Electric Storage Resource Participation Model (Additional Hybrid Resource Questions Addressed)

Version: February 6, 2019

General:

Q What is in Order 841? What are the directives to PJM?

A Please see this presentation: http://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special-electric/20180510-item-02a-energy-storage-order-presentation.ashx

And this word document outlining the directives: http://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special-electric/20180510-item-02b-ferc-directives-841.ashx

The order can be found here: http://pjm.com/-/media/documents/ferc/orders/2018/20180215-rm16-23-000.ashx

Here are the two filings made by PJM December 3, 2018:

https://pjm.com/directory/etariff/FercDockets/3872/20181203-er19-469-000%20.pdf

https://pjm.com/directory/etariff/FercDockets/3871/20181203-er19-462-000.pdf

Here is PJM issue tracking for this issue: https://www.pjm.com/committees-and-groups/issue-tracking/issue-tracking-details.aspx?Issue=%7b736CAC88-9404-4421-B178-BD392366098F%7d

Q What is an electric storage resource?

A As stated in FERC Order No. 841, the Commission defined an electric storage resource as "a resource capable of receiving electric energy from the grid and storing it for later injection of electricity back to the grid." This includes ESRs located on the interstate transmission system, on a distribution system, or behind the meter, regardless of their storage medium (e.g., batteries, flywheels, compressed air and pumped-hydro). PJM is tasked with defining the qualifications of what resources can use the ESR participation model in the FERC Order 841 compliance filing.

PJM's proposal adopts the FERC definition.

Q What are the current gaps associated with Order 841?

A Please see educational presentation: http://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special-electric/20180510-item-03a-esr-841-status-quo-review.ashx

Q **Where are the current rules for Electric Storage Resources?**

A Please see compiled ESR rules here: http://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special-electric/20180510-item-03b-all-manual-citing-of-esr-status-quo.ashx

Q **When will Order 841 be discussed in the stakeholder process?**

A Please see work plan here: http://www.pjm.com/-/media/committees-groups/committees/mic/20180510-special-electric/20180510-item-03b-all-manual-citing-of-esr-status-quo.ashx

Additionally, all stakeholder discussions can be found in issue tracking and a presentation on the manual changes can be found here: https://www.pjm.com/-/media/committees-groups/committees/mic/20190109/20190109-item-04-energy-storage-participation-model.ashx

Q **How does PJM plan to comply with FERC Order 841?**

A PJM submitted 2 filings on December 3, 2018:

https://pjm.com/directory/etariff/FercDockets/3872/20181203-er19-469-000%20.pdf

https://pjm.com/directory/etariff/FercDockets/3871/20181203-er19-462-000.pdf

Feedback sessions to get thoughts and recommendations from stakeholders were scheduled as special sessions of the Market Implementation Committee: Electric Storage Participation – FERC Order 841 on May 10, June 14, June 27, August 3 and September 14, 2018. Meeting materials can be found here: http://www.pjm.com/committees-and-groups/committees/mic.aspx. Additionally, stakeholders can email their questions or feedback to esr@pjm.com

Energy Market: General

Q **What changes will be made to enable ESR to offer both positive and negative MW?**

A Under the PJM Proposal, three modes of operation will be available for ESR offers: Continuous Operation, Charge, and Discharge modes. Both Charge Mode and Continuous Operation modes will allow submission of negative MW bids

Q **Does PJM optimize a resource's service as energy, reserve, regulation, etc.? Over what time horizon?**

A Energy, reserves, and regulation are all co-optimized.

a) The Ancillary Services Optimizer clears and assigns regulation and inflexible reserve resources 60-minutes prior to target time and looks ahead 60-minutes beyond target time

b) Intermediate-Term Security Economic Dispatch (SCED) solves 30 minutes prior to target time for demand, generator loading strategy, Demand Response, CT commitment, and inflexible synchronized reserve recommendations. It looks ahead 15, 30, 75, and 120 minutes beyond target time.

c) Real-time SCED runs the final dispatch contour and assigns non-synchronized reserve and flexible synchronized reserve resources. It solves 10 minutes prior to the target time and looks ahead 10 minutes beyond the target time.

Q Is it acceptable to offer only the minimum MWh associated with one cycle to avoid an infeasible schedule?

A Per status quo, capacity storage resources will maintain their ability to self-schedule to meet their day-ahead market must-offer requirement. However, if PJM manually dispatched the unit to discharge, or a Performance Assessment Interval was assessed the ESR would be required to provide requested MW.

Q What is the Minimum Run Time for solar and wind resources?

A There is no minimum run time for wind and solar because they self-schedule.

Q Currently, can electric storage self-schedule in day-ahead and real-time?

A All electric storage is currently eligible to self-schedule into both the DA and RT Energy Markets by operating as fixed non-dispatchable price-taking resources. A resource cannot currently enter negative incremental MW segments in the offer curve in Market Gateway. Currently pumped storage reflects pumping (charging) by entering negative eco min and eco max values but not a negative offer curve. In the PJM proposal, ESRs can self-schedule both positive and negative MW in day-ahead and real-time.

However, in the PJM proposal, ESRs will be able to offer a price and costs curve with negative MW.

Q Can self-scheduled electric storage resources alter their schedules for use in the RT Energy Market only on an hour-to-hour basis and only up to 65 minutes prior to the start of the operating hour?

A Self-scheduled non-dispatchable resources need to provide 20 minute notice for a change in commitment status (Manual 11 Section 2.3.3) and, if a Capacity resource, must follow any instructions from PJM dispatchers. The resource will incur deviation charges for not following any Day Ahead schedule. The provisions of Manual 11 Section 9.1 generally apply to changes in offers for resources that are economically committed and dispatchable in real time. Currently, all non-pumped storage resources are eligible to enter hourly-differentiated offers in DA and Rebid periods. Only resources that opt-in to Intraday Offers can alter their energy offers up to 65 minutes before the operating hour. However, resources cannot increase their price offer in RT if a unit has a DA schedule.

In the PJM proposal, ESRs can opt into intra-day offers but will not have any additional ability to update schedules. However, through the modifications of parameters like maximum charge and maximum discharge in both day-ahead and real-time ESRs will be able to manage their state of charge.

Q **Instead of self-scheduling, can storage participate by submitting price-based offers into DA and RT Energy Markets and self-managing state of charge?**

A Pumped hydro cannot do this under the status quo. Other ESRs could theoretically submit price-based offers for positive MW only (discharging). However, our interpretation of Order 841 is that we must make such a mechanism available to ESRs.

In the PJM Proposal ESRs can offer price-based offers with the same limitations as current traditional resources, and rules for intra-day offers. However, ESRs will be able to manage their own state of charge via different operating modes and charge/discharge limits.

Q **Would storage have to submit cost based offers?**

A Yes, storage in the ESR participation model would need to submit cost based offers. Cost based offers are required in energy and ancillary services markets. A $0 cost-based offer is generally acceptable with minimal supporting documentation. Currently the rules for cost-based offers are listed in PJM Manual 15: Cost development guidelines. Battery and flywheels currently have a $0 cost offer. Price-based offers can be developed at the discretion of the ESR owner/market.

Fuel Cost policies will be required for energy storage resources, and if the PJM Cost Development Guidelines: Manual 15 does not account for the costs the resource owner can put appropriate calculation language in the Fuel Cost Policy.

PJM intends to receive feedback on cost based offers for batteries, flywheels and hybrids at the February 2019 MIC.

Q **Will ESR be able to reflect changing opportunity costs during the course of the day?**

A ESR that opt-in to use the Intraday Offer (IDO) feature will be eligible to provide hourly differentiated for market- and cost-based offers in the real-time energy market. IDO education can be found here: https://www.pjm.com/-/media/etools/emkt/intraday-offers-education-sept-2017-session.ashx?la=en

Energy Market: Day-Ahead

Q How do demand bids, load response, virtual bidding and pumped storage currently work in the Day Ahead Energy Market?

A Please see Keyur Patel and Stefan Starkov's presentation here: http://www.pjm.com/-/media/committees-groups/committees/mic/20180614-special/20180614-item-04-demand-virtual-bidding-pump-storage-in-da-market.ashx

Q What parameters are required for a Day Ahead (DA) offer?

A Parameters for all resources bidding into the DA market are located in Manual 11: http://www.pjm.com/~/media/documents/manuals/m11.ashx . Currently, pumped storage hydro can self-schedule or bid into the DA Market using the hydro optimizer. The parameters for the optimizer are listed in Attachment B of Manual 11. They include: initial storage level, final storage level, maximum storage level, minimum storage level, pumping efficiency factor and minimum/maximum generating and pumping limits.

In the PJM proposal, ESRs will need to offer different parameters into the Day-Ahead Market. The parameters that will be required are dependent upon the operational mode of the resource.

MODE	Max Charge Limit	Max Discharge Limit	Min Discharge Limit	Min Charge Limit	Discharge Ramp Rate	Charge Ramp Rate
Continuous Mode	Entered into DA and updated in RT	Entered into DA and updated in RT				
Charge Mode	Entered into DA and updated in RT			Entered into DA and updated in RT		Entered into markets gateway for DA window
Discharge Mode		Entered into DA and updated in RT	Entered into DA and updated in RT		Entered into markets gateway for DA window	
Unavailable						

Additionally, FERC Order 841 suggested additional parameters that PJM would require to take in for informational purposes.

State of Charge & Max/Min State of Charge – This is not required for operation of the PJM proposal as the resource can update charge and discharge limits in day-ahead and real-time.

Minimum/Maximum Charge/run Time – Minimum/Maximum charge/run are all commitment parameters that are being handled by the resource.

Q Are ESR excluded from Day Ahead Scheduling Reserve (DASR)?

A No, ESRs are eligible to provide DASR by exception historically this has consisted of pumped hydro. Details can be found in Manual 11, Section 11: http://www.pjm.com/~/media/documents/manuals/m11.ashx. If an energy storage resource would like to be included in calculation of DASR the request would need to be made per M11.

Q Given PJM's recent move to 5-minute settlements, can storage schedule at a 5-minute granularity?

A The PJM Day-Ahead Market is made up of hourly schedules. However, in real time ESRs will be able to update their charge/discharge limits in real time.

Q Does PJM post a pre-DA price forecast that can be used by self-scheduled resources in the DA Energy Market? For example, does PJM post the implied prices from day two of the prior day's DA Energy Market run?

A No.

Q Can storage deviate in real time from their DA Energy Market schedule and settle ex-post? If so, would deviations just be paid/charged at the RT Price or would there be any additional charges or penalties?

A Yes, an electric storage resource may deviate from their DA schedule, and if deviating following PJM dispatch will not receive deviation charges. However, if deviating from PJM dispatch, deviation charges may be incurred. All resources must provide 20 minute's notice for a change in commitment status. Deviations from the DA schedule can incur Balancing Operating Reserves charges, in addition to balancing settlement at the RT Price.

Additional information can be found here: https://www.pjm.com/-/media/training/nerc-certifications/markets-exam-materials/advanced/operating-reserves.ashx?la=en

Regulation and Reserves

Q If an ESR is electrically connected to the grid and available for dispatch, why would it need an energy schedule to be considered for providing regulation/reserves?

A Currently resources can enter the Regulation Market as "regulation only" resources and do not have to provide an energy schedule. The PJM proposal includes the ability to offer synchronous reserves and regulation without an energy offer. However, a lost opportunity cost cannot be calculated without an energy offer.

Q Can an ESR provide regulation with only part of its capability, i.e. with a non-zero basepoint?

A Yes, ESRs with an energy schedule are able to operate at a non-zero basepoint.

Q Does PJM's energy-neutral regulation signal account for round-trip charge/discharge losses to maintain the ESR's charge level?

A PJM does not currently send out an energy neutral regulation signal. Regulation D provides the residual signal that would best control RTO ACE to zero, as opposed to forcibly converging the signal back to zero within a fixed period of time. The Regulation A signal is offset to reduce accumulation in the Regulation D signal, resulting in a conditionally neutral Regulation D signal. For more information on the current regulation signal, please refer to the following link: http://pjm.com/-/media/committees-groups/task-forces/rmistf/postings/regulation-market-whitepaper.ashx?la=en

The accumulation of historical Regulation D deployment does not account for round-trip charge/discharge losses, as efficiency ratios would be resource-specific. A resource can account for its efficiency losses by offsetting the regulation base point from 0 MW.

Q Can I regulate in one (5-minute) interval and switch to energy or reserve service in the next?

A A unit that is cleared for regulation should not have a reserve requirement. A unit that is cleared for regulation can still respond to the sync event and get paid for MW above and beyond their regulation assignment.

Regulation, although settled on 5 minute basis is still cleared/committed as an hourly product. Regulation is cleared on an hourly basis and performance will only be scored within an hour for intervals with at least 15 contiguous minutes of sufficient data (Manual 12 Section 4.5.9). Eligible resources providing regulation at the initiation of a synchronized reserve event will be compensated for Tier 1 response for MWs produced beyond their regulation commitment (Manual 11 Section 4.2.10).

Q What are the types of reserves offered by energy storage resources?

A The types of reserves are dependent on the resource type and participation model.

Energy Market Participation	Resource Type	SR Tier 1	SR Tier 2 Self	SR Tier 2 Pool	NSR (Offline)
Energy Resource (has Offer)	Traditional Pumped Storage	Default no, enable upon request	Yes, status quo	Yes, special LOC rules if backed down	When offline (MW == 0)

	ESR Proposed	Default no, enable upon request	Yes	Yes, traditional rules if backed down	No, always synchronized
Non-Energy Resource	Traditional Battery	No	Yes, status quo	Yes, but LOC = 0	No

Q What will be the process to mark as 'Non-Energy Resource'? What will be the process and frequency for changing that designation?

A The PJM proposal plans to expand the non-energy option from regulation to synchronized reserves. Non-energy option currently allows resources offer no energy schedule but still supply regulation. ESRs will be able to participate with or without an energy schedule but will not receive lost opportunity cost unless there is an energy schedule.

The process for this designation has not be developed yet, but the process will be outlined in the PJM Manuals and require an email to PJM. Non-Energy Resource should also be specified in an approved Fuel Cost Policy. This designation will be available for update once a capacity delivery year. Non-Energy resource option will not be available for capacity resources.

Q What is the process and frequency for changing that designation and how does it affect regulation LOC payments?

A Regulation Lost Opportunity Cost (Reg LOC) is the difference in net compensation from the Energy Market between what a resource received when providing Regulation and what it would have received for providing energy only. If the Non-Energy Resource (NER) flag is true, the resource's incremental offer is ignored in the regulation LOC calculation. If the NER flag is false, then the unit must have an energy incremental offer, and the incremental will be used to calculate a Reg LOC for the rank price. If the NER flag is false and the unit does not provide an incremental, then the unit is made ineligible for regulation service in the engine. The NER designation can be changed on a market day boundary, today manually.

State of Charge:

Q If PJM is not managing state of charge, under what circumstances and for what specific purposes would state of charge telemetry be required?

A The PJM Proposal only requires ESRs that are already providing telemetered MW to include telemetered state of charge. The state of charge will be used for informational purposes only. Telemetry will only be required per the current rules.

Telemetry is required per Manual 14D:

- Generators participating in the PJM market as capacity resources
- Generators 10 MW (Maximum Facility Output) or larger.
- Generators greater than 1 MW (Maximum Facility Output) and connected at a bus operating at 50 kV or greater
- Solar parks 3 MW (Maximum Facility Output) or greater
- Distributed generators (such as, the treatment of many units dispersed over a wide area as one aggregated unit) modeled less than 10 MW (Maximum Facility Output)
- Generators that are not required to supply real-time (two-second scan) metering will not be eligible to set real-time LMP. .

Q Does PJM provide sufficient tools to enable self-management of state of charge when operating in energy markets? For example: spread bidding, rapid changes to bid/offer prices and bid/offer levels.

A PJM currently allows any resource type to participate in the energy market as self-scheduled resources, where the participant makes the decision of when to start and operate. ESR that opt-in to use the Intraday Offer (IDO) feature may update energy offers in the real-time energy market up to 65 minutes before the operating hour. The PJM proposal will allow for incremental energy offers with "negative MW" segments. This will allow bids to consume energy to model strike price levels for consumption.

Q Who provides state of charge estimate for hour ending midnight to be entered as a starting point for the DA algorithm?

A Under the PJM Proposal, state of charge will not be managed by PJM.

Other

Q What is reactive and how is it compensated? What are reserves in real time and how are they compensated?

A Please see Scott Benner's presentation here: http://www.pjm.com/-/media/committees-groups/committees/mic/20180614-special/20180614-item-05-esr-reactive-and-reserves.ashx

Q What is status quo for interconnection behind the customer's load meter?

A Please see Scott Baker's presentation on this issue starting on slide 3: http://www.pjm.com/-/media/committees-groups/committees/mic/20180614-special/20180614-item-03-esr-review-of-interconnection.ashx

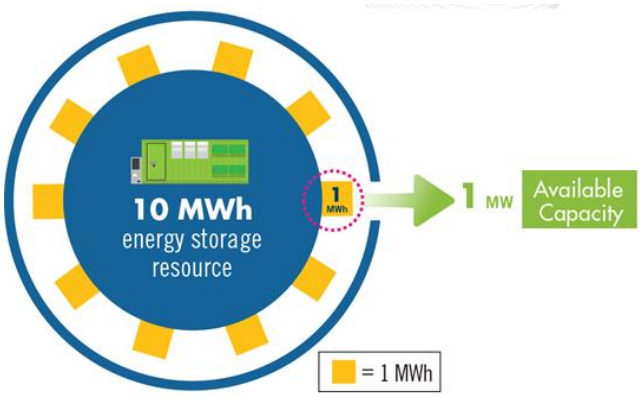
Q **Participation rules for regulation are clearly specified, but in practice how can storage participate in PJM's synchronized and non-synchronized reserve markets?**

A Units can offer or self-schedule in to the PJM Tier 2 Synchronous Reserve Market similar to Regulation. PJM will only clear Tier 2 reserves if there are not enough Tier 1 reserves on the system. Tier 1 is calculated as the available headroom of resources that are online for Energy. All Electric Storage Resources are excluded from Tier 2 synchronized reserves unless an exception is requested. To provide synchronized reserves, a resource must be able to provide the assigned MWs in 10 minutes and be able to deliver those MW for up to 30 minutes.

Pumped-Hydro resources are eligible for non-synchronized reserves because they can be online in 10 minutes. Generation resources that are not available to provide energy are no considered for non-synchronized reserves. There are no offers into Non-Synchronous Reserve and assignment is automatically designated in real-time to eligible resources.

Q **Is there a minimum duration in the capacity market for storage?**

A Currently an ESR must be available spanning a 24 hour block with a minimum 10 hour run time requirement available by adjustment (per PJM Manual 21). Currently PJM derates the unit by modifying the amount of CIRs that the unit is able to produce over the ten hour run time requirement. Additionally, ESRs will need to submit outage tickets when unavailable for non-state-of-charge reasons.



Q **Will PJM treat all storage exactly the same as generators when assessing Non-Performance Charges and Bonus Performance Credits?**

A Yes, we do not expect any exceptions to Performance Assessment Interval.

Parking lot

Reactive Requirements

Cost Offers – Cost offers will be discussed at the February 2019 Market Implementation Committee

Hybrid FAQs

Q What are Hybrid storage resources?

A There is currently no official definition of "hybrid resources" however PJM has identified different types of hybrid resources for discussion: collocated Solar/Storage hybrid, gas/storage, wind storage – for each there is a distinction between the categories dependent on whether they can/cannot charge from the grid.

Q Can intermittent + storage hybrids that charge off the grid use their storage to mitigate non-performance assessment risk?

A Yes.

Q Do the tariff revisions proposed for Order 841 address participation of hybrid solar storage and combustion turbine (gas) + storage units?

A As filed, PJM's tariff revisions proposed for Order 841 do not directly address the participation of hybrid storage units. However, Energy Storage is defined as resources that take from the grid for later injection – and conceivably a hybrid could qualify.

Q Does PJM impose any limitations on the participation of solar storage facilities in DA and RT energy markets?

A No.

Q Are solar + storage facilities eligible to participate in the energy market via self-scheduling and submitting an offer curve?

A Yes, however all resources need to have a cost offer in case of mitigation

Q Will PJM manage the state of charge (SOC) of solar and storage hybrid facilities?

A No.

Q Are participation rules different for DC-coupled vs AC-coupled systems?

A PJM strives to treat all resources in non-discriminatory, technology neutral fashion. It has not been determined if different participation schemes are required for DC- vs AC-coupled in the various markets that PJM administers.

Q **What are PJM's metering requirements for solar + storage facilities? Does participation depend on how the facility is metered, e.g. one meter for the coupled system vs separately metered solar and storage?**

A Metering requirements are being finalized, but at this time, PJM will require additional real-time metering for AC- and DC- coupled devices to calculate market compliance by technology type. Because Intermittent Capacity and Capacity Storage Resources have different market rules for calculating Capacity Interconnection Rights (CIR), PJM will require metering to support the demonstration of compliance to each CIR calculation method.

Q **Are combustion turbine + storage hybrid facilities eligible to participate via self-scheduling and submitting an offer curve?**

A Yes, hybrid CT facilities are currently eligible to participate via self-scheduling, and submit a cost-based offer curve that represents the facility's operating costs. PJM intends to discuss Manual 15 Cost Offer Development changes throughout this spring to support Hybrid Fuel Cost Policy and the calculation of cost-based offers for mitigation.

Q **Will PJM manage the dispatch and SOC of hybrid gas + storage facilities for DA and RT energy?**

A No

Q **What are PJM's metering requirements for CT + storage facilities and does participation depend on how the facility is metered?**

A TBD

Q **Is a solar + storage resource eligible to participate in the regulation market as either a RegA or RegD resource?**

A Yes

Q **Are combustion turbine + storage facilities eligible to participate in the regulation market as either a RegA or RegD resource?**

A Yes, as long as they meet applicable requirements.

Q **Is solar + storage eligible to participate in synchronized and non-synchronized reserves?**

Q **Yes**

Q **If so, what are the participation rules and do they differ from the stand-alone storage participation rules outlined in Order 841?**

A So long as the storage component of the hybrid resource meets the definition of Energy Storage Resource as PJM proposed in its Order 841 compliance filing, then the reserve market participation rules for the hybrid resource will be the same as PJM proposed in its Order 841 compliance filing for stand-along storage.

Q **Are combustion turbine + storage facilities eligible to participate in synchronized and non-synchronized reserves?**

A Yes

Q **If a storage hybrid CT can increase the output achievable by the CT + storage facility in 10 minutes, can it increase the facility's synchronized reserve capability?**

A Yes. PJM allows a resource to specify a "synchronized reserve maximum limit" (Spin Max) which can be used in the reserve calculation. The participant would be responsible to enter a value that best represents the capability for deployment, with a compliance obligation to deploy for up to 30 minutes.

Q **If a CT has a 15-minute startup time without storage (and therefore is ineligible to sell non-synchronized reserves) but an effective startup time of less than 10 minutes with storage, is the hybrid unit eligible to sell non-synchronized reserves?**

A No. However, PJM would consider the resource eligible for synchronized reserves. PJM's proposal for Order 841 defines an ESR as "always synchronized", because the inverter technology allows the battery to inject to the grid in cycles, faster than what can be metered. When the hybrid resource has stored charge to allow for a 10 minute time to start, Manual 11 requires the resource to "must-offer" its reserve capability. PJM would expect an offer of the MW available by the hybrid at the 10-minute mark, which would be a function of the energy supplied by the battery, limited by the inverter size. The CT portion of the hybrid could be used to support the 30-minute deployment obligation for compliance. If a 15-minute CT in a hybrid configuration does not have the stored charge to allow a 10 minute time to start, then the resource is not eligible for either synchronized or non-synchronized reserves.

Q **Is solar + storage eligible to participate in RPM? If so, how does PJM calculate UCAP?**

A Yes, hybrid resources are eligible to participate in RPM as a single resource representing the combination of technology types. Because the determination of CIRs for Capacity Storage Resources and Intermittent Resources differ due to differences in, for instance, the dispatchability of such resources. PJM will calculate the net CIR value as the sum of CIR of the component technology types. If the solar + storage hybrid asks to participate in RPM, PJM would require sub-metering of the storage separate from the solar component. If the storage portion can charge from the grid, PJM will calculate UCAP as ([Storage stockpile energy in MWH divided by 10 hours] x EFORd for the battery portion) plus (ICAP x Capacity Factor [per Manual 21] for the solar portion) for the hybrid resource limited by the total inverter Maximum Facility Output. However if the storage portion is DC-coupled and cannot charge from the grid, no methodology exists to calculate additional CIRs and the level of CIRs would be limited to what is calculated for the intermittent component .

Q **Are combustion turbine + storage hybrid resources eligible to participate in RPM? If so, does PJM calculate UCAP?**

A Yes. Per above, if the battery can charge from the grid, the hybrid net CIR will be calculated from the sum of component CIR by technology type. The storage CIR is calculated from the total storage capability (in MW-hours) over a continuous 10-hour operating period, limited by the inverter maximum output. The CT component CIR is limited by design criteria (nameplate output). PJM will continue to calculate UCAP as the aggregate of ICAP x EFORd, where the EFORd is calculated from the availability of the component equipment. The CT component will be required to submit outages to GADS consistent with a non-hybrid CT. If the battery cannot charge from the grid, no additional CIRs will be awarded for the storage portion of the hybrid.