJM asserts the current settlement equations for Regulation service do not properly take into account the effective megawatts of resources, thus incorrectly compensating resources and sending incorrect financial signals to the market. PJM asserts that, as a result, the mileage ratio multiplier distorts the market signal for RegD resources, incentivizes RegD resources to offer as price-takers and to self-schedule, and inefficiently signals long-term investment for both RegA and RegD resources.[57]

29. PJM explains that, by design, RegD resources—including batteries—move much more than RegA resources. Therefore, PJM states, the inclusion of mileage ratio in the settlements equation, combined with a benefits factor (or Regulation Marginal Rate of Technical Substitution) that frequently has been less than one (especially prior to the January 2017 operational changes), has caused RegD resources to be overcompensated relative to RegA resources when viewed on an effective megawatt basis.[58] PJM states that overcompensation, in turn, has caused too many RegD resources to enter the market in pursuit of a flawed financial signal, which ultimately has worked against reliability considerations. PJM also states the efficient and correct financial signal is one that promotes reliability while properly compensating all Regulation resources, whether RegA or RegD, based on their effective megawatt contributions to the management of ACE.[59] PJM asserts using the Regulation Marginal Rate of Technical Substitution as a multiplier in the settlements equation will allow all Regulation resources, whether RegA or RegD,

[55] *Id.* at 13-14.

[56] *Id.* at 25.

[57] *Id.* at 22-23.

[58] *Id.* at 23-24.

[59] *Id.* at 24.

to be settled at the same dollar per effective megawatt value, thereby ensuring that a correct financial signal is sent to the market.[60]

30. PJM asserts there are two potential misconceptions regarding its proposed change to the settlements equation: (1) mileage is no longer recognized in the construct; and (2) RegD resources may not be fully compensated when the Regulation Marginal Rate of Technical Substitution is less than 1.0. PJM argues removing mileage ratio from the settlements equation does not remove recognition of the requested movement for each resource type, asserting that the mileage requested of Regulation resources is already recognized in Regulation clearing. Specifically, PJM argues that its Regulation market clearing mechanism already allows resources to capture "dollar per mile" cost, and adding mileage ratio into settlements double counts the movement and improperly compensates resources.[61] Additionally, PJM asserts that, under the Regulation Proposal, all resources, whether RegA or RegD, will be fully compensated at their Regulation offers.[62]

III. Notice of Filing and Responsive Pleadings

31. Notice of PJM's October 17, 2017 filing was published in the *Federal Register*, 82 Fed. Reg. 49,204 (2017), with interventions and protests due on or before November 7, 2017. Notice of PJM's October 25, 2017 filing was published in the *Federal Register*, 82 Fed. Reg. 50,647 (2017), with interventions and protests due on or before November 15, 2017.

32. Timely motions to intervene were filed by the IMM; American Electric Power Service Corporation (AEP);[63] the PJM Power Providers Group (P3); Exelon Corporation

[60] *Id.* at 24-26.

[61] *Id.* at 27. PJM contends the performance offer portion of the numerator in the "Adjusted Performance Cost" calculation used for clearing already captures the resource's price to provide Regulation movement, in $/ΔMW. *See id.* at 28 (providing the formula for Adjusted Performance Cost used in Regulation market clearing).

[62] *Id.* at 28.

[63] AEP intervened on behalf of its affiliates Appalachian Power Company, Indiana Michigan Power Company, Kentucky Power Company, Kingsport Power Company, Ohio Power Company, Wheeling Power Company, AEP Appalachian Transmission Company, AEP Indiana Michigan Transmission Company, AEP Kentucky Transmission Company, AEP Ohio Transmission Company and AEP West Virginia Transmission Company.

(Exelon);[64] AES Ohio Generation, LLC; The AES Corporation (AES); NRG Power Marketing LLC and GenOn Energy Management, LLC; Wabash Valley Power Association, Inc.; American Municipal Power, Inc. (AMP); GlidePath Development LLC; Dominion Energy Services, Inc.; NextEra Energy Resources, LLC (NextEra); the PSEG Companies;[65] EDF Renewable Energy, Inc. (EDF); Energy Storage Association (ESA); Invenergy Storage Development LLC, Grand Ridge Energy Storage LLC, and Beech Ridge Energy Storage LLC (collectively, Invenergy); Achieving Equilibrium, LLC; Beacon Power, LLC (Beacon); and Renewable Energy Systems Americas, Inc.

33. Protests and/or comments were filed by AEP, AES, Beacon, EDF, ESA, the IMM, Invenergy, NextEra, and P3.

34. Answers were filed by the IMM and PJM on November 30, 2017 and December 2, 2017, respectively. Answers to the IMM Answer and/or the PJM Answer were filed by AES, NextEra, Beacon, ESA, and EDF.

35. Additional answers were filed by the IMM and PJM on December 22, 2017 and January 12, 2018, respectively. ESA filed an additional answer on January 26, 2018. The IMM filed an additional answer on February 2, 2018.

IV. Summary of Comments on PJM's Regulation Proposal

36. AEP, the IMM, and P3 support the Regulation Proposal as a necessary reform. The IMM agrees with PJM that the Regulation market suffers from a design flaw due to the Commission's Order No. 755 compliance directives. The IMM argues the marginal benefits factor is not correctly defined in the current PJM market rules and, additionally, is not correctly or consistently implemented in the optimization, clearing and settlement of the Regulation market, resulting in perverse economic incentives, the over-procurement of RegD relative to RegA, increased Regulation costs, and harm to ACE control.[66] The IMM explains that PJM's December 2015 modifications to the marginal

[64] Exelon is the holding company for Atlantic City Electric Company, Baltimore Gas and Electric Company, Commonwealth Edison Company, Delmarva Power & Light Company, PECO Energy Company, and Potomac Electric Power Company.

[65] The PSEG Companies include Public Service Electric and Gas Company, PSEG Power LLC, and PSEG Energy Resources & Trade LLC.

[66] IMM Comments at 3-4; *see also* P3 Comments at 5 (providing similar comments).

benefits factor function and January 2017 signal redesign addressed operational issues and did not address the fundamental market design issues in the Regulation market.[67]

37. P3 and AEP emphasize that the Regulation Proposal was vetted through the stakeholder process and supported by PJM stakeholders.[68] P3 agrees with PJM that the Regulation Proposal is needed, asserting that PJM has shown that there is a significant problem with the current market, including overcompensation for some resources and reliability issues resulting from compensation misalignments.[69] P3 asserts that, while the Commission's original concerns expressed in Order No. 755 may have been the over-valuing and over-compensation of slower-ramping resources, at the expense of faster-ramping resources, PJM's actual operating experience is now showing the opposite. P3 contends that, in hindsight, the Commission under-valued the output of the slower-ramping resources, and overestimated the ability of fast-ramping resources to provide a sustained Regulation level output, resulting in operational and reliability problems.[70]

38. In contrast, AES, Beacon, EDF, ESA, Invenergy, and NextEra oppose the Regulation Proposal, asserting that it is unduly discriminatory and contrary to the requirements adopted in Order No. 755. Other commenters raise many concerns with respect to PJM's Regulation Proposal, including the signal redesign, Regulation market operations, performance scoring, and the transition mechanism.

A. PJM's Proposal to Remove Mileage Ratio from the Settlement Equation and Whether PJM's Proposal is Inconsistent with Order No. 755 Comments

39. Beacon, EDF, ESA, Invenergy, and NextEra oppose the elimination of the mileage ratio from the Regulation settlement equation, on grounds that PJM's proposal violates the Commission's directives in Order No. 755, and is unduly discriminatory and unjust and unreasonable.[71] These parties underscore the Commission's findings in PJM's Order No. 755 compliance proceeding and argue that PJM's present proposal, to use Regulation Marginal Rate of Technical Substitution in settlement, like PJM's proposal in 2012, calculates Regulation performance payments as a function of the movement *expected*

[67] IMM Comments at 4-7.

[68] AEP Comments at 2; P3 Comments at 6.

[69] P3 Comments at 5.

[70] *Id.* at 6.

[71] *See, e.g.*, Beacon Protest at 5-12; EDF Protest at 12-14; ESA Protest at 13-15; Invenergy Protest at 7-9; NextEra Protest at 5-10, 33-39. *See also* NextEra Answer at 3-5; Beacon Answer at 3-4; ESA Answer at 3-4; EDF Answer at 15-16.

from a resource at the time of Regulation market clearing instead of the *actual* movement by the resource within the operating hour and thus should be rejected as a violation of Order No. 755.[72] For example, EDF characterizes the Regulation Proposal as "mostly semantic re-packaging of its proposal to remove actual mileage from the Regulation settlement in lieu of applying the benefits factor, which the Commission explicitly rejected in the November 2012 Compliance Order."[73] ESA emphasizes that nowhere in PJM's proposed offer formula or settlements formula is there a value for the volume of actual mileage a resource—only a historical expectation of that volume embedded in the Regulation Rate of Technical Substitution Curve.[74]

40. ESA contends that the mileage ratio multiplier communicates the value of providing Regulation under each signal. ESA asserts that when a resource moves up and down more quickly and more often, it incurs more wear and tear and increased variable operation and maintenance costs, and lowers efficiency. Thus, ESA argues, the mileage ratio is the parameter resources use to assess the economic tradeoffs of choosing which signal to follow.[75] According to ESA, PJM's proposal ignores the actual performance of Regulation resources in settlement, producing "the wrong payments for actual work done and thus misinform[ing] market participants of the economics associated with RegD provision."[76] According to Invenergy, the negative impacts of eliminating the mileage ratio are exacerbated by PJM's signal redesign, because "at the same time PJM is imposing additional work requirements on RegD resources, it is also seeking to eliminate the compensation owed for that additional work," which uniquely impacts RegD resources.[77]

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[72] *E.g.*, EDF Protest at 12-14; ESA Protest at 8-9; NextEra Protest at 35-38; NextEra Answer at 5; Beacon Protest at 5-12.

[73] EDF Protest at 14.

[74] ESA Protest at 15; *see also* Beacon Protest at 8 ("[I]t is important to note that the [Regulation Rate of Technical Substitution] curves reflect an expected operational relationship between RegA and RegD resources based on a modeled historical time period. In other words, it is not based upon the actual performance of a resource in a particular settlement interval.") (citing PJM Manual 11, § 3.2.7) (emphasis and footnotes removed).

[75] ESA Protest at 13.

[76] *Id.* at 14.

[77] Invenergy Protest at 9.

41. ESA also argues that the Regulation Proposal results in inconsistent market clearing and settlement, because PJM proposes to use the area under the Regulation Rate of Technical Substitution Curve to calculate the effective megawatts of RegD resources, while proposing to compensate RegD resources based on the marginal value of the curve, the Regulation Marginal Rate of Technical Substitution, which is "always lower than the RegD effective megawatts used in market clearing."[78] As a result, ESA argues, RegD resources are always under-compensated on an effective megawatt basis. Beacon raises similar concerns, contending that PJM's proposal would significantly misrepresent the effective capacity of all but the last RegD resource cleared.[79]

42. The IMM, in support of PJM's proposal, asserts that PJM's current market-clearing mechanism does not confirm that resulting combinations of RegA and RegD megawatts are consistent with the proportions incorporated in the marginal benefits factor curve and therefore consistent with feasible market solutions.[80] The IMM contends this approach clears too much RegD relative to RegA megawatts.[81] The IMM describes a feedback loop in which the excess procurement of RegD combined with the overpayment of RegD resulted in an increase in the level of $0.00 offers from RegD resources, which are guaranteed to clear.[82]

43. The IMM also argues the current market design does not properly compensate RegD resources on an effective megawatt basis because, although prices are set on the basis of dollars per effective megawatt, only RegA resources receive payments based on this price per effective megawatt, and, in addition, RegD resources have their performance payment multiplied by the mileage ratio.[83] According to the IMM, following the January 2017 signal redesign, the weighted-average mileage ratio during

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[78] ESA Protest at 9-12 (discussing specific example scenarios).

[79] Beacon Protest at 20-21.

[80] IMM Comments at 8.

[81] *Id.* The IMM also explains that due to the changes implemented in January 2017, the total level of RegD cleared in the market decreased 16.4 percent in the first nine months of 2017 compared to the first nine months of 2016. *Id.* at 13.

[82] *Id.* at 13. For example, the IMM asserts that all RegD megawatts clearing the market in the period between January 1, 2016 and April 30, 2017, had an effective offer of $0.00. The IMM also states from May 1, 2017 through September 30, 2017, an average of 98.2 percent of cleared RegD megawatts had an effective cost of $0.00. *Id.*

[83] *Id.* at 17.

certain hours increased more than 100 percent,[84] thereby increasing payments to RegD resources on a performance-adjusted basis.[85] The IMM asserts the extreme mileage ratios result when the RegA signal is fixed at a single value for an extended period (i.e., pegged) while the RegD signal is not.[86] The IMM contends these results are an example of why it is not appropriate to use the mileage ratio to measure the relative value of RegA and RegD resources.

44. The IMM contends when the marginal benefits factor is above one, RegD resources are underpaid on a per effective megawatt basis—although this could be offset by a high mileage ratio—and when the marginal benefits factor is less than one, RegD resources are overpaid on a per effective megawatt basis.[87] The IMM argues the average marginal benefits factor was less than 1.0 in 2016 (0.60) and the first nine months of 2017 (0.95), resulting in an average overpayment of RegD resources.[88]

B. Answers

45. PJM contends that removing the mileage ratio from the settlement equation and incorporating Regulation Marginal Rate of Technical Substitution will ensure that all resources, whether they use the RegA or RegD signal, are settled based on effective megawatt contribution to managing ACE, consistent with clearing and operating those

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[84] The IMM explains that weighted-average mileage ratios during certain hours (i.e., non-critical control hours) increased from 2.81 in the first nine months of 2016, to 5.97 in the first nine months of 2017 (an increase of 112.4 percent). *Id.* at 18.

[85] For example, according to the IMM, in the first nine months of 2016, RegD resources earned 12.1 percent more per performance adjusted megawatt than RegA resources, but in the first nine months of 2017, RegD resources earned 83.5 percent more per performance adjusted megawatt than RegA resources. *Id.* at 19-20.

[86] *Id.* at 18. The IMM asserts that, during such events, RegA resources are providing ACE control by providing a fixed level of megawatt output which means zero mileage, while RegD resources alternate between helping and hurting ACE control, both of which result in positive mileage. *Id.*

[87] *Id.* at 20-21.

[88] *Id.* at 21. The IMM asserts that RegD resources were paid $11.2 million (1,855.6 percent) more than they should have been paid per effective megawatt in the first nine months of 2016. The IMM also contends that RegD resources were paid $14.1 million (385.3 percent) more than they should have been in the first nine months of 2017. *Id.*

resources, and that no resource will experience undue discrimination.[89] PJM reiterates that it forewarned in its January 2013 Compliance Filing that including a mileage ratio in the settlement equation and excluding the marginal benefits factor eventually would lead to operational issues,[90] and PJM argues that the adverse operational impacts can be mitigated by ensuring that all Regulation resources are cleared and settled based on effective megawatt contributions to managing ACE.[91]

46. In defense of PJM's proposal, the IMM argues that ESA and Beacon "attempt to make a false distinction between marginal effective work done by RegA and RegD megawatts in the market clearing and marginal effective work done in operation," asserting that the mileage ratio bears no relationship to the actual amount of ACE correction provided.[92] The IMM also contends that ESA's and Beacon's arguments that PJM's proposal results in a mismatch between clearing and settlement result from their "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)."[93]

47. The IMM also challenges Beacon's assertion that there is a lack of supporting evidence that the mileage ratio has resulted in an over-supply and over-procurement of RegD resources.[94] The IMM contends 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 marginal benefits factor in settlement. Instead, the IMM argues the market-clearing engine only sees the marginal benefits factor adjusted prices of RegD resources (which are offering at zero) and acquires too much RegD.[95] The IMM reiterates that this disconnect has resulted in over-procurement and over-supply of RegD resources, and excessive costs to provide Regulation service, contributing to wasteful investment in a saturated market.[96]

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[89] PJM Answer at 4.

[90] *Id.* (citing January 2013 Compliance Filing at 1).

[91] *Id.* at 5.

[92] IMM Answer at 5.

[93] *Id.* at 6-9 (providing a detailed technical discussion).

[94] *Id.* at 9-12.

[95] *Id.* at 11.

[96] *Id.* at 11-12. The IMM provides a detailed rebuttal to Beacon's illustrative of

48. The IMM, in its December answer, asserts that the PJM proposal does not eliminate actual mileage from the settlement calculation, because it "includes actual mileage in the determination of realized within hour offers, the realized within hour marginal offer, the realized within hour price of regulation and the realized within hour settlement."[97] The IMM goes on to assert that all performance offers are provided on a dollar-per-mile basis using the historic, expected mileage of a signal to determine the ex-ante offer for purposes of clearing the market; however, the IMM avers, "once a resource clears, the actual within hour mileage of followed signal is used to convert every $/mile offer into the actual $/MW performance hour based on the actual mileage of the followed signal within the hour among all cleared resources."[98]

V. Discussion

A. Procedural Matters

49. Pursuant to Rule 214 of the Commission's Rules of Practice and Procedure, 18 C.F.R. § 385.214 (2017), the timely, unopposed motions to intervene serve to make the entities that filed them parties to this proceeding.

50. Rule 213(a)(2) of the Commission's Rules of Practice and Procedure, 18 C.F.R. § 385.213(a)(2) (2017), prohibits an answer to a protest and or answer unless otherwise ordered by the decisional authority. We will accept the answers because they have provided information that assisted us in our decision-making process.

B. Commission Determination

51. For the reasons discussed below, we reject PJM's Regulation Proposal. Although we appreciate PJM's and stakeholders' efforts to develop a proposal to address ongoing operational issues and market inefficiencies,[99] we find that PJM's proposal is inconsistent with the Commission's directives in Order No. 755 and Commission regulations because,

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example of how RegD resources are not be compensated for the actual amount of work provided under PJM's proposal. *Id.* at 12-14. In its answer, Beacon contends that the IMM appears to misunderstand Beacon's example. Beacon Answer at 2-4.

[97] IMM December Answer at 5.

[98] *Id.*

[99] According to PJM, these issues include: (1) lack of effective ACE management; (2) over-compensation of RegD resources, which has ultimately worked against reliability; (3) undercounting the contribution of RegD resources in meeting the Regulation requirement; and (4) inaccurate price signals for RegD resources that incentivize $0 offers and self-scheduling. *See* PJM Transmittal at 23-24.

under the Regulation Proposal, Regulation resources would not be "compensat[ed] 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."[100]

52. In Order No. 755, the Commission held that performance "must be measured based on the absolute amount of regulation up and regulation down [a resource] provides in response to the system operator's dispatch signal."[101] In the background portion of this order, we summarize PJM's previous attempts to comply with Order No. 755. Our findings here largely parallel the Commission's earlier findings. For example, in the PJM Order No. 755 compliance proceeding, the Commission rejected PJM's proposal to use the marginal benefits factor in the settlement equation, finding that "[b]y failing to include actual mileage in the settlement equation, PJM appears to be inconsistent with Order No. 755."[102] In that proceeding, the Commission found that PJM failed to demonstrate that the benefits factor—which performs the same function as PJM's proposed Regulation Rate of Technical Substitution—"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."[103] The Commission also rejected PJM's argument that consideration of mileage in clearing the market, which is based on the historic ratio of control signals, eliminated the need to consider mileage in settlement.[104]

53. Here, we similarly find that the Regulation Proposal is inconsistent with the Commission's regulations and Order No. 755 because it does not account for actual mileage in settlement. The Commission established in Order No. 755 that "[a] resource's performance must be measured based on the absolute amount of regulation up and regulation down it provides in response to the system operator's dispatch signal."[105] In its Regulation Proposal, PJM fails to demonstrate that the Regulation Marginal Rate of

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[100] 18 C.F.R. § 35.28(g)(8) (2017). Because the Commission in this order rejects the Regulation Proposal as inconsistent with the Commission's directives in Order No. 755 and the Commission's regulations, we do not address the merits of additional concerns raised by commenters.

[101] Order No. 755, FERC Stats. & Res. ¶ 31,324 at P 133.

[102] November 2012 Order, 141 FERC ¶ 61,134 at P 46.

[103] *Id.* P 87.

[104] *Id.* P 46.

[105] Order No. 755, FERC Stats. & Regs. ¶ 31,324 at P 133.

Technical Substitution—which estimates the effective megawatts expected to be provided in real time by the marginal RegD resource—compensates resources for the quantity of service actually provided. Additionally, because the Regulation Proposal compensates capacity from all RegD resources based on the *marginal* (i.e., lowest) substitution benefit provided by the last resource cleared, the proposal does not accurately reflect the effective megawatts contribution of RegD resources when they operate in a given hour.

54. We disagree with PJM's contention that, because PJM's market-clearing process accounts for the "dollar per mile" cost of RegD resources, the Regulation Proposal meets the Commission's requirements, and PJM's related contention that accounting for mileage in the settlement equation double counts the mileage of RegD resources. The IMM makes similar claims, but neither PJM nor the IMM has adequately demonstrated its case. Rather, we find that the mere fact that PJM's market-clearing process accounts for expected mileage of the marginal unit in setting the Performance Market Clearing Price does not mean that a resource is ultimately compensated for the quantity of Regulation service it later provides in response to PJM's dispatch signal. Accounting for the dollar per mile cost of resources in the Regulation clearing process only helps determine what the clearing price for regulation should be. Once the price is determined, the resource must also be compensated based on the quantity of Regulation service actually provided.

55. According to PJM, removing the mileage ratio from the settlement equation and incorporating the Regulation Marginal Rate of Technical Substitution is warranted and reasonable given its two-signal Regulation construct.[106] PJM also argues that unless it removes the mileage ratio from settlement and incorporates Regulation Marginal Rate of Technical Substitution, the PJM Regulation market will continue to experience adverse operational impacts. However, we find that PJM has failed to provide evidence that its particular proposal, which eliminates any consideration of actual mileage in settlement, is required to address the operational issues that PJM states it has experienced.[107] In Order No. 755, the Commission provided RTOs with the flexibility to design market rules that accommodate their markets,[108] and PJM is free to propose Regulation compensation

[106] We acknowledge that PJM is the only RTO/ISO with two discrete Regulation dispatch signals that evaluates the trade-off between slow- and fast- responding resources.

[107] For instance, in the Complaints proceedings in Docket Nos. EL17-64-000 and EL17-65-000, a number of other factors related to operational issues in PJM's Regulation market were raised, such as the signal design and benefits factor. *See, e.g.*, PJM Answer, Affidavit of Eric Hsia at P 21, Docket No. EL17-64-000 (filed May 15, 2017).

[108] *See* Order No. 755, FERC Stats. & Regs. ¶ 31,324 at P 75.

reforms tailored to address the unique concerns that have arisen in its current Regulation market construct, such as potential over-procurement of RegD resources or inappropriate compensation levels. However, any such reforms must fall within the framework the Commission established in Order No. 755 to ensure just and reasonable and not unduly discriminatory or preferential rates, and thus must include the consideration of actual mileage in compensation.[109]

56. For the reasons discussed above, we reject the Regulation Proposal because it does not comply with the requirement of Order No. 755 and the Commission's regulations to compensate all Regulation resources based on the quantity of Regulation service provided.[110] Given PJM's statement that the Regulation Proposal reforms are interdependent and a change in one area will impact other areas, we will not address other aspects of the Regulation Proposal, such as the proposed modifications to the performance score and lost opportunity cost calculations. We therefore reject the PJM Regulation Proposal, but note that PJM may pursue a revised version in light of our findings and the comments of record here.[111]

57. Finally, we note that, while not summarized here, commenters raised broader concerns about PJM's operation of the Regulation Market, including concerns about Regulation Market changes PJM has implemented since December 2015 and concerns about what should be included in the PJM Tariff. We note that some of these issues were also raised in the Complaints in Docket Nos. EL17-64-000 and EL17-65-000. In an order issued concurrently with this order, we partially grant the Complaints and establish a staff-led technical conference to address those broader issues raised in the Complaints.[112] Given the overlap between issues raised in this proceeding and those

[109] *See* November 2012 Order, 141 FERC ¶ 61,134 at P 46 ("By failing to include actual mileage in the settlement equation, PJM appears to be inconsistent with Order No. 755."); 18 C.F.R. § 35.28(g)(8) (requiring "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").

[110] *See* 18 C.F.R. § 35.28(g)(8).

[111] Because PJM has not shown that the aspects of its proposal discussed herein are just and reasonable and not unduly discriminatory or preferential, we are not addressing other aspects of PJM's proposal that were protested, and absence of discussion is not an indication of how the Commission would rule on the merits of those issues.

[112] *Energy Storage Association v. PJM Interconnection, L.L.C.*, 162 FERC ¶ 61,296 (2018).

raised in the Complaints, we will also use the technical conference to examine PJM's two-signal Regulation market design with respect to the requirements of Order No. 755.

The Commission orders:

PJM's Regulation Proposal is hereby rejected, as discussed in the body of this order.

By the Commission. Chairman McIntyre is not participating.

(S E A L)

Nathaniel J. Davis, Sr.,
Deputy Secretary.