

markets as a Market Seller.”³ However, as will be evident in the responses below, this definition is not meant to encompass all electric storage devices, or the way in which they may participate in PJM’s capacity,⁴ energy,⁵ or ancillary services markets⁶ (collectively, the “PJM wholesale markets”).

Of the newer forms of electric storage resources, the vast majority of those participating in the PJM wholesale markets today are batteries, most of which operate in the Regulation market. However, the functionality and market activity associated with electric storage resources are changing. As such, PJM believes the Commission’s request for information about these resources and their ability to contribute towards reliability and competitive market outcomes at the wholesale level is well timed. PJM also believes that its wholesale markets, governing documents, and business manuals are well positioned to accommodate electric storage resources of different types and configurations.

Practically speaking, there are commercial and/or technological limitations that may currently restrict participation of electric storage resources (and in particular batteries and flywheels) in PJM’s wholesale markets. These include the costs associated with providing energy for longer periods of time and the requirement that resources must be available to provide capacity with very limited excuses on a year-round basis.⁷ However in general, as long as Market Participants are able to demonstrate that electric storage resources are able to meet the

³ See Operating Agreement, Schedule 1, section 1.3. All references herein to Operating Agreement, Schedule, shall apply equally to the identical provisions of Tariff, Attachment K-Appendix.

⁴ PJM’s capacity market is called the Reliability Pricing Model (“RPM”).

⁵ PJM’s energy markets are the Day-ahead Energy Market and Real-time Energy Market. Generic references herein to PJM’s “energy market” shall refer to both of these markets.

⁶ PJM’s ancillary services markets are Regulation, Synchronized Reserve, and Non-Synchronized Reserve.

⁷ See e.g., *PJM Interconnection, L.L.C.*, 151 FERC ¶ 61,208 (2015) (“Capacity Performance Order”), *order on reh’g and compliance filing, PJM Interconnection, L.L.C.*, 155 FERC ¶ 61,157 (2016) (“CP Rehearing Order”).

eligibility and performance criteria for each respective wholesale market, there is nothing prohibiting such resources from participating in the PJM wholesale markets (with the exception of electric storage resources participating in the Non-Synchronized Reserve Market as a demand-side resource,⁸ as discussed below). This is due to the fact that PJM’s market rules are written to allow all resources to participate, regardless of technology classification. Moreover, as explained below, PJM and its stakeholders have begun a broader process of determining how to better incorporate distributed energy resources, including electric storage resources, into the PJM wholesale markets. PJM looks forward to working with its stakeholders through this process, as well as engaging with the Commission and other entities in the electric industry generally, to determine how to best achieve this outcome.

Commission Questions

The Eligibility of Electric Storage Resources to be Market Participants

- 1. If electric storage resources are eligible to qualify as sellers in the capacity, energy, and/or ancillary service markets, please indicate the resource types (e.g. limited energy resource, generator, demand response, etc.) for which they may qualify in each market. In addition, please list where each applicable resource type is defined in the tariff, as well as the criteria for qualifying as each resource type.**

PJM Answer: Market Sellers in PJM can submit offers for electric storage resources in PJM’s wholesale markets as either generation resources or demand-side resources. Electric storage resources that are directly interconnected to the transmission system, or interconnected to the distribution system and inject power past the applicable customer meter,⁹ are considered to be generation resources. Generation Interconnection Customers submit requests to be studied

⁸ PJM’s references herein to “demand-side resources” refer generically to those resources that work to reduce end-use customers’ demand in the wholesale markets.

⁹ The “customer meter” is typically the retail electricity customer meter, but may also be a municipality’s or cooperative’s meter where such entity’s load is managed as one customer.

through the PJM generation interconnection queue to determine their resource's ability to deliver energy to the bulk power system. This process is outlined in the Tariff¹⁰ and PJM Manual 14A,¹¹ and is facilitated by an online application process.¹² Generation Interconnection Customers with electric storage resources must submit requests for interconnection using Tariff, Attachment BB (Form of Interconnection Service Agreement for Certified Inverter-Based Generating Facility used for inverter-based resources 10 kW or less); Tariff, Attachment Y (Form of Screens Process Interconnection Request used for synchronous generation interconnection of 2 MW or less or inverter-based resources 5 MW or less); or Tariff, Attachment N (Form of Generation Interconnection Feasibility Study Agreement, used for synchronous resources greater than 2 MW or inverter-based resources greater than 5 MW). In addition to being studied for generation deliverability, electric storage resources are also studied for load deliverability impacts related to their load capability when receiving electricity (*i.e.* charging).

Electric storage resources that are located behind a customer's meter are eligible to receive compensation as demand-side resources, with the exception of Non-Synchronized Reserves. Non-Synchronized Reserves must be provided by resources that are not synchronized to the grid. In order for a demand-side resource to curtail and provide reserves, it must be synchronized to the grid and consuming power, and therefore would always be classified as Synchronized Reserves and never Non-Synchronized Reserves. To participate in the PJM wholesale markets as a demand-side resource, electric storage resources that are behind a customer's meter typically will be used to decrease a customer's load at the meter. In some

¹⁰ See generally Tariff, Parts IV and VI.

¹¹ See PJM Manual 14A, *Generation and Transmission Interconnection Process*, rev. 18 (Jan. 28, 2016), <http://www.pjm.com/documents/manuals.aspx>.

¹² See PJM, Generation Interconnection, available at <http://www.pjm.com/planning/generation-interconnection.aspx>.

circumstances, electric storage resources will also increase a customer's load in order to participate in a market by following PJM's Regulation signal.

In the PJM Region, demand-side resources participate either as Emergency Load Response or Economic Load Response resources. Emergency Load Response is provided by Market Sellers that are required to reduce load in real-time during an Operating Day if called upon based on their commitments in RPM. Economic Load Response is provided by Market Sellers that wish to voluntarily reduce load in response to market prices during an Operating Day. Like other types of resources that participate in PJM's markets only by providing load reductions, these demand-side electric storage resources are not studied by PJM through the generation interconnection process. As such, they are not studied for deliverability, and, thus, demand-side electric storage resources are not allowed to inject energy beyond the customer's meter and onto the distribution or transmission system, as applicable.¹³ When any resource, including electric storage resources, operating behind a customer's meter injects energy onto the distribution or PJM transmission system past the applicable customer meter, they are deemed to be making a wholesale sale of electricity pursuant to FERC Order No. 2003,¹⁴ and are therefore required to come through PJM's generation interconnection queue.

Within these broad categories of generation and demand-side resources, there are different eligibility and performance requirements for each of the PJM wholesale markets in which Market Sellers participate. These requirements will be discussed in further detail below in

¹³ When participating as a demand-side resource as part of a municipality or cooperative, an electric storage resource may inject power onto such entity's distribution system. However, because they do not inject beyond the municipality's or cooperative's meter, such resources are still considered a demand-side resource since PJM treats the municipality or cooperative itself as the customer.

¹⁴ See *e.g.* *Standardization of Generator Interconnection Agreements and Procedures*, 104 FERC ¶ 61,103 (2003).

response to the Commission’s questions on the technical qualification and technical performance criteria for participating in PJM’s markets.

Currently, there is a total of 5,814 megawatts of electric storage resources participating in the PJM wholesale markets that can “receive electric energy from the grid and store it for later injection of electricity back to the grid.” Table 1 summarizes how these different types of electric storage resources currently participate in PJM’s wholesale markets, by type and amount.

Table 1

Electric Storage Technology	Resource by	Installed Capacity/Qualified Rating (MW)	Capacity	Energy	Ancillary Services
Pumped Storage (Generation)	Hydro	5,537	Yes	Yes	Yes
Battery (Generation)		245	No	No	Yes
Flywheel (Generation)		20	No	No	Yes
Battery (Demand-side Resource)		12	Yes	No	Yes

Moreover, PJM has two defined terms particular to electric storage resources - Capacity Storage Resource and Energy Storage Resource. “Capacity Storage Resource” is defined as “...any hydroelectric power plant, flywheel, battery storage, or other such facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets and which participates in the Reliability Pricing Model.”¹⁵ A Capacity Market Seller of a Capacity Storage Resource can submit an RPM Sell Offer comprised of megawatts from a Capacity Storage Resource alone, or can submit an RPM Sell Offer comprised of megawatts (or load reductions) from the Capacity Storage Resource that is aggregated with megawatts (or load reductions) from other Capacity Resource types, including Demand Resources, Intermittent Resources, Energy Efficiency Resources and Environmentally-

¹⁵ Tariff, Attachment DD, section 2.13A.

Limited Resources.¹⁶ Capacity Storage Resources are exempt from the RPM must-offer requirement as a Capacity Performance Resource that applies to all other types of generation resources.¹⁷

An Energy Storage Resource is defined as any “...flywheel or battery storage facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets as a Market Seller.”¹⁸ Energy Storage Resources are offered into the energy market only, not RPM. This term is defined in order to establish that energy used to charge an Energy Storage Resource is not considered to be Station Power.¹⁹ The definition of Station Power also excludes energy “... (ii) used for pumping at a pumped storage facility; (iii) used for compressors at a compressed air energy storage facility.”²⁰

2. **Are certain types of resources ineligible to participate as sellers in the capacity, energy, or ancillary service markets by definition? If so, please explain which types of resources are ineligible to participate in which markets and why, including citations to any authority for such ineligibility (e.g., NERC standards, etc.).**
3. **To the extent that electric storage resources are *ineligible* to qualify as sellers in the capacity, energy and ancillary service markets for a resource type, please explain why.**

PJM Answer: There are limited instances where resource types are ineligible to participate in PJM wholesale markets. First, as previously described, demand-side resources (including electric storage resources) are ineligible to provide Non-Synchronized Reserves.

¹⁶ See PJM Manual 18, *Capacity Market Operations*, section 4.9, rev. 32 (Apr. 1, 2016), <http://pjm.com/~media/documents/manuals/m18.ashx> (“PJM Manual 18”). See also Tariff, Attachment DD, section 5.6.1(h).

¹⁷ See Tariff, Attachment DD, section 6.6A. For the 2018/2019 and 2019/2020 Delivery Years, such resources still have a must-offer requirement as Base Capacity Resources. See *id.* at section 6.6(g).

¹⁸ See Operating Agreement, Schedule 1, section 1.3.

¹⁹ See *id.*

²⁰ See *id.*

Moreover, at present, battery resources are eligible to participate in the Synchronized Reserve Market but do not in practice. PJM believes this is because battery resources can more fully utilize their capability in the Regulation Market and collect more revenues. The Synchronized Reserve Market contains a requirement that all resources must be able to respond to a reserve deployment within 10 minutes and maintain that level of energy injection or load curtailment for 30 minutes.²¹ This means that a Market Seller of a battery resource that can inject 1 MW for 15 minutes would only be able to offer 0.5 MW into the Synchronized Reserve Market because it would need to offer a quantity that could be sustained for 30 minutes. This halves the capability of the battery in the Synchronized Reserve Market. In the Regulation Market, however, no such duration requirement exists, and therefore the same battery can provide 1 MW of Regulation. However, if a Market Seller wanted to offer into the Synchronized Reserve Market, PJM would welcome its participation provided it could meet this market's eligibility criteria.²²

- 4. When electric storage resources are eligible to participate in the capacity, energy, and ancillary services markets, are there different rules for different types of electric storage resources? For example, are there different qualification or performance requirements for batteries versus pumped storage resources? If so, please state these rules and explain the distinctions they draw for the participation of different types of electric storage resources.**

PJM Answer: The three types of electric storage resources discussed herein that participate in PJM's wholesale markets are pumped storage resources, batteries and flywheels. The primary difference between these resource types is the energy duration (*i.e.* the amount of time they can produce megawatts) associated with their capability. Generally speaking, pumped

²¹ See PJM Manual 11, *Energy and Ancillary Services Market Operations*, rev. 80, section 4.2.1, (Mar. 31, 2016), <http://pjm.com/~media/documents/manuals/m11.ashx> ("PJM Manual 11").

²² See Manual 11, section 4.2.1.

storage resources can produce more energy over a longer period of time than batteries or flywheels, and thus have an easier time meeting requirements for providing capacity, energy, or ancillary services that may require longer dispatch durations. That being said, the performance requirements applicable to the participation of each type of electric storage resource in the PJM wholesale markets are the same.

Further, the rules regarding how Market Sellers must compute the costs included in their cost-based offers into PJM's energy and ancillary services markets for pumped storage resources, batteries and flywheels are different, and are outlined in PJM Manual 15, "Cost Development Guidelines" sections 7 and 11, respectively.²³ Specifically, the fuel cost associated with a pumped storage resource is calculated using the resource's pumping power cost and its pumping efficiency. Pumping power cost is calculated by multiplying the real-time Locational Marginal Price ("LMP") (\$/MWh) by the energy used in pump mode (MWh). Pumping efficiency is calculated by dividing the megawatt-hours of generation produced while operating in generation mode by the megawatt-hours required to pump the water needed to produce those same megawatt-hours.²⁴ The pumped storage fuel cost is then calculated as pumping power cost divided by the pumping efficiency.

Fuel cost for batteries and flywheels are currently zero. However, because these resource types primarily participate in the Regulation Market, energy storage unit losses are calculated as part of a battery or flywheel's cost to provide Regulation. The following equation is used to calculate this value:

²³ PJM Manual 15, *Cost Development Guidelines*, rev. 26 (Nov. 5, 2014), <http://pjm.com/~media/documents/manuals/m15.ashx> ("PJM Manual 15).

²⁴ See PJM Manual 15, section 7.1.

$$\text{Energy Storage Unit Losses}(\$/\text{MW}) \\ = \text{Average of 7 Days} \left\{ \frac{(\text{Hourly LMP} \left(\frac{\$}{\text{MWh}} \right) * \text{Hourly Net Energy Consumed}(\text{MWh}))}{\text{Hourly Accepted Regulation Offers (MW)}} \right\}$$

5. **Can electric storage resources set the price in the capacity, energy, and ancillary service markets? If not, please explain all circumstances under which electric storage resources are not eligible to set the market-clearing price.**

PJM Answer: Yes, electric storage resources have the ability to set the price as either a generation or as demand-side resource in the capacity, energy, and/or ancillary services markets, (with the aforementioned exception of demand-side resources in the Non-Synchronized Reserve Market).

Qualification Criteria and Performance Requirements

1. **What are the minimum capacity requirements and minimum offer sizes to sell capacity, energy, and ancillary services?**

PJM Answer: The minimum requirement for offers to provide capacity, energy, or ancillary services in PJM is 0.1 megawatts. This value is both the minimum requirement (i.e. the floor) and also the minimum incremental offer amount.²⁵

2. **What are the technical qualification criteria for each type of resource eligible to participate in the capacity, energy, and ancillary service markets, as applicable?**
3. **What are the technical performance requirements for providing capacity, energy, and ancillary services in PJM’s markets, as applicable?**

PJM Answer: The “technical qualification criteria” and “technical performance requirements” for each resource participating in every one of the PJM wholesale markets are detailed in hundreds of pages of PJM’s governing documents and manuals. For example, Tariff, Attachment DD contains rules governing the participation of generation resources and demand-side resources in RPM, which all describe “technical qualification criteria” and “technical

²⁵ See Tariff, Attachment DD, section 5.6.

performance requirements” for such resources, and is nearly 200 pages long. Rather than detailing these (and other) parts of its governing documents and manuals in responding to these questions, PJM is instead providing tables summarizing what it believes are the most significant qualification criteria and performance requirements applicable to RPM, the energy market, and ancillary services markets, by resource type when applicable, and is providing citations to where these rules are explained in more depth.

Table 2-Capacity Market

Capacity Resource Product Types	Performance Criteria	References
Capacity Performance	Obligated to deliver energy during the relevant Delivery Year as scheduled and/or dispatched by the PJM during Performance Assessment Hours.	Tariff, Attachment DD, section 5.5A
Base Capacity	For the Delivery Years 2018/2019 and 2019/2020, ²⁶ obligated provide energy output to PJM as scheduled and/or dispatched during any Performance Assessment Hours occurring in the calendar months of June through September.	Tariff, Attachment DD, section 5.5A
Capacity Performance DR (Effective 2016-2017 Delivery Year and subsequent Delivery Years)	Capacity Performance DR is available for an unlimited number of interruptions during the Delivery Year, and will be capable of maintaining each such interruption between the hours of 10:00AM to 10:00PM Eastern Prevailing Time for the months of June through October and the following May, and 6:00AM through 9:00PM Eastern Prevailing Time for the months of November through April unless there is a PJM approved maintenance outage during October through April.	Manual 18, Section 4.3.1
Base Capacity DR (Effective 2018/2019 – 2019/2020 Delivery Year)	Base Capacity DR is available for unlimited number of interruptions during June through September in the Delivery Year and will be capable of maintaining such interruption for at	Manual 18, Section 4.3.1

²⁶ Starting in the 2020/2021 Delivery Year, all resources participating in RPM must be Capacity Performance Resources, including Capacity Storage Resources. *See Capacity Performance Order and CP Rehearing Order.*

	least 10-hour duration.	
Limited DR (Effective through 2017/2018 Delivery Year for RPM and through the end of the initial FRR Capacity Plan for FRR Entities ²⁷)	Available for interruption for at least 10 times during the summer period of June through September in the Delivery Year, and will be capable of maintaining each such interruption for at least a 6-hour duration.	Manual 18, Section 4.3.1
Extended Summer DR (Effective 2014/2015 – 2017/2018 Delivery Years for RPM and 2014/2015- the end of the initial FRR Capacity Plan for FRR Entities)	Available for an unlimited number of interruptions during an extended summer period of June through October and the following May, and will be capable of maintaining each such interruption for at least a 10-hour duration.	Manual 18, Section 4.3.1
Annual DR (Effective 2014/2015 – 2017/2018 Delivery Years for RPM and 2014/2015- the end of the initial FRR Capacity Plan for FRR Entities)	Annual DR is available for an unlimited number of interruptions during the Delivery Year, and will be capable of maintaining each such interruption for at least a 10-hour duration.	Manual 18, Section 4.3.1

Table 3- Energy Market

Applicable Requirement	Description of Requirement	References
Day-ahead Energy Market must-offer requirement	Rules related to must-offer requirement for Capacity Performance Resources and Base Capacity Resources (generation only).	Operating Agreement Schedule 1, section 1.10.1A(d)
Procedures for offering into the Day-ahead Energy Market and Real-time Energy Market	Rules for all resources offering into the Day-ahead and Real-time Energy Market.	Operating Agreement, Schedule 1, section 1.10; Manual 11, section 2.3.1
Rules for Offers with Parameter Limited Schedules	Rules related to cost-based and market-based parameter limited schedules for offers from Capacity Performance Resources and Base Capacity Resources (generation only).	Operating Agreement, Schedule 1, section 6.6; Manual 11, sections 2.3.3 and 2.3.4

²⁷ Pursuant to the Commission’s recent CP Rehearing Order at P 319, PJM is required to further extend the transition period for application of the Capacity Performance rules to Fixed Resource Requirement (“FRR”) Entities to after completion of their FRR Capacity Plan that was in place as of the Commission’s Initial Capacity Performance Order.

Emergency Operations	Procedures that all resources must follow during PJM-declared emergencies.	Manual 13 ²⁸
Cost-based Offers	Procedures for developing cost-based offers submitted into the energy market.	Operating Agreement, Schedule 2; Manual 15
Deviations, Make Whole and Lost Opportunity Cost	Rules related to following PJM's dispatch instructions and associated settlements implications.	Operating Agreement, Schedule 1, section 3.2.3

Table 4- Ancillary Services Markets

Market	Requirements	References
Synchronized Reserve	<p>Provide cleared megawatt value when dispatched during a Synchronized Reserve Event within ten (10) minutes, and to be capable of maintaining that output for the entire event, or thirty (30) minutes, whichever is shorter.</p> <p>Two tiers: Tier 1 and Tier 2 Tier 1 - resources are on line following economic dispatch and able to ramp up from their current output in response to a Synchronized Reserve Event, or Demand Resources capable of reducing load within 10 minutes. It is assumed that batteries (as well as other resource types such as nuclear, hydroelectric and wind) are not able to provide Tier 1 Synchronized Reserve, but may ask for an exception by showing they can reliably provide Tier 1 service.</p> <p>Tier 2 - additional capacity that is synchronized to the grid and operating at a point that deviates from economic dispatch to provide additional Synchronized Reserve not available from Tier 1 resources and dispatchable demand-side resources that have controls in place to automatically drop load in response to a signal from PJM.</p>	Operating Agreement, Schedule 1, section 1.7.19A; PJM Manual 11, section 4.2.11
Non-Synchronized Reserves	Used to economically fulfill the total PJM Primary Reserve requirement, which are 10-	Operating Agreement, Schedule 1, section

²⁸ Manual 13, *Emergency Operations*, rev. 59, (Jan. 1, 2016), <http://www.pjm.com/documents/~media/documents/manuals/m13.ashx>.

	<p>minute reserves that can include a combination of Tier 1 and Tier 2 Synchronized Reserves and Non-Synchronized Reserves. The primary performance requirements of Non-Synchronized Reserves – 10 minutes response for a maximum of 30 minutes – is the same as Synchronized Reserves. Demand-side resources, including batteries operating as demand-side resources, are not eligible to provide Non-Synchronized Reserves, as discussed previously.</p>	1.7.19A.01; Manual 11, section 4b.2
Regulation	<p>Capable of receiving the Automatic Generation Control (AGC) signal (i.e. Regulation signal) from PJM and submit the resource’s response back to PJM via telemetry (in a manner determined by PJM, which may vary by resource size).</p> <p>Required to provide a dispatch range of at least twice the amount of Regulation assigned, and the resource must be able to symmetrically provide the total amount of Regulation assigned (a full raise and lower of assigned regulation from set-point).</p> <p>Demand-side resources providing Regulation are required to fulfill the regulation range requirements without injecting energy into the Bulk Electric System (i.e. past the applicable customer meter).</p> <p>Testing is required pursuant to requirements in the PJM Manuals, and all Regulation resources must maintain a 100-hour rolling average performance score of 40% to remain eligible to provide Regulation. A reduction in this average below 40% results in a re-qualification process.</p> <p>Two Regulation signal types: RegA and</p>	<p>Operating Agreement, Schedule 1, section 1.7.18; Manual 11, section 3.2; Manual 12,²⁹ sections 4.4 and 4.5</p> <p>Manual 12, sections 4.5.1, 4.5.5 and 4.5.6</p> <p>Manual 12</p>

²⁹ PJM Manual 12, *Balancing Operations*, rev. 32, (Apr. 28, 2016), <http://pjm.com/~media/documents/manuals/m12.ashx>.

	<p>RegD with Market Sellers of such resources choosing which signal they would like to qualify for (one or both)</p> <p>RegA - signal is a slower ramping signal that requires longer energy duration in order to follow accurately.</p> <p>RegD - signal is a faster ramping signal that dispatches resources (such as batteries and flywheels) in an energy neutral manner over a short period of time.</p>	
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4. What are the bases for these qualification and performance standards (e.g., North American Electric Reliability Corporation (NERC) reliability standards)? Please provide the technical and operational justifications for these qualification and performance standards, with citations if possible.

PJM Answer: The qualification and performance standards for generation and demand-side resources participating in PJM wholesale markets are primarily driven by the need to meet reliability requirements established by NERC, as well as PJM’s mandate to operate efficient wholesale markets. Examples of these requirements, by market, are provided below:

Capacity and Energy

Qualification requirements for capacity resources are largely driven by resource adequacy studies, including the “1 in 10” loss of load expectation (“LOLE”) planning parameter which is used by PJM to establish adequate reserve margins and capacity product availability requirements (i.e. annual vs. sub-annual availability). This standard, NERC BAL-502-RFC-02 states: “The Planning Coordinator shall perform and document a Resource Adequacy analysis annually. The Resource Adequacy analysis shall calculate a planning reserve margin that will

result in the sum of the probabilities for loss of load for the integrated peak hour for all days of each planning year analyzed being equal to 0.1.”³⁰

Performance requirements of Capacity Resources, namely the requirement for availability during system emergency conditions and a must-offer requirement in the Day-ahead and Real-time Energy Markets, are driven by PJM operational considerations for the availability of Capacity Resources to be called upon to deliver energy when they are needed most, as well as ensuring efficient and competitive market outcomes in the energy markets.

Ancillary Services

PJM operates in accordance with NERC Resource and Demand Balancing standards to ensure its capability to utilize reserves to balance resources and demand in real-time and to return interconnection frequency within defined limits following a repairable disturbance. PJM satisfies the NERC BAL standards by maintaining sufficient generating capacity under automatic control to satisfy its frequency regulation obligation as a member of the Eastern Interconnection. NERC establishes definitive measures of control performance. These control performance standards are documented by NERC in numerous BAL standards, and are summarized as follows:³¹

- Continuous Monitoring — Each Balancing Area monitors its control performance on a continuous basis against two standards:

- o Standard One - CPS1 — Over a year, the average of the clock-minute averages of a Balancing Area’s ACE divided by minus 10 B (where B is Balancing Area frequency bias) times the corresponding clock-minute averages of the Interconnection’s frequency error must be less than a specific limit. This limit, ‘ ϵ ’, is a constant derived from a targeted frequency bound (limit) that is reviewed and set, as necessary, by NERC.

³⁰ See e.g. NERC, BAL-502-RFC-02, available at <http://www.nerc.com/files/BAL-502-RFC-02.pdf>.

³¹ See Manual 12, section 3.1.1.

o Standard Two - CPS2 — The average ACE for each of the six ten-minute periods during the hour (i.e., for the ten-minute periods ending at 10, 20, 30, 40, 50, and 60 minutes past the hour) must be within specific limits, referred to as L10.

- Disturbance Conditions — In addition to CPS1 and CPS2, the Disturbance Control Standard (DCS) as presented in BAL-002-0, “Disturbance Control Performance,” is used by each Balancing Area to monitor control performance during recovery from disturbance conditions. The DCS states that ACE must return either to zero or to its pre-disturbance level within fifteen minutes following the start of the disturbance.

For Synchronized and Non-Synchronized Reserves, the PJM RTO Reserve Zone is defined as that amount of 10-minute reserve that must be synchronized to the grid. The Synchronized Reserve requirement is defined as the greater of the ReliabilityFirst Corporation (“RFC”) imposed minimum requirement or the largest contingency on the system. NERC standards may impose greater requirements for synchronized reserve following Disturbance Control Standard (DCS) violations. Any such impositions would be incorporated as an increase to the overall control zone synchronized reserve requirement.³²

The Day-Ahead Scheduling Reserve Requirement adheres to the requirements for Day-Ahead Scheduling Reserve (30 minute) defined by RFC and all applicable reliability councils for areas within the PJM Region.³³

³² See, e.g., Manual 11, section 4.2.2.

³³ See *id.*, section 11.1.

Bid Parameters for Electric Storage Resources

- 1. What are the required bid parameters for each defined resource type to sell in the capacity, energy and ancillary service markets? Are there additional bid parameters that each defined resource type may submit? Are there any bid parameters unique to electric storage resources in each market?**

PJM Answer: There are no bid parameters for Sell Offers in the RPM Auctions. However, bid parameters applicable to Capacity Storage Resources that subsequently bid into the PJM energy markets are Start-up Time, Notification Time and Minimum Down Time.³⁴

In order to participate in PJM's energy markets, all Market Sellers must submit the following parameters for all types of resources: Economic Minimum, Economic Maximum, default status (i.e. whether the resource self-scheduled or being dispatched by PJM). Market Sellers of pumped storage resources offering into PJM's energy markets may elect to either 1) self-schedule their unit (in which case they must specify the foregoing parameters in their offer), or 2) have their unit dispatched by PJM pursuant to the pumped storage optimization tool. If a Market Seller of a pumped storage resource elects the latter option, it must specify the following parameters: Initial Storage, Final Storage, Maximum Storage, Minimum Storage, Pumping efficiency factor, Minimum/Maximum generating and pumping limits.³⁵

Other than the offered amount, there are no bid parameters for electric storage resources that are offered to provide ancillary services in PJM, *per se*. However, Market Sellers of resources providing Regulation must demonstrate that their resource is capable of providing a given amount of Regulation by complying with the testing requirements of Manual 12, sections 4.4 and 4.5. Notably, these guidelines require such Market Sellers to offer in a minimum of 0.1

³⁴ See Operating Agreement, Schedule 1, section 6.6(f). For further information on parameter limited schedules for cost-based offers and market-based offers for all resource types, including rules related to how and when they apply, see Operating Agreement, Schedule 1, section 6.6 and PJM Manual 11, sections 2.3.3. and 2.3.4.

³⁵ See Manual 11, Attachment B.

megawatts of Regulation, and the ability for the Market Seller's resource to follow PJM's symmetric Regulation signal. Currently, all types of electric storage resources are eligible to provide Regulation to PJM.

Similarly, Market Sellers of resources that offer Synchronized Reserve must comply with the requirements of Manual 11, sections 4.2.1, 4.2.11 and 4.2.12. Importantly, such resources (as well as those providing Non-Synchronized Reserve) must specify a certain megawatt level that they intend to offer as Synchronized Reserve, must be able to achieve this level of reserves within 10 minutes, and must be able maintain the reserve level for either 30 minutes or the duration of the Synchronized Reserve Event, whichever is shorter.

Distribution-Connected and Aggregated Electric Storage Resources

- 1. Are there opportunities for electric storage resources connected to the distribution system, or a subsystem thereof, to participate in the capacity, energy, and ancillary service markets? If so, please describe those opportunities (i.e., in which markets, as what type of resource, and subject to what tariff provisions may such electric storage resources participate?).**

PJM Answer: As described previously, there are ample opportunities for electric storage resources that are connected to the distribution system, or a subsystem thereof, to participate in the PJM wholesale markets provided they can adhere to the markets' applicable requirements. Today, electric storage resources connected to the distribution system overwhelmingly participate in PJM's ancillary services markets, and in particular the Regulation market, both as generation and demand-side resources. These resources provide Regulation as demand-side resources by modifying customers' load behind a customer meter, following PJM's Regulation signal, and do not inject power past the customer meter.³⁶ Electric storage resources are also eligible to participate as generation resources when providing Regulation (and any other

³⁶ See note 9, *supra*.

ancillary services) by injecting power past the applicable customer meter. However in order to provide such service, they are required to come through the previously described interconnection process.

- 2. Are there opportunities for aggregated electric storage resources to participate in the capacity, energy, and ancillary service markets? If so, please describe those opportunities (i.e., in which markets, as what type of resource, and subject to what tariff provisions may such electric storage resources participate?).**

PJM Answer: There are opportunities for aggregated electric storage resources to participate in RPM and PJM's ancillary services markets. In RPM, demand-side resources, including those that provide load reductions by utilizing electric storage resources, can be aggregated by a Market Seller in order to provide load reductions.³⁷ PJM currently has approximately 0.8 MW of demand-side resources that provide load reductions utilizing battery technology.

Moreover, with the recent implementation of PJM's Capacity Performance proposal, Capacity Market Sellers of storage resources are eligible to aggregate with other storage resources, as well as Intermittent Resources, Demand Resources Energy Efficiency Resources, and Environmentally-Limited Resources to provide generation capacity.³⁸

In PJM's Regulation market, Market Sellers of electric storage resources, like all other types of resources, may elect to be part of a performance group for the purpose of aggregating their performance score with other resources, and improving their overall performance score (and consequently, how much the Market Seller can be paid for providing Regulation). While this is not the same type of aggregation that is allowed in RPM, it is a form of aggregation, and

³⁷ See Tariff, Attachment DD, sections 11 and 11A.

³⁸ See Tariff, Attachment DD, section 5.6.1(h).

the rules related to becoming part of a performance group are specified in Manual 12, section 4.5.7.

Market Sellers of electric storage resources, like all resources, cannot aggregate megawatts from resources in PJM's energy market if the resources are at different locations and offer their energy in as a single resource. This is due to the fact that PJM would dispatch the aggregated resource as a single asset, and if the physical resources that compose the aggregate resource have different impacts on transmission constraints, allowing those resources to aggregate could have negative impacts on reliability. However, there are some opportunities for electric storage resources to be aggregated and offered in PJM's energy market. For example, if multiple batteries were located behind a single node, and all batteries were owned directly or indirectly by the same entity, these batteries would be eligible to have their energy output aggregated and offered into PJM's energy market. While there are not any Market Sellers with batteries that utilize this option in PJM today, they are not prohibited by PJM's market rules.

- 3. If electric storage resources are providing services to the wholesale market and to another entity (e.g., a distribution utility), and if there are tariff provisions that permit or penalize potential deviation from the RTO/ISO economic dispatch signal in that circumstance, please provide them.**

PJM Answer: Market Sellers of electric storage resources are eligible to provide service to the wholesale market and to another entity (e.g., under a bilateral contract with a distribution utility). However, for any portion of the resource's output that is committed to the wholesale market, the electric storage resource must follow PJM's dispatch signal or be subject to the generally applicable rules that pertain to resources that deviate from PJM's dispatch instructions. In PJM's energy market, Market Sellers are subject to monetary penalties for deviating from

PJM's dispatch and/or not being eligible for make-whole payments.³⁹ In RPM, the Market Seller of an electric storage resource is required to follow PJM's dispatch instructions, or will be subject to Non-Performance Charges which, for Capacity Performance Resources could total more than the capacity revenues it receives for a Delivery Year.⁴⁰ Market Sellers of electric storage resources that deviate from PJM's instructions in PJM's Regulation market will be negatively impacted on their performance score, and consequently will be paid less for the Regulation they provide.⁴¹ Similarly, electric storage resources that do not provide the amount of Synchronized Reserve that they commit to providing will be penalized per the rules of that market.⁴²

When Electric Storage Resources are Receiving Electricity

1. **Under what circumstances would an electric storage resource submit bids to buy energy in the wholesale markets (i.e., when would an electric storage resource be a wholesale buyer under PJM's market rules/tariff)?**

PJM Answer: PJM Market Sellers of electric storage resources do not submit bids to buy energy in the wholesale markets.

2. **If electric storage resources must bid to buy electricity from PJM's market, what are the minimum load obligations, minimum bid sizes, or other minimum parameters to buy electricity in each market? For example, is there a minimum consumption limit to be eligible to pay the locational marginal price (LMP) for energy or a minimum charging duration that must be met to be a wholesale buyer?**

PJM Answer: Not applicable.

³⁹ See e.g. Operating Agreement, Schedule 1, section 3.2.3.

⁴⁰ See Tariff, Attachment DD, section 10A.

⁴¹ See Manual 12, section 4.5.

⁴² See e.g. Manual 11, section 4b.

3. **Do electric storage resources participating in the capacity, energy, and ancillary service markets always pay LMP for the electricity they receive, and if not, under what circumstances do they not?**

PJM Answer: No, Market Sellers of electric storage resources do not always pay LMP for the electricity provided to the resource. If the electric storage resource is taking power off the system solely to inject into PJM's energy or ancillary services markets at a later time (i.e., it is used solely in the wholesale markets), then such resource is considered an Energy Storage Resource and would pay the wholesale LMP for such energy. If, however, the resource also operates outside of the PJM markets, such as an electric vehicle charging station or a battery configuring its state of charge for purposes other than providing a wholesale service, then it would pay the retail rate of the Load Serving Entity providing the power it uses while in charging mode.

4. **Are there circumstances when an electric storage resource receives energy but is not considered load and therefore does not pay for its consumption? For example, if an electric storage resource provides frequency regulation and is asked to receive energy (i.e., provide regulation down) is that considered consumption or provision of frequency regulation, and is the resource charged a wholesale rate for this action?**

PJM Answer: A Market Seller of an electric storage resource always pays for the *energy* it consumes (MWh). However, it may also receive a payment from PJM for a service being provided when receiving electricity (i.e. "charge mode"). This is the case when the electric storage resource charges but is providing Regulation by doing so. In this case, the service being paid for is the capability to consume energy, paid on a \$/MW basis. The energy throughput of the resource while providing the Regulation service is settled at LMP (i.e. charged to the Market Seller).

Potential Changes to the Rules Affecting Electric Storage Resources

- 1. Are there any forthcoming or pending proposals or on-going stakeholder processes that could change or contemplate changing the rules by which electric storage resources can sell into PJM’s markets? If so, please describe the proposals or stakeholder processes briefly and provide citations to any relevant websites or public documents.**
- 2. Are there any forthcoming or pending proposals or on-going stakeholder processes that could change or are contemplating changing the rules by which electric storage resources buy electricity from PJM’s market? If so, please describe the proposals or stakeholder processes briefly, and provide citations to any relevant websites or public documents.**

PJM Answer: There are currently no pending proposals specifically addressing rules related to how Market Sellers of electric storage resources can buy or sell power in the PJM wholesale markets. However, because PJM’s rules for participating in its markets are generally written to be technology neutral, technically every pending filing before the Commission related to PJM’s market rules could impact the manner in which electric storage resources participate in the PJM wholesale markets. In particular, PJM highlights its hourly offer proposal as an example of a pending filing that, if accepted by the Commission, will enable Market Sellers of electric storage resources to more easily participate in PJM’s energy market for the reasons stated therein.⁴³

With regard to stakeholder initiatives, PJM recently commenced a special session of its Markets and Reliability Committee (“MRC”) focused on distributed resources in PJM, including electric storage resources. Specifically, the MRC special session meetings will focus on the topics of distributed resources interconnecting to the transmission system and participating in the PJM wholesale markets, and educating PJM members on these issues. Once education is complete, specific items deemed appropriate for PJM to address will be designated to a new sub-

⁴³ See Docket No. ER16-372-000, Docket No. EL15-73-000.

group of the MRC, and/or to other PJM Committees as determined in the special sessions.⁴⁴ Further, PJM's Seasonal Capacity Resource Senior Task Force is currently exploring whether revisions may be needed to PJM's market rules to better realize the ability of certain resources to provide capacity that are only available on a seasonal, as opposed to annual, basis, including electric storage resources. Last, as part of the Regulation Market Issues Senior Task Force, PJM is currently discussing with its stakeholders long term design changes to its Regulation Market that include the amount of RegD resources capable of providing Regulation in PJM at any given time, as well as the performance measurement methodology and compensation.

Respectfully submitted,



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⁴⁴ See PJM, Issue Charge: Distributed Resources in PJM, available at <http://pjm.com/~media/committees-groups/committees/mrc/20160418-special/20160418-item-02a-distributed-battery-storage-issue-charge-revised-1.-d.-28.-d.-16-clean.ashx>.

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that I have this day caused to be served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Audubon, PA, this 16th day of May, 2016.

By: 
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