Testimony

Energy Storage Technologies: State of Development for Stationary and Vehicular Applications

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Thank you, Mr. Chairman and Members of the Subcommittee. I am Thomas Key, Technical Leader, Renewable and Hydropower Generation for the Electric Power Research Institute (EPRI), a non-profit, collaborative organization conducting electricity related R&D in the public interest. EPRI has been supported voluntarily by the electric industry since our founding in 1973. Our members, public and private, account for more than 90% of the kilowatt-hours sold in the U.S., and we now serve more than 1000 energy and governmental organizations in more that 40 countries.

We appreciate the opportunity to provide testimony on “Energy Storage Technologies – State of Development for Stationary and Vehicular Applications”. My testimony today comes from the viewpoint of the electric power system and focuses on the role that electric energy storage plays in the power delivery system of today and in the future.

Today the power delivery system is a complex network of over 450,000 miles of transmission, 5 million miles of distribution, and 22,000 substations that tie together electricity supply and demand. At EPRI we partner with our members to ensure that this existing grid infrastructure is working reliably and safely, and that new technologies are available to meet future requirements. The power delivery system of the future, in a carbon constrained world, will be required to support both a new generation mix, with lower emissions, and a more effective participation by consumers in managing their efficient use of electricity. We believe that the ability to cost-effectively store electric energy will be an important part of this delivery system of the future.

Before I discuss the benefits of energy storage, I feel it would be worthwhile to explain how we operate the electric power system with only a small amount of electric energy storage today, and why this will change in the future.

The existing grid has operated for nearly a century as a massive just-in-time delivery system, providing electricity to meet demand practically as soon as it is generated and without storing in inventory. This is made possible by the size and diversity of the power grid, which allows system operators to ignore the small fluctuations associated with individual electrical load changes. When an electrical load turns on in one place, the effect is reduced by another turning off somewhere else. This characteristic allows system operators to follow load changes by throttling only a few generators. Large shifts in load occur daily over a period of hours and can generally be forecast, giving system operators the chance to schedule, dispatch and gradually ramp generation up and down according to the demand for electricity. Natural gas fueled turbines are the primary generation resources used to meet peak demands. Reserve generation, some actually spinning, is required to maintain reliability and to meet system contingencies.

This just-in-time electric delivery system requires that generation, transmission and distribution capacity are large enough to serve the maximum load that can occur at any point in time. The maximum load, for example on the hottest days in summer, can be significantly larger than the average load on the system, but may occur only once or twice a year. One consequence of the large variation in electricity demand and just-in-time delivery is that the power system assets are often under underutilized, such as at night and during temperate seasons. The overall utilization of electric generation in 2006, according to EIA data, was 48%. Utilization of the power delivery system in this traditional power system model is less than generation. Natural gas fueled turbines are the primary generation sources used to meet peak demands, and these plants remain idol most of the time. In effect natural gas also allows us to operate with only about 2% pumped hydro storage, a significantly lower supply than in Europe and Japan.

We believe that this traditional model will not work as well in the future as it has in the past. Our growing economy and rising standard of living continue to push the demand for electrical power upwards, but social, economic, and environmental reasons have made the construction of new generation, transmission, and distribution assets unattractive, particularly when those assets are underutilized. Even so new electric generation and related transmission resources will be needed. The changing nature of these resources will increase the need for energy storage on both the supply and demand sides. New electric energy storage technologies coupled with energy efficiency measures are keys to a better utilization of existing and future power system assets.

The large scale adoption of renewable energy technologies, with today's wind at the transmission level and future roof top solar at the distribution level, change the way utilities and grid operators will manage power delivery. Unlike conventional generation systems, which can be controlled by adjusting the fuel input, renewable energy technologies generate only when the wind is blowing or when the sun is shining. They cannot be controlled to meet demand and may provide insufficient energy to the grid when it is needed or too much energy to the grid when it is not needed. Specific cases are already documented where wind has challenged system operators in New Mexico, California and the Big Island of Hawaii. In all of these cases energy storage is being considered as a solution.

Another important factor related to the need for storage is the increasing cost of fossil fuels that has made their efficient use more vital than ever before. This is particularly true with the use of oil in the transportation industry. One important method of actualizing this improved efficiency is electrification with technologies such as the plug-in hybrid electric vehicle (PHEV). Energy storage technologies developed for PHEV applications, and made available via the smart electric distribution grid of the future, can provide grid support in the electric distribution system. In this application energy storage directly improves energy efficiency and reduces our dependence on foreign oil, with related advantages to security and society.

In the future cost effective energy storage will be needed to increase utility system asset utilization, support energy efficiency measures and allow the increased use of renewable energy sources, reducing the carbon intensity of the American economy. EPRI has identified several specific benefits to the expanded use of energy storage technologies in the electric grid, including the following:

- Enable integration of renewable energy such as wind and solar with the existing electric power delivery system;
- Improve reliability and security of the electric power delivery system by proving grid support both at transmission level and close to the point of use;
- Increase asset utilization of existing power delivery infrastructure, as well as potential deferment of the construction of new assets, by shaving peaks;
- Improve utilization of primary fuels and reduce domestic consumption of petroleum through the electrification of transportation; and
- Provide needed load following and regulation services to electricity markets.

A number of different energy storage technologies are being considered to bring these benefits to fruition. Each technology has advantages and disadvantages, which make it suitable for certain applications. For instance, sodium-sulfur batteries have made strong inroads in distribution level peak shaving applications, and lithium ion batteries are considered the energy storage technology of choice for plug-in hybrid electric vehicles. For utility-scale load leveling and storage of wind energy, pumped hydro has been the workhorse for the industry. However, suitable locations for new pumped hydro are considered to be limited, suggesting a promising opportunity for large-scale compressed air energy storage (CAES) that can be sited in many areas.

In a CAES system, electrical energy is used to compress air, which is then stored in a pressurized reservoir. The compressed air can later be used to generate electricity by passing it through an expansion turbine with heat input. The heat input is often delivered through the combustion of natural gas. Although natural gas is burned in these systems, the stored heat energy allows efficiencies that are more than double those of conventional gas turbines, with correspondingly low carbon intensity. CAES systems are usually designed on large scales, with power ratings in the hundreds of megawatts, and the capability to deliver that power for hours. Large underground caverns, salt domes or aquifers are used to store the compressed air. Two such systems have been built, one in Germany and the other in the U.S., with at least three others proposed in the U.S. to date.

The hurdles in bringing needed energy storage technologies on line are related primarily to economics and risk. Specific challenges are different for large scale central systems and for smaller, more distributed, energy storage technology options:

Hurdles to deployment of large-scale, transmission-connected energy storage: Construction of proven large scale technologies, such as pumped hydro and CAES, would immediately assist operators in the integration of wind and nuclear energy. However, the costs of implementing these technologies can be unreasonably large. For example a 200 MW compressed air energy storage plant capable of storing 800 MWh of energy can be expected to cost $200 to $250 million, not including the cost of siting and permitting.

The very modest amount of pumped hydro built in the US illustrates this issue. Today there are 38 pumped hydro plants with a summer peaking generating capacity of 21GW. Fifteen years ago FERC had license applications for 18 GW of new pumped storage (42 plants total, with 31 in the west). However, deregulation, relatively cheap natural gas, and risk adverse private investors led nearly all developers to back out of construction. Only one large plant was build, the 800-MW Rocky Mountain facility commissioned in 1995 in Northern Georgia.

Another hurdle is the aggregation of energy storage benefits, which are spread across a number of stakeholders. While there is little doubt that the net social benefits of these large storage plants are positive, the benefits are distributed among power produces, system operators, distribution companies, end users, and society at large. The decision to build a plant, however, must be made by a single entity, and it is often unclear how that entity can capture enough benefit to justify the investment. A specific case in point is a CAES plant proposed to support wind development in West Texas in 2002. In a study commissioned by the Lower Colorado River Authority the sum total of all benefits for this large scale plant were clearly shown to exceed the cost. However, benefits were shared by wind plant operators, local power distributors, an independent system operator and rate payers. Not any single value stream, by itself, could secure financing.

Also impeding investment in large scale energy storage is that current situation where electric storage is not clearly defined as either a generation or a T&D asset in most jurisdictions. This presents a problem for deregulated utilities who would like to invest in storage. If a transmission utility invests in a system, and a ruling subsequently classifies that system as generation, the utility will have made a large investment it cannot recover.

Hurdles to deployment of smaller-scale, distributed electric energy storage: Distributed energy storage holds great promise for improving utilization of distribution assets and enabling a future grid with PHEV, roof top solar and distributed power system communication and control ("smart grid"). The actualization of this potential requires significant investment to develop, demonstrate and deploy new technologies. The utility industry is generally not in a position to make this initial investment, although there is high interest for trying out promising grid-connected technologies. Department of Energy programs to develop, test, and demonstrate energy storage technologies are believed to be right on target regarding utility industry interests in the distributed systems. More opportunities to partner on first-of-a-kind applications in different regions, and under different grid operating conditions, will be welcomed.

In the future EPRI will continue to work with its members and the Department of Energy to help realize the untapped benefit of new energy storage technologies in the electric power industry. We believe that the expanded use of energy storage is important to improving the efficiency, reliability and security of the electric power delivery network. Energy storage applications in both the transmission and distribution grid will be essential to meet the growing demand for electricity, using low emitting generation technologies, and gaining the full value of end-use energy management.