THE STATE OF ENERGY STORAGE

By Ellen Gooch

Energy storage is a (mostly) young industry and like many young industries it boasts a host of competing technologies, in various stages of maturity, each with their own benefits, drawbacks and ardent (occasionally rabid) supporters.

Key differences between the technologies include variations in cost, life cycle, durability, safety, density, the amount of discharge capacity (MW) and energy storage capacity (MWh) each can provide, as well as response time.

The oldest energy storage technology and today's storage leader, with nearly 99% market share and an installed base of more than 120,000 MW, is pumped hydro. Developed in the 1890s and installed globally following World War II, conventional pumped hydro requires two properly situated bodies of water conveniently free from environmental activists. There hasn't been a new installation in the US since the 1980s.

The second oldest type of large scale storage is compressed air energy storage (CAES). Worldwide, there are currently only two large installations that use this technology, one in Germany (290 MW) and one in Alabama (110 MW). Significant research is currently being undertaken to create a lower cost, higher efficiency types of second generation CAES, both underground (which can have a higher capacity) and above ground.

Next up we have flywheels. With a nearly instantaneous response time, high efficiencies, large power density and long cycle life, these can be used for such applications as frequency regulation and power quality. However, fly wheels currently cannot store enough energy to be suitable for large-scale grid support applications. Again, research is underway to improve the technology.

Then there are flow batteries, the most mature of which is Vanadium redox, which has been deployed in the field. Other types include Zn/Br, which are in the early stages of verification, and Fe/Cr and Zn/air, which are undergoing laboratory trials. With quick response times and long cycle lives, flow batteries have great potential for the utility market.

More technologies heading down the pike include sodium-metal halide, currently in development at GE (which is opening a manufacturing plant in Upstate New York capable of delivering 10 million battery cells a year, approximately 900 MW worth of storage), Lithium air, zinc air, underground pumped hydro and nano-supercapacitors, to name a few.

Which, at long last, brings us to the most mature storage systems for large scale utilization today, and the only technologies besides flywheels that offer near instantaneous response time. First is sodium sulfur batteries (aka NaS). These are produced by a consortium controlled by Tokyo Electric and NGK Insulators. The utility service company, Rubenius, is planning to build a 1 GW sodium sulfur facility in Mexicali, Mexico and has contracted to purchase 100% of the consortium's output for the next 6 to 10 years, thus ending further discussion today on this technology. The other mature battery technologies are lead acid (and various types of advanced lead acid) and Lithium batteries in some of their myriad "flavours", the differentiating details of which I intend to spare you.

The truth is, for the point of view of electric utilities, commercial and industrial (C&I) customers and even individual energy consumers, the type of battery (or, really, technology) used for large scale storage is pretty much irrelevant. What such entities want is a box – in many cases a really, really big box – that can achieve certain clearly defined goals – profitably.

BATTERY SYSTEM COST

With respect to profit, one of the topics most discussed, particularly in regards to Lithium batteries, is cost. Estimates for near and mid-term projected costs for Lithium batteries, as delivered by various research entities such as Lux, TIAX and Pike, are all over the map. Here is what we do know:

- Traditional Lithium cells are used in consumer devices, a category not known for overspending on components
- As volumes increase, costs will decrease
- Loads of research, much of it funded by the US Department of Energy, is being conducted, notably at the materials/chemistry level, to reduce cell costs
- The cell is only one part – albeit the most important part – of a battery system. As deployments increase and data is gathered, improvements in efficiency/costs at the system level will take place. Anyone who owned a personal computer in say, 1992, and now owns an Apple iPad, can understand that systems, regardless of function, improve over time
- Expense is relative. Large-scale utility systems are not commodity products. With the possible exception of community energy storage (CES) or UPS, neither are they off-the-shelf products. Each system is targeted to achieve a goal, or, more likely, a series of goals. When a system is capable of meeting several goals such as, for example, transmission and distribution (T&D) support and deferral, back-up capacity, and other ancillary services, it becomes more cost effective. This is borne out in the real world. While grants have been provided for the deployment of both Lithium and lead acid battery systems, such systems have also been purchased without the benefit of government largesse. I think it is safe to assume that the purchasers of these systems did so because they believe they will profit from them.

I would also like to debunk a current "truism" making the rounds of the internet blogs: there is no shortage, nor will there be a shortage of Lithium. Lithium accounts for less than 1% of a battery cell's active components. Even if Lithium battery production – or bi-polar disease requiring Lithium-based pharmaceuticals – miraculously spiked without warning, it would take less than two years to open new Lithium mines.

That said, there are several trends that will have a direct effect on the increased adoption of storage technology.

THE RISE OF RENEWABLE MANDATES

The EU has the Directive on Electricity Production from Renewable Energy Sources, which, while not yet a mandate, sets a goal of 20%

of energy production from renewables by 2020. Some EU member states have set higher goals. Germany wants the percentage to reach 35% by 2020.

Elsewhere in the world, China has set a target of 15% by 2020 and Australia has set a target of 20% by 2020. In the US, there are the Renewable Portfolio Standards (RPS). RPS, also know at the US federal level as Renewable Electricity Standard (RES) (legislation has stalled), are regulations that require a percentage of energy generation to come from renewable sources. Thirty of 50 states in the US, as well as the District of Columbia have such regulations. They vary in size of percentage, enforcement and definition of what constitutes a renewable resource (some count nuclear energy as a renewable resource, for example). In some places, certain types of renewables are preferred over others and are thus rewarded at a higher level. RPSs also vary in timeline: many state's RPSs won't kick in for five years or even a decade. The most ambitious is the RPS of the state of California, but New York is also determined. It plans on generating 30% of its energy needs through renewable resources by 2015.

Renewable energy is most often, as is the case with wind and solar, intermittent energy. It is difficult to effectively integrate intermittent energy into the grid. Frequency regulation is required. Wind farms often use capacitor banks (old school storage). Most of the energy assets which provide frequency regulation today are gas turbines, accounting for about 1% of peak load. As more renewable sources come on line, the need for frequency regulation will increase, possibly by double. This is where fast response storage comes in handy. Such storage can handle frequency regulation, keeping the grid at the sweet spot of 60 Hz, without the need for supplementary fuel. In addition, storage can provide other services that gas turbines cannot, such as other ancillary services and energy arbitrage.

> ***"If energy prices continue to rise, consumers might find that it actually pays to be green"***

OUR FRIEND THE FERC

Another regulation sure to effect the adoption of energy storage (at least in the US) is a new proposed ruling, currently under review, at the Federal Energy Regulatory Commission (FERC). This proposed ruling notes "the emergence of technologies capable of responding more quickly than the generators that have historically provided frequency regulation service." The rule would ensure that these other technologies (read: energy storage) would be protected from undue discrimination, would receive "reasonable compensation" and would also receive performance payments which would reflect a resource's accuracy of performance. Fast response energy storage is highly accurate.

ELECTRIC CARS COME OF AGE

A few months ago, the *New Yorker* ran a cartoon that touches the heart of energy storage. In it, two men stood in front of the American embassy in Tehran in 1973. One turns to the other and says, "A popular uprising in the Mid-East! – What could go wrong?"

No matter how laudable the region's intentions, the fallout from the Arab Spring is wholly unpredictable. This makes energy independence crucial. The vast majority of petroleum in the US is used in the transportation sector, for which the US spends about one billion dollars a day. This is why the US government is expending so much effort on diversifying energy sources for the transportation sector. One possibility is alternative fuels, which would require a new delivery infrastructure(s). Another is vehicle electrification, which has a delivery mechanism in place – the electric grid. True, modifications would need to be made and charging infrastructure better established; and, true, large scale deployment of electric vehicles would strain an already straining grid. But this is where energy storage can come in. Not only can it reduce the need for additional generation, it enables the ease of integration of renewable sources into the grid.

There is some argument that this will never happen – that electric cars are too expensive for anyone besides granola liberals and movie stars. First, as I have already argued, Lithium battery system costs will come down. Second, I'd be willing to bet that gas prices are going to go up, making EVs and hybrid EVs (HEVs) more attractive.

ENERGY ARBITRAGE – BY THE CONSUMER

As Kermit the Frog once said, it's hard to be green. Most consumers, whether they are individuals or commercial and industrial, would be thrilled to have a shiny, pollution-free world, as long as they don't have to pay much more or, preferably, nothing more for it. I have a friend whose parents live in California and have installed on their roof a solar panel. One of their greatest joys, she reports, is sitting with a glass of chilled chardonnay in front of the electric meter, watching it turn backwards. This constitutes a consumer trifacta: getting something for "free", feeling noble while doing so, and sticking it to big business. I'm not going to tell them how much of the energy they generate is actually not absorbed by the grid but instead released into the atmosphere as polluting heat. Why rain on their parade?

In a more practical world, such photovoltaic cells would instead be attached to storage. This would allow consumers to store energy when the sun shines and use it when needed, without losses.

For consumers in less sunny climes, storage can still be important. If energy prices continue to rise, these consumers might find that it actually pays to be green, or at least the sort of green that conserves energy through storage. It is coming to the point that the cost of purchasing storage and deploying it will be less expensive in some places than purchasing energy through the grid whenever you may need it – especially if you require it during times of peak demand. Further, in a smart grid, such distributed storage sources provide an additional level of flexibility to grid operators, allowing them access to this energy as needed (for a price, presumably). In short, using storage, any consumer big or small can participate in energy arbitrage, managing their demand on the grid to reduce costs. Such is, in part, the reasoning behind such movements as C&I energy management, community energy storage (CES) and the net zero home.

The energy sector is an immensely complex and mutable ecosystem, but it is clear the storage will become an important part of its structure. MI

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