The Energy Storage Association (ESA) appreciates this opportunity to submit comments on PJM’s Capacity Performance proposal. The ESA fully supports PJM’s goal of enhancing reliability during peak power and extreme weather conditions, and believes that energy storage can play a valuable role in meeting PJM’s objectives.

Adding energy storage to the RPM resource mix will allow PJM to meet its reliability goals at a lower cost and with more flexibility than simply increasing the amount of traditional generation. Storage can directly meet peak demand, especially during double-peaked winter days. Beyond that, storage provides PJM operators the ability to rapidly respond to unit outages, manage system ramp rates, and reduce uplift costs created by the lack of flexibility of other resources on the system. However, PJM proposes to treat storage much as a traditional generator, instead of recognizing its unique operational characteristics and the flexibility it adds to the system. For all of these reasons, the ESA recommends that PJM revisit the storage requirements suggested in the Capacity Performance proposal, and, instead, proceed with rules that recognize storage resources’ full reliability contributions to the system. Such an approach will prove to be both operationally superior and lower cost than PJM’s proposed approach.

**Comment 1: Storage meets all objectives of the Capacity Performance product.**

PJM has listed five objectives for the Capacity Performance product. Modern storage technologies can provide PJM with all of the features stated as goals for Capacity Performance:

- **Fuel security**: The fuel for modern storage is the grid itself. Storage resources will only be deprived of fuel in the event of a transmission outage. Storage resources have zero additional risk of forced outage due to fuel unavailability. Moreover, the performance of modern storage resources is largely unaffected by weather.
energy storage systems have provided reliable service in Alaska since 2003 and are deployed in extreme temperature situations such as powering satellites in space.

- **Enhanced operational performance during peak periods**: Storage enjoys one of the lowest forced outage rates of any resource type. Many advanced energy storage resources are designed to be modular with many independent units running in parallel, an architecture that improves overall system reliability through its inherent redundancy. By comparison, most conventional generation facilities are comprised of a few large units. The “shaft risk”, a capacity resource’s contribution to loss of load probability from the failure of a single unit or piece of equipment, is much lower for storage under the modular architecture. A modular architecture with many parallel units also allows maintenance of those units to be performed in sequence, reducing outage rates and improving the resource’s availability.

- **High availability of generation resources**: Storage is available 24 hours a day, 365 days a year. With zero direct emissions, it is never limited by environmental constraints.

- **Flexible unit operational parameters**: Storage is the most operationally flexible resource in the system, bar none. Most modern storage technologies offer instantaneous start-up, nearly infinite ramp rates, unlimited daily starts and stops, no minimum run time or down time, and a dispatchable range equal to 200% of their ICAP, as shown in the following figure (source: AES Energy Storage). This flexibility not only provides reliability benefits to PJM but reduces uplift costs for ratepayers because storage has no start-up costs in order to provide energy at peak load and storage can charge in the valley loads when other resources must operate at minimum generation output.
Operational diversity: Storage has unique operational characteristics that make it a valuable part of PJM’s resource portfolio. When coordinated with other resource types, storage can effectively allow base load plants to follow load, manage the startup and cycle times of interday assets, avoid or reduce uplift costs associated with the intraday asset class, and increase the flexibility of demand response.

Comment 2: The proposed 16 hour duration requirement is an unnecessary barrier to storage participation in RPM.

PJM has proposed that Capacity Performance resources be required to provide their full ICAP for 16 hours per day for three consecutive days. Most modern energy storage installations are designed with a much higher power to energy ratio than this. The 16 hours/day for three day requirement is a barrier even for storage technologies that typically have lower power to energy ratios, such as pumped hydro. Over the course of three days, a Capacity Performance resource must be able to discharge for 48 hours with only 16 hours for recharging. This limited time for recharging means that most facilities will not be able to fully recharge each day, further reducing capacity value. For example, the 30,931 MWh, 3,003MW Bath County Pumped Storage Station would only have a capacity value of 1,391MW under proposed Capacity Performance rules.

The ESA believes that this dramatically undervalues the contribution modern energy storage can make to system reliability. Modifying PJM’s proposal to more accurately determine the capacity
value of storage will allow emerging technologies to fully participate in RPM without compromising the goals of the Capacity Performance proposal in any way whatsoever.

**Comment 3: Resources with no winter performance risk should be treated as Capacity Performance.**

The motivation for this redesign of RPM are clearly set forth in the first paragraph of PJM’s proposal:

> Last winter’s generator performance—when up to 22 percent of PJM capacity was unavailable due to cold weather-related problems—highlighted a potentially significant reliability issue. PJM’s analysis shows that a comparable rate of generator outages in the winter of 2015/2016, coupled with extremely cold temperatures and expected coal retirements, would likely prevent PJM from meeting its peak load requirements.

Further information provided by PJM has clarified that the January 2014 reliability problems were almost entirely due to natural gas fuel curtailments. For example, at the Capacity Performance meeting on September 11, PJM presented these two charts, showing forced outage rates vs. temperature with and without natural gas curtailments:
These charts make graphically clear what PJM staff reported at that meeting, that once gas curtailments are removed, there is no statistically significant relationship between temperature and forced outage rates.

PJM’s goal appears to be to procure sufficient Capacity Performance resources so that winter peak loads can be completely met using only Capacity Performance resources. From this, it appears that the defining difference between Capacity Performance and other resource types is winter availability. This does not appear to provide a clear reason for placing additional performance requirements on resources that suffer from neither fuel uncertainty nor weather sensitivity. As shown in the graph on page 17 of PJM’s Capacity Performance Proposal, the base capacity product is designed to meet system needs 51 weeks per year. No reason has been given why a non-weather sensitive resource that can be relied on for 51 weeks should abruptly be considered unavailable during the one week of the year. Based on this, the ESA recommends that performance requirements for storage be made identical between the Base and Capacity Performance products.

Since the problems the Capacity Performance proposal addresses stem almost entirely from natural gas fuel supply risk, stakeholders have asked why the proposal creates a new 16 hour
requirement for resources that do not face this risk. In the Capacity Performance FAQ, PJM clarified that the basis for the 16 hour requirement is “is the typical nature of peak load periods where weather conditions that drive those peak load events can persist for periods of several days.” However, at the September 11, 2014 meeting, PJM staff reported that the 16 hour requirement (an extra 6 hours over the base capacity product) was not a result of reliability analysis but was needed availability to get through the two peaks in winter. For resources, such as storage, that can rapidly start to meet the two peaks and have no min gen requirements such duration requirement is unnecessary, e.g. storage can meet two peaks over a sixteen hour period without needing the ability to achieve full output continuously for 16 hours. Instead Capacity Performance requirements for storage should be based on the duration actually needed to supply energy during the peak periods.

Furthermore, at the September 11 stakeholder meeting on Capacity Performance, PJM stated that for assets that have the choice between offering as Base and Capacity Performance, PJM believes the more stringent penalties of Capacity Performance will be sufficient to ensure availability. The ESA believes that the same logic applies to most energy storage. Storage owners who are willing to take on the obligations and risks of the Capacity Performance product should not be burdened with additional performance requirements.

It remains unclear to the ESA what the justification is for requiring all Capacity Performance resources, and energy storage in particular, to be able to run for 16 continuous hours. We urge PJM to critically examine the assumptions that have led to this aspect of the proposal, and consider if it goes beyond what is necessary to solve the problems driving this initiative.

*Comment 4: Peak hour resources remain valuable during winter operations.*

Examining historical winter load data confirms that daily load curves still have peak hours, even during the coldest winter days. The traditional mix of base, load following, and peaking resources remains the most economical means of reliably serving winter load.

To quantify this, the ESA examined load shapes on peak winter days from the 2007/08 through 2013/14 delivery years.¹ We estimated the value of shorter duration peaking resources based on

¹ Data obtained from [http://www.pjm.com/markets-and-operations/energy/real-time/loadhryr.aspx](http://www.pjm.com/markets-and-operations/energy/real-time/loadhryr.aspx). To account for RTO expansion and load growth, loads in years prior to 2013/14 were scaled by the ratio of each year’s average
the difference between load in the highest and fifth highest hour of the day. This is a conservative minimum estimate of the amount of load that can reasonably be expected to be served by a storage device with four hours duration, or other similar resources. This approach is consistent with the methods currently used by PJM to evaluate the load serving capabilities of other resource types.

![Difference in load between top and fifth highest hour of day](image)

On average, nearly 5,000MW of capacity resources will be needed only to serve the top four hours of winter peak days. Even on the peak winter day with the flattest load curve, there was a 1,608MW gap between the peak hour and the fifth highest hour of the day. Load curves this flat are rare, and only occurred on relatively low load days: only the 38th and 48th highest winter peak days had less than 2,000MW of excess load in the top four hours.

The shape of winter days further enhances the value of storage. Winter days were split between single peaked days, defined as days where the peak four hours are adjacent to each other, and double peaked days, where the peak four hours are divided between the morning and evening. On days with a single peak, there was never less than 3,567MW of load that was concentrated in that peak could be served by a four hour resource.
On days with split peaks, storage resources would be able to recharge during the mid-day valley and meet additional hours over the course of the day. On every split peak winter peak day in our study, a four hour storage resource would be able to fully recharge between the morning and evening peaks without ever charging during an hour ranked higher than 11th in load for the day. In other words, a four hour storage resource can be relied upon to deliver power during the top eight hours of winter days, and to not charge during the hours ranked ninth and tenth. See graphic below:

Based on this data, the ESA concludes that no less than 2,000MW and most likely 3,500MW of PJM’s winter load can be served by storage resources that can maintain full output for 4 continuous hours. For 5-hour resources, results are at least 2,700MW and most likely 4,900MW.

To put this same conclusion differently, excluding peak hour resources from the Capacity Performance tier will lead to end-use customers purchasing 2 – 3.5GW of capacity that will only be needed during four-hour windows around the morning and evening peaks. The cost impact of this is very significant: allowing an additional 2 – 3.5GW of resources to qualify as Capacity
Performance would reduce the RPM clearing price by an estimated $62 - $108/MW-day and, save load between $3.5 and $6.1 billion dollars each year.²

The ESA believes the Capacity Performance proposal could be improved and made much more cost effective by reducing restrictions unrelated to winter availability from the product definition. RPM has been highly successful at integrating alternative capacity resources such as demand response, intermittent renewables, energy efficiency, and hopefully in the near future, energy storage. By doing so, it has saved ratepayers tens of billions of dollars in capacity charges. Although we appreciate that PJM views the current process as an opportunity for broad capacity market reforms, we believe it would be counterproductive for the response to gas fuel issues of January 2014 to result in marginalizing non-traditional capacity resources.

Comment 5: A note on measuring storage resources.

The ESA continues to believe that the most accurate way of assessing the reliability benefits of storage resources is by applying storage’s energy value during the times it is needed most, in the quantities actually needed. This was the basis of our previous presentation at the Planning Committee’s Storage in RPM working group. However, we also acknowledge PJM’s note that our analysis of the capacity value of storage resources assumes “perfect foresight in actual operations such that they are operated in an optimal manner”³.

To allow for less than perfect dispatch, here we treat storage as a fixed-power, fixed duration resource. For example, in the 4-hour case above, we considered 1MW of storage as 1MW available for 4 hours, not as 4MWh of energy to be assigned as needed. This makes our estimates highly conservative: on average, realizing the peaking benefits discussed above will only use about 56% of the resources’ stored energy. This leaves plenty of margin for actual dispatch to vary based on system conditions as they evolve on any given day.

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² Estimate uses 2017/18 RTO VRR curve and assumes Capacity Performance will clear between points (a) (b).

Comment 6: Proposed Capacity Performance product definitions for Storage Resources.

The ESA proposes that storage be allowed to qualify as Capacity Performance in two asset classes: the existing intraday cycling asset class and a proposed new “Short Duration High Availability” class.

To qualify under PJM’s proposed intraday cycling asset class, storage must:

- Meet all the flexibility requirements listed by PJM on page 24 of the Capacity Performance proposal.
- Be able to discharge for up to 10 continuous hours without recharging. We note that by deploying a 10-hour resource as two six hour blocks with two hours of charging between PJM would be able to serve the top 12 hours of every one of the top 50 winter peak days in the last 7 years. It is not until the 167th highest winter peak that we find a day where the load curve is flat enough that such a resource would only be valuable during the top 11 hours of the day.

We also propose a new asset class, “Short Duration High Availability,” (SDHA) within the Capacity Performance product that would allow a quantity of shorter duration resources consistent with daily load shapes to qualify as Capacity Performance.

To qualify for this asset class, a resource would have to meet the following requirements:

- Startup + notification time less than 10 minutes
- Unlimited starts per day
- Minimum run time is less than or equal to 5 minutes
- Minimum down time is less than or equal to 5 minutes
- Dispatchable range greater than or equal to 150% of ICAP
- Capable of providing synchronized reserves.
• Able to provide four hours of continuous energy at rated ICAP two times per day if allowed to recharge for up to four hours during the mid-day valley.

The Capacity Performance proposal notes that “PJM values resource flexibility especially on peak winter days...The ability for resources to be flexible throughout an operating day is integral to efficiently dispatching the system and minimizing uplift.” (page 23). The ESA has suggested parameters for the SDHA asset class specifically to meet this need. We believe that no other asset class will come close to matching the ability of SDHA resources in reducing uplift costs.

The ESA acknowledges that there may be a need to limit the total quantity of Short Duration High Availability resources. Based on our reliability analysis, we believe that the RPM resource mix can accommodate at least several thousand megawatts of these resources with no increase whatsoever in LOLE. We welcome an opportunity to engage with PJM on further refining these estimates.

Because we do not wish to add unnecessary complexity, we have not proposed a mechanism to cap the amount of Short Duration High Availability resources. The ESA is open to whatever approach PJM feels most appropriate. Given that the likely limits on this asset class are several orders of magnitude greater than what is currently installed, it is reasonable to simply defer this problem for a future stakeholder process. We would also agree with an approach that set a threshold (say, 2,000MW) on the amount of short duration resources that would trigger a stakeholder process to review reliability value of storage. Such a mechanism could work by suspending granting of CIRs to new short duration resources once the threshold was reached. We would also support making Short Duration High Availability resources a fifth RPM product, with clearing caps set by reliability analysis, much as is proposed for the Base, Summer Extended and Limited products.

**Comment 7: Allowances for storage co-located with other assets.**

The ESA suggests that PJM consider allowing facilities that have both storage and other assets to be considered as a single unit for purposes of meeting the Capacity Performance Availability and Flexibility requirements. This could enable some generation resources to meet the availability requirements that would otherwise have difficulty doing so, such as wind resources that have
high winter capability but inability to guarantee firm output. It could also enable some fossil fuel resources to better meet the flexibility requirements by adding storage equipment at their site.

**Conclusion**

In summary, ESA believes that energy storage can play a valuable role in meeting PJM’s objectives, but PJM’s current proposal undervalues storage resources’ contributions to reliability. In these comments we have suggested an approach that we believe more accurately represents the value of storage in RPM, and has the potential to both increase operational performance and reduce cost to ratepayers.

Thank you for the opportunity to comment on the proposal; ESA looks forward to further discussion with PJM and stakeholders on our suggested approach.

Respectfully submitted.

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