The Energy Storage Coalition (ESC) appreciates this opportunity to submit comments on PJM’s Capacity Performance proposal. The ESC 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.

Today the only storage included in the PJM RPM market is pumped storage. In the past 5 – 10 years there have been numerous advances in grid-scale storage, including batteries, flywheels and compressed air storage technologies. Adding advanced 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 in both hot and cold weather. Furthermore, advanced storage provides PJM operators great flexibility as it can be “turned off and on” within seconds, making it ideal to respond rapidly to unit outages, manage double peak winter days, and reduce uplift costs created by the lack of flexibility of other resources on the system.

The ESC broadly agrees with PJM’s proposed treatment of energy storage and, in particular, that PJM is opening the RPM market to new storage technologies. We support PJM’s decision to avoid administratively set requirements on storage duration in favor of evaluation based on real-time performance. We also support PJM’s proposal to allow storage to combine with other generators, such as wind and solar, to increase the capacity value of the renewable resource. But that said we believe additional development and clarification of the rules for storage participation are needed in order for PJM’s proposal to be complete. The ESA recommends that PJM better define the storage requirements in the Capacity Performance proposal, as well as the rules for energy market participation, in order to recognize storage resources’ unique operational characteristics and physical parameters.
Our comments are divided into two sections. For the last year PJM and stakeholders, including ESC members, have been developing rules for energy storage participation in RPM. The first section of our comments summarizes the ESC’s understanding of how energy storage contributes to reliability and can participate in capacity markets. The second portion of our comments suggest extensions and modifications to PJM’s capacity performance proposal’s treatment of storage. In some cases, these comments are suggestions on how areas not covered in PJM’s proposal may be addressed; in other areas, we suggest modifications to PJM’s approach that bring storage closer to compatible treatment with other capacity resources.

**Benefits of Storage in Capacity Markets.**

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 through a dependable fuel source:** 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. Battery 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.

**Peak hour resources remain valuable in the Capacity Performance Construct.**

During the work on incorporating storage into RPM, ESC members and PJM staff have spent considerable time examining intraday loads to help determine how resource run time limits affect capacity value. In summary, these analyses showed that:

- For the foreseeable future, several megawatt-hours of storage has equivalent reliability value to a megawatt of generation, provided that the storage is dispatched optimally. PJM staff has cautioned that current scheduling procedures do not guarantee storage will always be used at the optimal times. As discussed in more detail below, the ESC believes that PJM’s suggested approach of avoiding a fixed requirement for storage capacity while placing the risk of a storage asset not being available when needed on the asset owner appropriately balances these concerns.

- Storage is especially valuable on double-peaked winter days. Over the last seven years of winter peak days, there have always been at least four mid-day hours where storage could recharge during low-load hours.\(^1\) PJM’s proposal will not forgive storage’s obligations when it is unable to recharge, but does not explicitly forbid mid-day recharging. Subject to our suggestion below that uncommitted storage always be allowed to recharge when doing so creates no reliably risk, we support this approach.

Based on studies of both winter and summer peaks, the Energy Storage Association concluded that at least 2,000MW and most likely 3,300MW of storage with four-hour duration can be accommodated as RPM Capacity Performance resources with no increase in LOLE. The potential cost benefits of this are significant; allowing an additional 2 – 3.5GW of resources to qualify as Capacity Performance would reduce the RPM clearing price by an estimated $10 - $40/MW-day and, save load between $800 million and $1.6 billion dollars each year.\(^2\) There is significant savings to load from using storage to meet daily peaks.

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\(^1\) A low-load hour was defined as an hour that was not one of the top 10 peak load hours for the day.
\(^2\) Estimate uses 2017/18 RTO VRR curve and assumes Capacity Performance will clear between points (a) (b).
Suggested Clarifications and Modifications to PJM’s Capacity Performance Proposal

PJM’s proposal presents a framework for storage participation in RPM that ESC members believe is forward-thinking, appropriately captures both the potential benefits of storage in RPM, and properly places performance risk on storage asset owners. However, other than pumped hydro, storage is a relatively new resource, and many aspects of storage participation in energy markets remain undefined. The nature of this Enhanced Liaison Committee process has lead to a focus on big-picture questions of capacity market design, leaving many operational details unspecified. In this section, we present the ESC’s position on development of operational procedures and refinements to the Capacity Performance proposal that we believe help paint a complete picture of storage’s future participation in PJM markets.

Comment 1: Cost-based energy offers for storage need to be developed.

The fundamental requirement of a capacity resource is to be available to provide energy when needed. Outside of emergency procedures, PJM expresses this obligation as a requirement to offer into daily and real-time energy markets. Part of these energy offers are “cost-based offers,” which express a unit’s actual cost to produce energy. Cost-based offers serve to maintain competitive behavior: when market diversity screens reveal that a unit has potential for exercise of market power, the unit is limited to its cost-based offers. The ESC fully agrees that energy storage should fit into this framework identically to any other generation resource, but notes that there are currently no rules for developing cost-based offers for advanced storage. Such rules are necessary for the treatment of storage in Capacity Performance to be considered complete. We propose that the Board direct PJM to include or initiate a stakeholder process to formulate cost development rules for advanced storage that include the following features:

- **Allow for variable intraday costs.** Current PJM rules only allow assets to specify a single price for an entire day. Advanced storage faces variable costs: the cost of energy from a storage unit is a function of the price at which the unit purchased power and round-trip inefficiency losses. Therefore, the variable cost of storage varies with the changing price of energy throughout the day. Energy market rules for storage should acknowledge this, and allow storage to have variable price and cost based offers over the course of a day. We note that gas-fired units face a similar issue, which is currently being addressed by PJM stakeholders.
• As for other resource types, reflect run time limitations through opportunity costs. Many generation types have environmental or physical equipment limitations on how many hours per day they are allowed to run. Current market rules accommodate this through “Energy Market Opportunity Costs” and “Non-Regulatory Opportunity Cost: Physical Equipment Limitations.” These rules allow units with run time limitations to estimate the opportunity cost of running such a unit during lower priced hours at the expense of running it during higher priced hours. Including these opportunity costs in a unit’s cost-based offers gives scheduling software the data it needs to schedule run-time limited units in an economically optimal manner. Energy storage devices face run time limits very similar to those addressed by these rules. Rules to allow these limitations to be reflected in opportunity costs should be developed for advanced storage.

Comment 2: Treat physical parameters of storage comparably with other resource types.

Capacity and energy market rules recognize that various technologies have limits on how quickly they can start, minimum run times, minimum cycle times between runs, and other factors. The Capacity Performance proposal places some limits on these parameters for capacity performance resources, but still allows for a diverse spectrum of operating parameters. For example, a capacity performance resource must be able to start within 14 hours of being scheduled day-ahead, and during the operating day units are allowed to have startup times and maximum run times consistent with their historical performance. The ESC recommends that the physical parameters of storage be treated compatibly with other resource types. Specifically, we recommend addressing the following issues:

• Storage might not always be fully charged. Proposed capacity performance rules require storage to be available on one hour notice during hot weather, cold weather, and maximum generation alerts. To meet this requirement, most storage devices would have to fully charge prior to such an alert and remain idle at full charge until called upon. This would result in units being idle roughly 640 hours per year. This is of concern because many storage types seek to remain at roughly 50% charge in order to provide full ability to either charge or discharge. To ensure resources are fully available when needed, we

recommend that during hot and cold weather (but not maximum generation) alerts storage startup times reflect a need to charge from 50% to 100%. We agree with PJM that during maximum generation alerts storage must manage its charge to be fully available on one hour notice, unless otherwise dispatched by PJM for energy or ancillary services.

• **Storage is energy-limited.** Proposed capacity performance rules subject storage to penalties whenever it is unable to provide energy, regardless of the need to pump or recharge. We do not believe that this is equitable with the treatment given to other technologies that also have maximum run times, minimum down times, or have maximum starts per day. The ESC recommends that storage operators be required to telemeter their charge states to PJM, that offer parameters reflect physical limitations of advanced storage resources where needed, and that recharge times be given comparable treatment to the minimum down times of other technology types.

These rules strike an appropriate balance between treating physical attributes of comparably with other resource types and making responsible for ensuring their units are available when needed.

In particular, we note that our proposed rules are still stricter than those governing other technologies: fossil units that are not available due to long startup or cycle times are not subject to penalties regardless of how severe an emergency develops when they are unavailable. Given that PJM has recently stated that even the one-hour notification previously given to demand response was too long and inhibited emergency operations, it seems inevitable that many traditional generators may be prevented from operating during emergencies by their physical limits. We do not believe that our requested accommodations for storage are in any way more lenient than those already given to incumbent generation.

**Comment 3: Explicitly specify when system conditions prohibit charging.**

The Capacity Performance proposal states that storage devices will not be excused from penalties if system conditions prevent pumping or charging. The ESC agrees with this recommendation, provided that these system conditions are explicitly specified. We recommend that storage be allowed to charge at any time when energy is economically available and real-time emergency or pre-emergency procedures are not in effect. That is, charging is forbidden any time the system is in scarcity pricing or emergency procedures step 1, “Pre-Emergency
Mandatory Load Management Reduction Action” or higher is in effect for the location where the storage is sited.

**Comment 4: Retain the Base Capacity product as an option for new resources**

The Capacity Performance proposal includes a less-demanding Base Capacity option. As proposed, initially up to 20% of procured capacity would be Base Capacity. PJM envisions the Base Capacity product being phased out over time, and in particular proposes that no new resources be allowed to enter the market as Base Capacity.

We urge the Board to reject the requirement that all new/planned capacity be Capacity Performance. Some storage assets may be unable to meet the Capacity Performance requirements. Furthermore, the Capacity Performance proposal also allows storage co-located with intermittent renewable resources to increase the intermittent resource’s capacity value. We support that approach, especially given recent interest in combined solar/storage development. However, many intermittent resources can not realistically meet capacity performance requirements\(^4\) and are effectively restricted to participating as Base Capacity. Since there are no advanced storage resources or combined storage/intermittent resources currently in RPM, all such resources would be new. Eliminating the Base Capacity option would leave these resources with no opportunity to participate in RPM, limiting the entry of new resources in the RPM market.

**Comment 5: Expand the treatment granted storage co-located with renewables**

The Capacity Performance proposal would allow storage co-located with intermittent renewables to support the renewable’s capacity value by increasing its output during peak hours. We support this approach and believe that it provides valuable recognition of an area of current interest to policy-makers and developers. The ESC recommends that the Board approve this proposal, and expand it to storage and intermittent resources that are located in electrically equivalent areas (within the same constrained LDA) but not at the same physical location. Such “contractual co-

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\(^4\) For example, capacity performance resources are required to perform during cold weather alerts, many of which occur at night.
Comment 6: Clarify the ability of uncommitted resources to offset underperformance of RPM resources

Under the current proposal resources with no capacity commitment or committed resources providing energy beyond their UCAP may help compensate for other underperforming resources. This can happen in two ways: by contractual agreement between the resource owners, or through partial allocation of non-performance penalties to over performers. However, the rules for these two methods do not appear consistent. Contractual penalty offsets may cover any time period, be made between any resources in the same constrained LDA, and fully offset all non-performance charges. On the other hand, penalty charge allocation only covers limited time windows, does not apply to resources without RPM commitments, and under some conditions will be at a rate per MWh that is lower than the penalty rate.

We recommend that those rules be made consistent. Resources that output beyond their RPM commitments (including the entire output of uncommitted resources) should be awarded a pro-rata share of non-performance penalties collected within the same LDA, up to the full non-performance penalty rate per MWh in effect for each hour.

Some storage technologies inherently have short run-times and will remain unable to participate in capacity markets. Other storage assets will voluntarily make a capacity commitment at less then their full output to ensure they have sufficient run-time. The change we propose to penalty allocations would provide a market-based incentive for such units with “surge” output to deliver extra energy during critical periods.
**Conclusion**

The Energy Storage Coalition recognizes PJM’s proposal to integrate energy storage into its capacity markets as an important step forward. PJM’s framework lays the groundwork for an enhanced role for energy storage and renewables in the region’s resource adequacy planning. We appreciate this opportunity for dialog with PJM’s board, and look forward to future participation as market treatment of energy storage continues to evolve.

Respectfully submitted,

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24M Technologies, Inc.
ABB, Inc.
Advanced Emissions Solutions
AES Energy Storage
AltaLink
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Axion Power International, Inc.
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Energy and Environmental Economics, Inc.
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Eneridge, LLC
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Pacific Northwest National Laboratory
Panasonic
Parker Hannifin – Energy Grid Tie Division
Pete Hamilton, Better Energies, LLC
Pierce Atwood LLC
PJM Interconnection, LLC
Prudent Energy Corporation
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