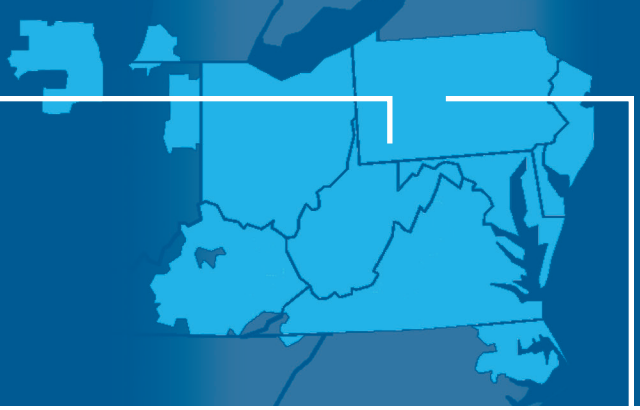
Energy Storage in PJM



Energy Storage Boosts Electric Grid Reliability & Lowers Costs

Energy markets that have evolved to integrate more energy storage are realizing significant benefits. Across the United States, energy storage facilities have become essential infrastructure, enhancing grid reliability and cost savings.

In Texas, energy storage has played a critical role in managing the state's rapidly rising electricity demand and volatile weather. During a single winter storm in Texas, energy storage helped keep the lights on and homes warm while saving the ratepayers more than $700 million in energy costs. That same year, throughout the Summer of 2024, energy storage resources enabled Texas to withstand historic electricity demand and Summer heat – providing reliability services that saved the families and businesses more than $750 million compared to 2023. In California, energy storage has reduced the risk of black outs and brown outs – and in 2022, played a key role in preventing a costly grid failure.

Communities are also seeing the direct benefits of deploying local energy storage. In Nevada, a single energy storage facility built on the site of a retiring power plant will contribute to utility bill reductions of up to 20%. In regions with the greatest reliability challenges, energy storage has demonstrated its unique ability to enhance grid resilience while also making electricity more affordable.

Energy Storage can Help the Region Address Rising Demand for Electricity

Since 2019, US energy storage deployment has grown 25x with almost 29 GWs now connected to the grid, representing enough capacity to cumulatively power 22 million homes. In 2024, energy storage was the second most deployed resource, yet PJM lags other regional electric grids because of outdated market rules and restrictive modeling practices. More than 12 GWs of energy storage resources were added to the grid in 2024, reinforcing its status as one of the fastest growing and most rapidly deployed energy resources. As PJM anticipates a historic rise in peak energy capacity needs, other regions that have faced increasing electricity demand have relied on energy storage as a cost-effective, scalable solution to bolster grid reliability and expand capacity.

ENERGY STORAGE IS READY TO QUICKLY FILL THE GAP

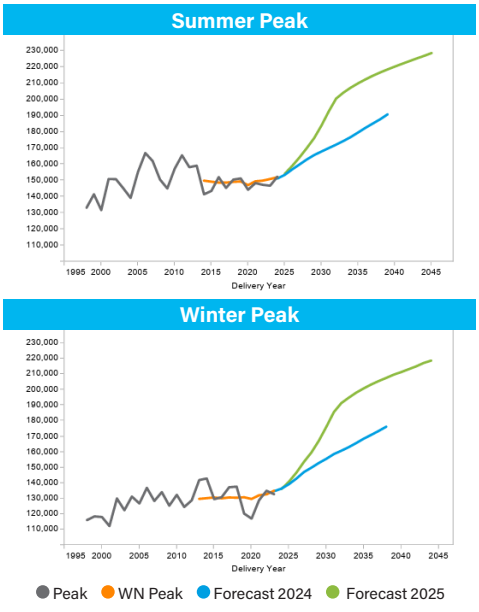
PJM's annual and peak load is expected to grow by an additional 100 GWh and 15 GW by 2030. Storage is part of the solution to quickly and reliably meet that need.

- New energy storage capacity can be built in **12-18 months**, unlike other resources which can take years
- Texas built more than **5 GWs of energy storage in 1 year** to address reliability needs and support economic growth
- PJM currently has more than **1 GW** of pending projects and **55 GW** in the Interconnection Queue.

States are Leading: 18 GWs of Storage Targets

States and utilities are driving energy storage deployment. Maryland plans to build over 3 GW of storage by 2033, while Virginia is advancing toward its 3 GW mandate by 2031 and its legislature has passed a bill increasing the target to 10 GW. New Jersey is rolling out a state program to incentivize 2 GW by 2030, and Indiana is emerging as a regional leader in new storage capacity. With common-sense market reforms, PJM can help ensure these resources maximize their regional benefits.

Long-Term Load Forecast



Source: PJM 2025 Long-Term Load Forecast

Learn more at energystorage.org

AMERICAN CLEAN POWER

PJM Can Integrate Energy Storage Resources and Strengthen Reliability with Targeted Market Design Reforms

Opportunity Cost Bidding

Currently, storage can participate in PJM's capacity, energy, and ancillary service markets, but some outdated rules designed for traditional generation prevent it from competing on a level playing field. A major issue is how opportunity cost—the cost of forgoing an alternative use of a resource—is treated in PJM's markets. Since energy storage has limited energy duration, it must manage when to charge and discharge to maximize grid value. However, PJM's market rules do not allow storage to fully reflect the opportunity cost of using energy now versus saving it for a higher-value period later, restricting its ability to maximally support grid reliability, efficiently participate in reserves, respond to price signals. Updating these rules is critical to unlocking storage's full potential in PJM's markets. **Opportunity cost bidding** reform would enable storage to include these opportunity costs in its bids, improving market efficiency in several ways:

1. **Increased Reliability:** improved price signals ensure storage is available during peak demand or grid emergencies, strengthening system reliability.
2. **Optimized Dispatch:** Storage can strategically charge and discharge based on future price forecasts, ensuring energy is deployed when it provides the greatest grid value.
3. **Enhanced Market Efficiency:** More accurate price signals improve price formation and resource utilization by reflecting storage's true opportunity costs.
4. **Greater Flexibility:** Storage can more effectively provide energy, reserves, and frequency regulation by prioritizing the highest-value services.
5. **Revenue Clarity:** Storage operators gain better visibility into potential revenues, encouraging further investment in storage resources.

Ultimately, these reforms help unlock the full potential of energy storage, allowing the resource to deliver greater regional grid reliability and efficiencies that lead to lower costs.

Ramping Products

PJM currently lacks both ramping products to meet real-time flexibility needs and a day-ahead uncertainty product to meet forecasted net demand, leaving the system vulnerable to changes in forecasted and actual supply and demand that can strain reliability and efficiency. Without these market-based products, PJM must rely on out-of-market operator actions, such as uplift payments and manual commitments, which distort price signals and fail to incentivize the right resources to be available when needed. In contrast, other RTOs, including MISO, CAISO, and SPP, have implemented ramping and day-ahead uncertainty products to proactively manage fluctuations, ensuring a more efficient and resilient grid. Without similar mechanisms, PJM risks increased reliability challenges, price volatility, higher uplift costs, and poor price signals to invest in needed flexibility, especially as more intermittent renewables and energy storage come online.

Implementing these products would not only enhance market efficiency but also strengthen PJM's ability to integrate clean energy resources while maintaining grid stability. Like other reserves, ramp and uncertainty products are most efficiently procured using a sloping Operating Reserve Demand Curve (ORDC) reflecting the reliability value of each product. Accurately valuing ramp and uncertainty reserves in PJM is best conducted in the context of PJM's other reserves, which are even high value. **PJM's ORDC thresholds must be sufficiently high to reflect system value in scarcity conditions to both incentivize resource availability and appropriately value the benefits being offered to the grid.**

Market Reform	Role of Energy Storage	Grid Benefits	ISO/RTOs Implementing or Planning Ramping Product
Ramp & Uncertainty Product: A market mechanism designed to manage fast, short-term fluctuations in net load.	Energy storage reacts instantly (in milliseconds), unlike other resources which take many minutes or hours to ramp. Storage smooths fluctuations and supports base generation by preventing the need for inefficient ramping.	By quickly responding to short-term load changes, storage reduces reliance on slower, less flexible resources, ensuring the grid remains stable. This prevents inefficient generation cycling and ultimately reduces excessive renewable curtailment, improving efficiency.	▪ CAISO ▪ ISO-NE ▪ MISO ▪ NYISO ▪ SPP
Day-Ahead Uncertainty Product: A market tool to ensure sufficient availability to meet forecasted net demand.	This market tool ensures sufficient resources are available on the next day to meet net demand forecasts, including a margin for uncertainty. Storage is always on and therefore meets availability needs at low cost, reducing the burden on traditional steam generators that must incur substantial start-up costs. Storage also provides greater flexibility to the grid to accommodate low-cost renewable generation. By optimizing energy use across hours, storage enhances the efficiency of the generation fleet.	By providing needed availability at lower cost, storage enhances the overall efficiency of the generation fleet, reduces excessive cycling of baseload fossil generators, reduces unneeded renewables curtailment, and ensures grid stability during periods of high demand.	▪ CAISO ▪ MISO ▪ NYISO ▪ SPP