



United States Senate Committee on Energy and Natural Resources,
Testimony of Andrew L. Ott, President and CEO, PJM Interconnection

“Full Committee Hearing to Examine Expanded Deployment of Grid-Scale Energy Storage”

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Executive Summary

For many years, PJM Interconnection has been ensuring nondiscriminatory access to the transmission grid and has established competitive markets where all resources compete on a level playing field to serve customer needs. We have helped bring about the vision of open access and competition that this Committee put forth in 1992 with the passage of the 1992 Energy Policy Act by embracing an “all of the above” strategy for resources. This has enabled the PJM markets to serve as a home for innovative new technologies ranging from energy storage to demand response as well as more-conventional resources such as coal, nuclear and natural gas.

PJM has a long history with energy storage in all of its forms and served as an early test bed for incorporating pumped storage hydro, lithium-ion batteries, vehicle-to-grid technology and other forms of energy storage into the wholesale electricity markets. The Federal Energy Regulatory Commission (FERC) recently issued Order 841, calling for full participation by these resources, whether in front of the meter or behind the meter. PJM fully embraces this effort, and in December 2018, PJM submitted to FERC proposed revisions to our Tariff that will continue to evolve our markets to ensure they are open and fair and incorporate energy storage resources without undue burden, while also preserving reliability. We are committed to ensuring that energy storage becomes an integral part of the fabric of a more reliable, more resilient and more cost-efficient power grid.

Through this testimony, I also propose certain initiatives for consideration by policymakers, including:

- Improvements in the pricing of all resources that stand by as reserves needed to keep the grid in balance — an initiative we have incorporated into a pending filing with FERC
- Ensuring that state/federal jurisdictional issues associated with energy storage resources connected at the distribution level are resolved smoothly as they have been so far in the PJM region
- Accommodating state and federal subsidies of particular generation resources in a way that does not erode the market’s need for an unbiased “all of the above” fair investment signal to attract the resources customers will need to meet their future power demands
- Providing additional guidance that supports the deployment of energy storage resources as transmission assets in those cases where deployment of storage resources represents the most cost-effective and efficient solution to a particular transmission reliability concern

Energy Storage in the PJM Region: An Overview of Successes and Policy Challenges Going Forward

Thank you for the opportunity to testify today. I am Andrew Ott and I serve as President and CEO of PJM Interconnection. PJM is the regional transmission organization responsible for the reliable operation of the bulk electric power grid serving 65 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM operates the largest bulk power system in the nation, as well as the largest competitive wholesale electricity market in the world.

I'm pleased to testify today to describe:

- PJM's experience integrating energy storage resources into wholesale market operations, including some of the first battery storage resources in the country to access wholesale markets
- The future of these promising technologies in continuing to provide benefits to the power system
- The policy issues and challenges you and other policymakers may wish to consider as energy storage resources increasingly seek to monetize their value in the nation's wholesale electricity markets



Energy Storage: An Array of New and Existing Technologies

I'd like to start by placing energy storage into context. So often today, when people think about energy storage, they think of batteries — in particular the lithium-ion chemistries that are most prevalent in the market today. And for good reason: The progress made on battery technology in the electronics and automotive sectors has made battery applications in the electric power sector possible, cost-effective and exciting.

But we shouldn't lose sight of the value of diversity in energy storage technologies. On the PJM system, we have several types of energy storage, of which lithium-ion batteries are only one:

- **Pumped Storage Hydro:** PJM has approximately 5,000 MW of pumped storage hydro, including one of the largest pumped storage hydro plants in the world — the Bath County Pumped Storage hydro facility on the border of Virginia and West Virginia. Most of our pumped storage hydro facilities were built decades ago to provide peaking capacity to meet customer demands. These facilities have proven to be highly effective, flexible resources that we integrated into our system years ago and continue to rely upon every day.



Bath County Pumped Storage Station, the world's most powerful pumped hydro facility. Source: Dominion

- **Thermal Storage:** Electric storage water heaters participate in the PJM Ancillary Services Markets to help balance the grid in real time. In addition, there are utility programs that use water heaters to peak-shave their load, often based on price signals from the PJM energy and capacity markets. There are approximately 90 MW of aggregated water heater capacity registered to participate in the PJM markets and probably hundreds of

megawatts that provide customer-side peak shaving that activate in response to PJM market signals. These are mostly operated by rural electric cooperatives.

Notably, in 2015 we worked alongside investor-owned utilities, public power and electric cooperatives, with Senator Hoeven and this Committee, to bring about an amendment to the Department of Energy's Energy Efficiency Standards in the Energy Efficiency and Improvement Act of 2015 to recognize the value of this low-cost and ubiquitous energy storage technology. Ironically, had Congress not acted, we were headed toward DOE phasing out the water heater technology used in utility programs, so we are grateful for your support with that needed legislative change.

- **Flywheel Technology:** PJM has one 20 MW flywheel battery in Pennsylvania.
- **Battery Technology:** PJM has 300 MW of mostly short-duration batteries that provide frequency regulation, which helps to keep the grid in balance. These batteries are mostly lithium-ion-based chemistries, although there are a few batteries that employ other chemistries such as sodium-sulfur or advanced lead-acid technologies. These battery resources are in diverse locations — next to high-voltage transmission lines, behind customers' meters, and everywhere in between. PJM markets have also been used as a test-bed for demonstrating and developing nascent electric vehicle-to-grid technology, a novel concept that involves aggregating fleets of electric vehicles that are able to provide services to the electric grid through two-way power flow between the car and the grid.

A Brief History of the Development of Energy Storage in the PJM Marketplace

PJM's markets have been quite successful in using the forces of competition and innovation to provide electricity both reliably and efficiently to the 65 million customers we serve in 13 states plus the District of Columbia. Our hallmark has been ensuring nondiscriminatory access to the transmission grid and establishing competitive markets where all resources compete on a level playing field to serve customer needs.

In this way, we have helped bring about the vision of open access and competition that emanated from this Committee back in 1992 with the passage of the 1992 Energy Policy Act. And along the way, we have embraced an "all of the above" strategy that has enabled the PJM markets to serve as a home for innovative new technologies, ranging from energy storage to demand response, as well as more conventional resources such as coal, nuclear and natural gas. The policy embraced by



A two megawatt lithium-ion battery located at PJM's headquarters providing frequency regulation. Source: PJM

Congress back in 1992, of using market forces to drive new technology and innovation rather than government picking technologies and winners and losers, has served us well over these many years.

PJM has a long history with energy storage in all of its forms. In 2008, PJM was the first to incorporate a lithium-ion battery into its wholesale electricity markets as a source of critical frequency regulation services, in which resources are called upon to respond quickly to ensure the grid remains in balance. This demonstration actually took place through the early deployment of a set of batteries in the parking lot of PJM’s headquarters as depicted above.

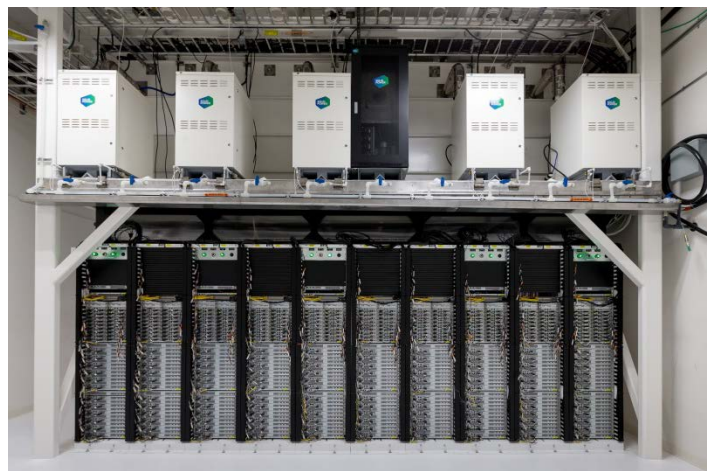
Those batteries were a “proof of concept” demonstration of the value of batteries in providing real-time frequency regulation service. PJM also worked early on with the University of Delaware to pilot the use of aggregated electric vehicles to provide frequency regulation response through vehicle-to-grid technology. And we have also served as a test bed for use of electric water heaters as an energy storage device, as I mentioned previously.

Those early trials have evolved — today PJM markets provide a revenue stream for a host of innovative technologies and innovative deployment models, including one of the nation’s largest battery deployments co-located with a wind farm in Mount Laurel, West Virginia. We allow energy storage technologies and other resources as small as 100 kW to participate in our energy and capacity markets and have seen energy storage technologies team with demand response providers to bid as resources in our Ancillary Services Markets.

I would note that these developments also helped to inform critical policy development at the Federal Energy Regulatory Commission, which issued a series of Orders, under both Republican and Democratic leadership, to open the markets and the grid to innovative energy storage technologies in a nondiscriminatory way. As a result of PJM’s early leadership and research, and supportive regulatory action on the part of FERC that recognized the benefits of fast-acting energy storage resources, PJM quickly became the largest market for battery technology over the ensuing years.

Energy Storage in PJM Today

Today, we have about 300 MW of batteries deployed throughout the PJM region. About half of this total capability (and mostly the larger batteries) are interconnected at the transmission level and thus are both visible and dispatchable by PJM operators to serve the needs of customers. The other half of the 300 MW represent smaller batteries that are deployed at the distribution level in what we would consider to be “distributed energy resources.” These could include batteries that are directly connected to lower-voltage distribution feeders or connected behind a customer’s meter, such as at a hospital, military base or other commercial customer facility.



Distributed battery energy storage system at a Microsoft datacenter. Source: Microsoft

These batteries often have dual uses; in addition to providing wholesale services to PJM, they may be providing voltage support to the distribution network or responding to a customer's time-varying retail rate, for example.

In 2018, on average, 27 percent of the frequency regulation requirement in the PJM system was supplied by energy storage resources — meaning all batteries, flywheels, and pumped storage hydro — and as high as 49 percent of our hourly requirement has been observed. Batteries represent, on average, over 80 percent of the total energy storage resource contribution to the frequency regulation market.

FERC has recently issued Order 841, which calls for full participation by these resources, whether in front of the meter or behind the meter, in Regional Transmission Organization (RTO) markets, to the extent the energy storage resources are technologically able to provide the particular service. Notably, FERC made clear that:

"... this Final Rule does not grant undue preference to electric storage resources as a group or to specific electric storage technologies; rather, it removes barriers to their participation, enhancing competition among all resources that are technically capable of providing wholesale services."¹

Looking forward, PJM has about 1,000 MW of stand-alone energy storage and about 2,000 MW of combined energy storage and renewables in its generation interconnection queue. Not all resources that enter the interconnection queue ultimately get built. In fact, only 23 percent of the projects that enter the queue ever come online. Regardless, this level of interest serves as a clear indication that markets are working to attract these new resource types and that the development and prospects for energy storage are growing.

Role of Energy Storage in PJM's Wholesale Markets

PJM is independent and resource neutral. As such, we believe all resources need to be able to compete in the wholesale markets on equal footing. FERC Order 841 directed RTOs and ISOs to make it easier for energy storage to participate in all wholesale energy markets by eliminating undue barriers that may exist and by explicitly recognizing certain physical and technical aspects of energy storage resources.

In December 2018, PJM submitted to FERC proposed revisions to our Tariff that will continue to evolve our markets to ensure they are open and fair and incorporate energy storage resources without undue burden, while also preserving reliability. We had requested that FERC rule on this filing by May 30 of this year, so that we could implement changes by the end of 2019. Although this date has passed, we are hopeful that FERC will act soon on this important matter so that we may work on the modifications to our business systems necessary to implement our filing and give the storage industry greater confidence for investment.

Our filing outlines certain modifications that enhance the ability that energy storage resources already have to participate in our energy, reserve and capacity markets. Although there are a number of technical issues in this filing,

¹ FERC Docket Nos. RM16-23-000; AD16-20-000; Order No. 841, Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Issued February 15, 2018.

we are pleased to have received recognition from the American Wind Energy Association and Solar Council that (with the exception of the issue I describe below):

"The Clean Energy Entities support many aspects of the PJM Compliance Filing and believe that in general it will lead to more transparent and fair rules for ESRs seeking to participate in PJM's markets."²

One issue that has garnered attention is how energy storage resources can participate in PJM's capacity market and therefore displace a coal, nuclear or natural gas unit to be available on call to provide energy when needed in system emergencies. Consistent with FERC's requirements, we have indicated that battery storage resources *can* be deemed capacity resources and be fully paid to the extent to which they have the duration capability to be available on call when needed. We require the same of a coal, natural gas or nuclear unit, and we require the same of pumped storage hydro or a demand response resource. Our approach is consistent with FERC's directive that the markets need not create undue preferences for energy storage resources but instead must be open to their participation consistent with their "technical capability" of providing the service in question.

Today, in PJM and in other areas of the country, battery duration is generally limited — duration could be anything from 15 minutes to one or two hours (typically never longer than four hours) at their rated capacity before they need to be recharged. However, even with these relatively short durations compared to other resource types on the grid today, we don't exclude these batteries from participating in the capacity market. Instead, short-duration batteries are prorated based on their capability (just as we do with renewable resources) to recognize this limited duration. In short, we are treating batteries comparably to any other resource that seeks to serve as a capacity resource. As capacity resources are integral to ensuring reliability and keeping the lights on, we think it is only fair, as well as consistent with the FERC Order, to pay them comparably to what we would pay a cleared nuclear, coal or natural gas resource when they provide a comparable service.

I would note that the duration requirements for energy storage capacity resources that we submitted to FERC are, in part, driven by the success that demand response has had in our capacity market. The advent of demand response, in which industrial operations or buildings and other facilities agree to curtail their load during system emergencies, has worked to "flatten" our expected load curve when demand response is called upon. In effect, this has transformed our capacity design requirements from serving what used to be a one-hour "needle" peak demand into a lower, wider but more sustained multi-hour peak demand.

PJM has been a national leader in integrating demand response. Our success in integrating demand response has worked appropriately to notably change our system requirements, a point that we need to recognize as we define when an energy storage resource can serve as a capacity resource and effectively displace a coal, nuclear or natural gas plant.

Nevertheless, we do agree that there are additional opportunities to aggregate batteries in order to meet the reliability requirements of a capacity resource. In this vein, we await the FERC's Order, which is still pending, setting the rules

² Protest of the American Wind Energy Association and Solar Council, FERC Docket No. ER 19-469 at p. 2 (February 7, 2019).

for aggregating distributed energy resources such as batteries. Guidance from FERC on the various technical issues associated with aggregating distributed energy resources such as batteries will help to provide further avenues for these resources to participate in our markets. In the interim, the economic signal we will be sending about system needs will help to spur the market to develop longer-duration batteries. This is good for customers, for the industry as a whole and for the nation in terms of enhancing the resilience of the grid.

Future Policy Issues for Consideration

Currently, there are a host of interwoven policy issues at both the state and federal level that incorporate or impact energy storage in one way or another. I point these out as issues that will come before the FERC, the states and potentially before this Committee through the hearing process. Each of these issues will need to be tackled as we move forward and witness increased technology innovation and deployment of more efficient energy storage resources:

- **Reserve Pricing:** PJM currently has a Reserve Pricing proposal before FERC that is designed to recognize the increasing value of maintaining adequate reserves, particularly as the level of intermittent renewable resources such as wind and solar continue to be deployed. As we know, although renewable resources can have great value, they are dependent on levels of wind and sun that can change on a moment's notice due to changes in wind patterns or cloud cover. Our pricing proposal before the FERC is intended to properly price these reserves and the value they bring to maintaining a stable system. We have recently made this filing but feel it is important for FERC to move forward on these proposals in a timely manner.
- **Subsidies:** An issue has arisen as to how to address government-mandated subsidies to particular technologies (either conventional or new) that have the effect of squeezing out of the market other, potentially more-efficient and cost-effective technologies such as new energy storage technologies.

We believe the fundamental tenets of the Energy Policy Act of 1992 called for competition across all resources. Subsidies of one kind or another, whether at the state or federal level, only work to distort investment signals and stymie the development of innovative technologies. Although we respect the right of Congress or the states to support different technologies or specific power plants for the jobs or environmental benefits they bring, we think this technology-specific approach ultimately defeats itself by prompting an ever-growing list of new subsidies needed to counter other existing subsidies.

We at PJM have championed market-based approaches that incorporate desired state and federal policies and have proposed various ways that those state and federal interests can be incorporated into the markets rather than operating outside of them. FERC has a major case on this very issue that has not moved forward for some time. We have asked the Commission to act soon to provide critical guidance in this needed area as both investors and customers depend on the regulatory decisions FERC makes.

- **Federal/State Coordination:** The states and the federal government need to coordinate in order to maximize the value of energy storage resources for both transmission providers and distribution providers, rather than “pigeonholing” technology and rules based on jurisdictional categories of distribution versus transmission. Unfortunately, the Commission’s recent Order on integration of storage resources into the wholesale markets has engendered a state versus federal dispute over jurisdiction. Ironically, in the PJM marketplace, we have allowed *with state approval* over 2,000 MW of distributed energy resources to participate in our markets, ranging from small-scale solar photo-voltaics to multi-megawatt natural gas plants. All of these requests have been coordinated with the local distribution utilities and followed state interconnection rules and guidelines. In short, at least in the PJM region, this dispute is something of a “tempest in a teapot” that ignores the realities of our successful integration of 2,000 MW of distributed energy resources into our markets where they can receive the full economic value of their investment.
- **Energy Storage as a Transmission Asset:** We look to policymakers to work with us on the various regulatory principles that would guide incorporation of energy storage resources as rate-based transmission assets. Energy storage resources could, in certain circumstances, be deployed more cost-effectively than building new transmission lines while avoiding the more complicated land-use and permitting issues associated with building a new greenfield transmission line. But there remain details to work through, including whether and how such resources can participate fairly in the markets when they are not being called upon to address a particular transmission constraint, how RTOs can assess the resilience of an energy storage resource co-located at an existing substation when compared with the development of a new alternative transmission line that could reduce the risk of a single point of failure, the cost allocation of such facilities, and myriad other issues. As we see increased interest from PJM transmission owners and merchant developers in this area, PJM is committed to working through these issues with our stakeholders, the states and FERC.

Conclusion

As FERC Commissioner Cheryl LaFleur recently mentioned publicly, energy storage technologies can serve as a “Swiss Army Knife” for the grid — they can be designed, deployed and controlled in such a way that they can provide multiple different services and reliability needs across the electric power sector: generation, transmission, distribution, all the way down to the residential customer.

In the future, we will see energy storage being deployed to solve transmission upgrade issues. We will see it deployed to provide stability to distribution feeders that have high solar deployment. And we will see it deployed behind customers’ meters so that individual customers can potentially respond to dynamic rates and have the ability to improve power quality or ride through a short power outage.

PJM’s role will be to ensure that our markets, our transmission planning, and our operations can accommodate these varied use cases so that energy storage can become an integral part of the fabric of a more reliable, more resilient, and more cost-efficient power grid for the future. We look forward to working with this Committee, FERC, states and stakeholders to make this a reality in the months and years to come.