Energy Storage Breakthroughs

AN EVOLVING TECHNOLOGY FOR MANAGING THE GRID

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FROM THE EARLIEST days of the electric power system, energy storage has been considered an important technology for managing the grid. Today, the changing ways in which electric power is generated and used are making storage even more attractive than before. The appearance of newer, more cost-effective technology options is making it likely that energy storage will finally become a reality in the near future.

The electric grid operates as an enormous just-in-time production and delivery system, with power generated at the same time it is consumed, and with little storage of electrical energy. This means that the transmission and distribution system must be built to accommodate maximum power flow rather than average power flow, resulting in underutilization of assets. Energy storage can improve asset utilization, enhance the network reliability, enable more efficient use of baseload generation, and support a higher penetration of intermittent renewable generation.

Energy storage exists in many electrical power systems. In the United States, about 2.5 percent of electricity that passes through the network has been stored. Pumped hydro facilities, the form of large-scale storage most familiar to utilities, represent most of this storage. Pumped hydro allows the storage of enormous quantities of energy, though it requires a huge initial investment. Compressed air energy storage (CAES) is a less-widely implemented technology that uses off-peak renewable electricity to compress and store air, which can later be used to regenerate the electricity. Such techniques could be used to store renewable energy for convenient dispatch at later times.

Short-duration storage technologies such as ultracapacitors and flywheels have uses in other applications, such as those in which power and energy requirements are not large but when the storage is expected to see a great deal of cycling. Such technologies can be used to address power-quality disturbances and frequency regulation, applications in which only a few kilowatts to megawatts are required for a few seconds or minutes.

A great deal of effort has gone into the development of electrochemical batteries. Utilities are familiar with lead-acid batteries which are extensively used for backup power in substations and power plants. In larger-scale applications, however, other battery chemistries such as sodium sulfur and vanadium redox flow batteries are more effective. Extensive research and development investments in these technologies have begun to pay off, and several recent installations are demonstrating the viability of battery energy storage in applications such as peak shaving for transmission and distribution asset deferral.

Lithium-ion battery technology has helped enable the portable electronics revolution and promises to do the same in the transportation market by enabling plug-in hybrid electric vehicles (PHEV). The widespread adoption of PHEVs would have significant effects on the utility industry. If 2 percent of vehicles in the United States were plug-in hybrids by 2020, this would mean 2 million PHEVs would exist on the grid. This represents a charging load approaching 40 gigawatts. Assuming such charging would be done primarily at night, PHEVs would reduce the diurnal fluctuation in electrical load. In some concepts, PHEVs might also be used as distributed energy storage systems, discharging energy back to the grid when necessary. Such a development could potentially give utilities access to gigawatts of power on demand.

What might a utility system based on such technologies look like? Large-scale technologies such as pumped hydro and CAES may be used to store large amounts of energy generated from wind farms and other renewable sources, allowing the energy to be dispatched when it is needed. Flywheels might be used to provide minute-to-minute frequency regulation while large-flow batteries provide more large-scale ramping over several hours. Strategically placed sodium-sulfur batteries could ease bottlenecks in the distribution system through peak shaving, while reducing demand charges to customers. Ultracapacitors placed at substations could mitigate the effects of momentary interruptions on distribution feeders. The massive aggregation of PHEV batteries could absorb energy produced by nuclear baseload plants during the night and could be used to provide spinning reserve or critical backup power to industrial customers during the day.

The real challenge for energy storage is not whether it is possible, but how it will be used. There is no question that storage represents an opportunity; it will take strategy and understanding of this opportunity to make sure it is exploited to its full potential.

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