ECONOMIC GAIN THROUGH ENVIRONMENTAL INNOVATION
Sustainable Industries

Saving for a rainy day

by Matt Krogh - 2.2.09


Solar panels in Nevada

>In August 2003, overheated and sagging transmission lines caused power outages that cascaded through much of the Northeast, the Midwest, and Southeast Canada, shutting down interconnected local grids and cutting off service to 50 million customers. The meltdown cost the nation between $4.5 million $8.2 million, according to Anderson Economic Group.

>In the five years since the epic blackout, a national push to increase supplies of low-carbon renewable energy—much of which is variable in nature—has taxed the ability of the nation's grids to accommodate even more frequent power fluctuations, resulting in nationwide costs from power interruptions ranging from less than $80 billion to more than $120 billion annually. More interesting, momentary interruptions are responsible for more than two-thirds the cost.

>The need to mitigate grid interruptions and firm up variable power as a reliable grid component—potentially a game-changer for the renewable energy industry—is driving a boom in energy storage development, with diverse new technologies providing ancillary services for grid reliability as well as bulk energy storage.

>"There is a tremendous amount of [development] going on worldwide related to energy storage, from the kilowatt up to the megawatt (MW) range," says Mike Howard, senior vice president at the Electric Power Research Institute (EPRI).

>In 2007, the market for grid energy storage including all different types of power reserves for ancillary services was $2.4 billion, according to Lux Research, an emerging technologies analyst firm. Lux predicts the bulk grid energy storage portion of the market will grow to $600 million by 2012; but it also estimates that if 10 percent of current wind farms implement large-scale energy storage, the energy storage market would exceed $50 billion.

>Venture capital has been powering energy storage companies. Greentech Media reports that in the third quarter of 2008, $80 million of venture capital went to renewable-energy-related batteries and energy storage, bringing total 2008 VC investments in energy storage technologies to $170 million. Hopkinton, Mass.-based A123, primarily a maker of transportation batteries, but also of grid-scale batteries, raised $149 million in the past year.

>“In the utility space we certainly see tremendous opportunity to marry the world of information technology and power electronics alongside advances in storage to transform the utility grid into a ‘digital’ grid,” says Marc van den Berg, managing director at VantagePoint Venture Partners.


Solar Two in Nevada uses molten salts as storage for solar energy.

>**Back-up players**

There is no question that demand for energy is on the rise. Between 2007 and 2018, analysts forecast a 15.4 percent increase in U.S. electricity generation, while the population grows from 301 million to 314 million, according to The U.S. Power Report, published by the Business Monitor International. Increased demand coupled with a quickly aging transmission grid (often located far from quality wind and solar power sites) is creating a huge market for energy storage companies targeting different niches.

>Storage types are best differentiated by the speed with which their stored power can be delivered in response to grid demand. Rapidly available power sources, while expensive to develop, provide needed flexibility to the grid. Recent developments in flywheels, batteries and compressed air energy storage (CAES) have made providing that flexibility via energy storage a viable business proposition.
In recent years, battery technology has taken a huge step forward, with grid-scale systems installed in multiple locations around the country [see “Batteries included,” Sustainable Industries, Jan. 2008].

>In Southern California, AES (NYSE: AES) has installed two of A123 Systems’ 1 MW lithium-ion battery systems. According to AES, the batteries will allow them to better moderate for wind variability while providing ancillary control of frequency and voltage. A123’s CEO David Vieau predicts that by 2009, the company’s H-APUs (Hybrid Ancillary Power Units) at AES sites will be the largest fleet of battery storage systems in operation on the electric grid, with round-trip efficiency of 90 percent and faster response than existing plants.

>Meanwhile, Xcel Energy (NYSE: XEL) is testing NGK's sodium-sulfur batteries at a Minnesota wind farm. The 1 MW configuration with 7 megawatt-hours of capacity when paired with an 11 MW wind farm, would provide onsite direct storage that reduces the need for additional transmission and smooths power flow.

>Flow batteries that use electrolyte solutions have been advanced by companies such as VRB, (which has recently halted operations for economic reasons). While flow batteries promise a much higher storage capacity than other battery types, they have yet to be installed to the level of more traditional lead-acid or lithium-ion batteries.

A 7.2 megawatt-hour battery in Minnesota.

>Another storage device, flywheels can react quickly to changes in the grid. Along with battery systems, flywheels can prevent the need for excessive throttle control of large generation facilities. Increased demand for fast-response storage technology, along with more sophisticated flywheel and battery technology, has given companies such as flywheel developer Beacon Power Corp. (NYSE: BCON) a much-needed boost into the marketplace. Tyngsboro, Mass.-based Beacon has created a scalable 1 MW solution that can provide real-time energy in configurations up to 20 MW.

>Compressed air energy storage (CAES) developers are also getting into the energy storage arena. CAES works by pressuring massive volumes of air, then incorporating pressurized air into gas turbine technology. Compressed air can reduce the natural gas needed for a given amount of energy by as much as 67 percent. Though rare, CAES is a proven technology—the world's second-ever system has been operated by Alabama's Electric Cooperative (AEC) since 1991, capable of providing 110 MW for 26 hours and used for off-peak storage, peak generation and spinning reserve.

>Energy developer CAES Development Co., commonly known as CDC, has announced permitting and the start of construction of a planned 2,700 MW storage and generation system in Norton, Ohio. Unlike AEC's project, which utilizes a salt dome for compressed air storage, the Norton facility employs a limestone mine (and designated brownfield site).

>While new to the scene, CAES developer General Compression is poised to enter the energy storage scene with a system that uses direct

mechanical compression in place of electric generation to pressurize stored air; then uses standard gas turbine technology enhanced by compressed air to retrieve the energy.

>**Renewables in moderation**

Moderation of renewables and their increased penetration is driving much of the development of new storage, says Tim Mancini of Sandia National Lab. Wind developers contend that most grids are flexible enough to accommodate up to 20 percent of energy from variable sources, but utilities and agencies such as the Bonneville Power Administration (BPA) may need that flexibility for other purposes—creating conflict with higher levels of wind penetration.

>"In the BPA control area, we're witnessing under-scheduling and over-generating (of wind) because of our underperformance penalty....the trouble with wind is, they have difficulty forecasting it," says John Pease, a project manager for BPA.

>Because of the difficulty of forecasting, Oregon State University researchers have started evaluating energy storage technologies that will support wind prediction efforts on the BPA grid. According to Ted Brekken, assistant professor at OSU's School of Electrical Engineering and Computer Science, students are testing storage systems that will be able to cover the difference between predicted and actual wind generation on an hour-by-hour basis. Wind farms that integrate storage capacity have a better ability to provide reliable power that won't be penalized by under-generating or failing to meet bids. BPA fines wind producers 110 percent of market cost of their shortfalls on 24-hour bids, while other systems fine as much as 250 percent of the bid shortfall.

>Pumped hydro, currently the most heavily used grid storage technology with over 15 gigawatts of capacity installed across the United States, is also infrastructure- and cost-intensive. Most systems consist of two linked reservoirs, a lower and an upper, that pump water up in low-cost, low-demand times, or generate electricity in periods of high energy prices and high demand. Hydropower is frequently used for energy management, frequency control and reserve, with an 80 percent round-trip efficiency, according to the Electricity

>**Storage Association.**

Creating more pumped hydro faces difficult environmental challenges and huge capital requirements totaling about $1 billion over 10 years, according to Pease. Pumped hydro is a good solution, but a long-term commitment, he says.

>New solar thermal storage technologies such as those under development at Sandia National Laboratory may be the next best bulk storage solution after pumped hydro. Sandia's development of molten salt thermal storage systems has already led to the construction of power plants in Nevada and California, including Solar Two and Solar Tres, a project of Torresol Energy nearing completion in Spain.

Abengoa Solar is building the world's largest solar plant near Phoenix, Ariz. The 280 MW concentrated solar plant includes thermal storage using molten salts. When fully operational, the plant would have the capacity to supply power to an estimated 70,000 homes.
Unlike photovoltaic arrays, which are susceptible to rapid reductions of power, stored solar thermal is decoupled from generation so it can be stored for days before being used for power generation. Its primary drawback may be constrained storage location—it's hard to move a tank of molten salt 14 meters tall and 40 meters across (the size of Andasol's plant under construction in Spain).

>New energy storage technologies provide a business opportunity for systems able to buy and store off-peak load for lower prices and sell it back into the market during the highest-priced peak generation times. Utilities like it because it cuts down on the need for new, expensive peaking plants; energy storage companies see it as a compelling business model.

>**The next frontier**

Not everyone agrees that storage is the key to integrating renewables into the grid, especially when costs for energy storage are compared to current costs of providing grid flexibility. Smart grid proponents argue that a better-interconnected and -managed national grid will smooth wind and solar intermittentcy by allowing remote generation to contribute at any part of the grid.

Smart grid development and increased connectivity—increasing the "control area"—have attracted a lot of attention because they can reap benefits without being infrastructure intensive. San Diego's 2006 Smart Grid Study showed that a $450 million investment would reap $1.4 billion in benefits, while Southern California Edison's new $1.46 billion smart meter program is projected to save 1,000 MW in peak power consumption, preventing the need for a new power plant.

>Changing the way power moves around the grid may solve some of the problems related to reliability and intermittentcy, but creating a more highly interconnected and managed grid won't be easy. "Jurisdiction is a huge problem," says Mancini. "It's a tough game to play when [the Federal Energy Regulatory Commission] has interstate jurisdiction, and states have intrastate jurisdiction." He adds that it will likely take changes in actual jurisdictional control to create a modern national grid.

>But according to Pease, smart grid's promise has gone unfulfilled in part because it provides reliable energy delivery but no new capacity. Storage systems allow incorporation of new variable sources far from the main parts of the grid—creating new capacity-—while also allowing new generation to utilize smaller transmission systems by spreading load over a larger period of time. Storage is also capable of improving the generating capacity of traditional power producers.

>One study of traditional coal-fired plants with compressed air storage shows an improvement from 71 percent to 77 percent utilization when storage is incorporated, also allowing nighttime generation (when emissions cause fewer smog issues) and peak shaving during the day.

>The recent boom in energy storage development hasn't been without a few hiccups, however, with the current recession curtailing some companies' renewable energy and storage-related efforts. Vancouver, BC-based VRB, once a leading proponent and manufacturer of vanadium flow-batteries, has recently had to stop operations and file for reorganization under Canadian bankruptcy regulations, while Avista Corp.'s (NYSE: AVA) planned 50 MW wind farm in Washington State (see "Avista delays wind farm," page 36) has been put on hold indefinitely.

>Others have seen the current climate as an opportunity, however, with Warren Buffet's investment firm putting $230 million into Chinese battery maker BYD Co. Ltd., and GridPoint Inc. (a smart grid and distributed energy storage company) receiving $100 million of venture capital in September 2008.

>In the meantime, RPS requirements for higher penetration of renewables are creating demand for hundreds of gigawatts of storage capacity nationwide.

>"Storage in particular represents an interesting space in itself in that the utility market has many drivers for distributed storage, but so does the telecom market, commercial businesses and the military," says VantagePoint Venture Partners' Marc van den Berg. "... This is just the kind of stuff we in the venture community love."

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