PJM Interconnection has long recognized the unique value of energy storage technology and welcomed its development. PJM is working to ensure that energy storage has the ability to become an integral part of a reliable, cost-efficient grid that supports increasing amounts of renewable resources.

Deploying the Resource

Energy storage on the grid improves operating efficiency and provides flexibility to the generation mix – attributes that will be increasingly important with the growth of variable resources such as wind and solar.

Electricity cannot be stored in the traditional sense like other commodities, such as oil. Generally, it is consumed at the time it is produced.

The challenge for grid operators like PJM is how to best store energy during times of abundant supply, when prices are low, for use later, during times of high demand and high prices, or when other power sources are unavailable.

Key Points

- PJM enjoys a long history with energy storage and is working to ensure its ability to become an integral part of the grid.
- Energy storage provides flexibility to the generation mix, which will be increasingly important with the expansion of variable resources like wind and solar.
- PJM deploys a number of types of energy storage on the grid, and energy storage resources participate in all PJM markets.
- Energy storage offers opportunities to address traditional challenges, like resource adequacy, using new technologies.

Order 841 Codifies Energy Storage Market Participation

The Federal Energy Regulatory Commission recognizes the importance of energy storage technology.

In 2018, it issued Order 841, requiring PJM and all wholesale market operators to remove barriers to participation for energy storage resources in the wholesale electricity markets.

In PJM, Order 841 went into effect in December 2019.

Energy Storage Expands Beyond Traditional Uses

Including new energy storage technologies on the grid is important because they can help offset the variability of renewable resources like wind and solar and provide reliability benefits, such as operating reserves.

Developments in the technology also provide new tools to address traditional challenges like resource adequacy, transmission congestion and the need for black start capability.

Increasingly, energy storage technologies are planning to pair with renewable resources, predominantly solar, to take advantage of the synergies.

Energy Storage Technologies

Following are some examples of storage technologies.

- **Pumped-Storage Hydroelectricity**: About 5,000 MW of pumped-storage hydroelectric resources are located within the PJM footprint, including one of the largest such plants in the world: Bath County Pumped Storage Station, which is on the border of Virginia and West Virginia. Pumped-storage hydroelectric plants employ two large, connected reservoirs at different elevations. During the nighttime hours, when electricity costs are lower, water is pumped from the lower reservoir to the upper reservoir, where it is stored. During the day,

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when power demand and/or electricity costs are higher, the water is released from the upper reservoir and flows through a turbine to generate electricity.

- **Battery Storage**: In 2008, PJM was the first to incorporate a lithium-ion battery into its wholesale electricity markets as a source of frequency regulation services, in which resources are called upon to respond quickly to ensure the grid remains in balance. The PJM footprint is home to one of the nation's first large-scale battery deployments – Laurel Mountain, where a 32-MW battery storage system is co-located with a 98-MW wind farm. The battery facility helps PJM quickly balance variations in load to regulate frequency as an alternative to adjusting the output of fossil fuel generators; it is capable of changing its output in less than one second. The total nameplate amount of battery storage projects in the PJM region is more than 290 MW.
- **Flywheel Storage**: This technology involves the use of a rotating flywheel to store energy. A motor draws energy from the grid to accelerate the flywheel, storing the energy in the rotating device. When the grid needs regulation, the flywheel drives a generator to produce electricity for the grid as the flywheel slows. For example, one power plant in Pennsylvania uses 200 flywheels to produce or consume 20 MW of power and provide frequency regulation service to PJM.
- **Compressed Air Energy Storage**: Compressed air energy storage pumps and compresses air in underground containment areas. The air is held until power is needed, then released through a combustion turbine with natural gas fuel. There are two such plants operating in the United States – both outside of the PJM region.
- **Electric Vehicles**: The concept that a battery could not only power a car, but also discharge power into the grid, was demonstrated more than a decade ago in a joint pilot project by PJM and the University of Delaware. The project ended up generating more than $100 per car, per month. Off-peak or low-cost electricity from the grid can charge vehicles, shifting load to the nighttime hours, or otherwise help to match supply and demand. Electric vehicle batteries can also be discharged to provide reliability services to the grid, such as frequency regulation or fast-start reserves.
- **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 regulate 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 perhaps hundreds of megawatts, that provide customer-side peak shaving during both summer and winter peaks.

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