PJM Interconnection supports projects of all types to expand the electricity storage capability of the electric grid. More storage capacity will be needed to deal with the forecasted major expansion of intermittent renewable energy sources and their potential impact on system reliability.

One of the challenges facing grid operators like PJM is the inability to "store" electricity for use at times of high demand or when other power sources are not available. However, new technologies are being developed and tested that offer the promise of more widespread storage options for grid operators and utilities. These technologies will become even more important as intermittent renewable energy sources play a greater role in the nation's electricity supply.

Unlike other forms of energy like oil and natural gas, electricity cannot be stored in the traditional sense. Electricity is consumed at the time it is produced.

The only large-scale storage option for electricity that has existed until recently has been pumped-storage hydroelectricity. These projects employ two connected reservoirs at different elevations. During the night-time hours, when electricity costs are low, water is pumped from the lower reservoir to the upper reservoir to be stored. During the day, when power demand and/or electricity costs are high, the water is released from the upper reservoir and flows through a turbine to generate electricity.

In effect, pumped storage converts low-cost off-peak energy into higher-priced on-peak energy. The largest pumped storage facility in the U.S. is located in the PJM territory.

Today, additional options for storing electricity are emerging and are being tested. These technologies – such things as battery arrays, flywheels, compressed air energy storage and even plug-in hybrid electric vehicles (PHEVs) – may give grid operators additional flexibility in their efforts to ensure the reliability of the electric system.


There are a number of reasons why additional storage capacity is needed on the grid. The primary one is the dramatic increase in electricity from renewable sources that is expected. These sources typically are intermittent – their production isn't available all the time, as for example, with the lack of energy when the wind isn't blowing or the sun isn't shining – and their output may not be available at times of peak demand when it is needed most.

Taking full advantage of renewable sources while dealing with the reliability challenges of the sources' power fluctuations will require a significant increase in storage on the grid.

The lack of sufficient storage already has caused issues for PJM. In some areas, abundant wind production in the off-peak (night-time) hours has forced electricity prices into the negative range. During low load periods, keeping renewable generation operating could force power reductions on baseload units like nuclear and coal plants.

Given the states' requirements for renewable energy and economic incentives for the development of renewable projects, the expected expansion of renewable power will magnify the issues, along with the challenges for grid operators in dealing with fluctuations in the output of these power sources.

The following are some example of new storage technologies for the grid:

**Battery storage** – A one-megawatt (MW) array of lithium-ion batteries provided regulation service in the PJM market for several years. The battery facility, housed in a trailer on the PJM campus, was owned by AES Energy Storage, a subsidiary of The AES Corp., a PJM member. A much larger battery facility, 32-MW AES Laurel Mountain in West Virginia, went into operation in 2011 in conjunction 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. In response to PJM requests to balance the grid, the battery unit can supply power into the grid by discharging its batteries or store excess electricity from the grid to charge its batteries.

**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. A Beacon Power flywheel system has been providing frequency regulation for the ISO New England grid since 2008, and a 20-MW facility was completed in New York in 2011.

**Compressed air energy storage** – Compressed air energy storage (CAES) is another promising form of storage. Like pumped-storage hydro, it uses less-expensive off-peak power, in this case pumping air into and compressing it in underground containment areas. The air is held until power is needed. Then it is released through a combustion turbine with the natural gas fuel, increasing the efficiency of the generator to provide more economical electricity at times of high demand.

**Plug-in hybrid electric vehicles** – Vehicle battery storage using plug-in hybrid electric vehicles (PHEVs) connected to the grid is another storage technology that is being evaluated. Off-peak electricity from the grid could charge PHEVs, shifting load to the night-time hours, while PHEVs also could provide regulation services to the grid in the daytime hours. PJM is part of two consortiums – the University of Delaware's Mid-Atlantic Grid Interactive Car Consortium (MAGICC) and The Ohio State University's SMART@CAR – to demonstrate and evaluate this vehicle-to-grid (V2G) approach.

Also being evaluated at PJM is thermal storage, using a large electric water heater that responds to grid needs when it receives pricing and regulation signals from PJM dispatchers.

Storage technologies can help grid operators and utilities address the impact of a large-scale addition of renewable energy sources to the electricity system, including the intermittent nature of renewables, the off-peak timing of much wind energy output and the potential impact on the loading levels of baseload coal and nuclear plants.

4/26/2012

955 Jefferson Ave.
Norristown, PA 19403
866.400.8980
610.666.8980