Research, Analysis & Strategic Solutions

Electricity Storage Technologies – Time for Utility Engagement?

This Research Brief will examines how utilities are engaging with emerging storage technologies.

It is based upon Delta's Multi-Client Study on this topic.

June 2008
Delta Energy & Environment
www.delta-ee.com

Key Points

- A number of new electricity storage technologies are emerging. Some are still firmly in the laboratory, while others – for example, sodium sulphur batteries and flywheels - have already found their way onto utility networks.
- A handful of utilities are rolling up their sleeves and engaging with these technologies – with most examples in Japan - Tokyo Electric Power has sold and installed over 100 MW of batteries. North America follows, then Europe. Other utilities are watching closely, but the vast majority are sitting on the sidelines.
- Several factors are driving this engagement, including increased wind power penetration, ageing grids, provision of ancillary services and grid constraints.
- Storage drivers are moving in only one direction - forwards, increasing the likelihood that these emerging storage technologies will play an important role in future electricity markets.
- There are pros and cons of early utility engagement – on balance, Delta believes that the pros outweigh the cons for most utilities.

Electricity storage's time may finally be arriving. New storage technologies are being deployed and demonstrated, and investors are paying increasing attention to storage technology developers, in part because they are likely to be critical enablers of low carbon electricity markets.

It is the utility – including network companies, vertically integrated utilities and transmission system operators – that stand to gain the most value from these technologies. However, only a handful of utilities are currently actively engaging with them.

The next pages describe how utilities are engaging with electricity storage technologies.

Figure 1
A 250 KW FLOW BATTERY SUPPORTS A UTILITY NETWORK IN UTAH

Source: VRB Power Systems

Delta Energy and Environment
Research, Analysis & Strategic Solutions

June 2008

Delta Research Brief

The Emerging Technologies

Table 1 provides an indication of the development status of the technologies. The only widely used electricity storage technology at present are pumped hydro stations, with over 100 GW of storage capacity worldwide – about 2% of global generating capacity.

Table 1
TECHNOLOGY DEVELOPMENT STATUS

Commercial	Pre-Commercial	Demonstration Phase	Developmental
Pumped Hydro Flywheels (local power quality) CAES Lead Acid Battery Ni-Cad Battery Sodium Sulphur Battery	Flywheel Flywheel (Grid device) Zinc-Bromine Battery Vanadium Redox Battery	Electrochemical Capacitor Hydrogen loop	Lithium Ion (grid applications) SMES (grid applications)

Source: Delta Energy & Environment

What is Driving Utility Engagement?

The title of this section may be misleading; the truth is that the majority of utilities are not engaging directly with emerging storage technologies. Most are aware, and some are keeping a close eye on technology developments, but less than a dozen across the globe have installed systems on their networks. The drivers of this engagement are summarised below.

Grid Upgrade Deferral

This application has come to the forefront in the United States, where weak grids and long rural feeders provide drivers for some utilities to consider electricity storage. Increasing demand for electricity (especially summer peaks, driven by increased use of air conditioning) and an ageing infrastructure are requiring large-scale renewal of distribution assets.

In many regulatory regimes, utilities can construct a new transmission or distribution line and recover the costs through use of system charges or another form of regulated return. However, in some jurisdictions, putting off capital expenditure on grid upgrade for several years can be very attractive. Here, storage is used to meet a proportion of daily peaks, meaning average load on the network or transformer can be allowed to rise significantly

There are only a few installations of electricity storage for grid upgrade deferral. American Electric Power, for example, installed the first sodium sulphur (NAS) battery in North America primarily to defer grid upgrade on a rural feeder (Figure 2). PacifiCorp installed a vanadium redox battery for the exact same application in Utah.

Figure 2
TECHNOLOGY AEP'S NAS INSTALLATION

USA Today , 2008

Utility Reliability Improvement

Utilities often have reliability targets imposed on them by regulators, or from customer demand for a premium product. The costs of planned and unplanned outages vary from country to country but can become very significant beyond a certain number of outages a year. In areas with a weak grid, the ability to island all the demand on a feeder using storage is potentially very attractive to utilities facing regulatory punishment for excessive blackouts.

Storage can be appealing to utilities that have long isolated feeders in remote areas – grid reliability is low and the alternative (installing a contingency feeder) is an expensive and time-consuming process. In addition, customer expectations for reliable power, as well as costs of blackouts, are constantly increasing. These factors are driving American Electric Power to install another two battery installations in 2008.

The best-known example of storage installed for this application is Golden Valley Electric Association's (GVEA's) 27 MW nickel cadmium system in Alaska (Figure 3). Pacific Gas and Electric is another high profile utility installing storage specifically to increase reliability – a 6 MW zinc bromine flow battery will be installed at a substation in 2009.

Figure 3
GVEA BATTERY HOUSE

SAFT, 2003

Load Shifting and Bulk Arbitrage

Storage can also shave the demand peaks and fill in the troughs. Lowering daily peaks provides obvious benefits to the electrical system as a whole: a smoother demand profile at any point on the network allows generation to operate at optimum capacity and reduces the need for peaking plant. Load shifting using storage is particularly attractive in a number of specific situations:

- Poorly inter-connected or small transmission systems - for example Japan – where the eight utility areas are very poorly interconnected.
- Small systems with little generation, including islands, where storage allows diesel gensets to be smaller and to run more efficiently. This is a key area of interest for storage in parts of Europe.
- Systems with high nuclear penetration including, again, Japan.

The Tokyo Electric Power Company has supported over 100 MW of storage at its industrial customer sites. Japan is the one country in the world where underlying imbalances between supply and demand have made for day-night price differentials that make load shifting attractive in a number of sectors.

The New York Power Authority (NYPA) is also working with one of its customers, the Metropolitan Transport Authority of New York, to install a 1 MW battery at Long Island bus station. The purpose of the on-site battery is to shift the station's grid demand from day to night.

Renewables Grid Integration

Many wind/solar farms are located in remote areas served by low capacity radial distribution networks. These networks often have insufficient capacity to ship the power to demand centres when the turbines are generating at full capacity. High

Delta Energy and Environment
Research, Analysis & Strategic Solutions

June 2008

Delta Research Brief

penetration of wind can also bring grid stability issues on specific lines, for example with frequency and voltage control problems. These situation-specific grid issues have meant that grid companies in some markets are increasingly reluctant to guarantee connection for new wind farms.

There are many examples of grid systems struggling to cope with increased wind penetration:

- Spain is rapidly approaching its limits in coping with wind. The system operators are now approaching a stage where they are being forced to curtail wind farms if they are to be connected.
- Ireland is probably the most promising market in Europe for storage to integrate wind into the grid. A weak grid, with little interconnection and a huge wind resource combine to offer a great opportunity for storage. A 6 MW flow battery is to be installed on a 32 MW wind farm and, if successful, this could kick start a strong new market for storage.
- The primary wind development area in California (with a potential of 4,500 MW) is connected to the main load centres by a very constrained transmission line. Although a new line may be built in the future, storage is being considered to enable wind developers to connect in the shorter term.

Renewables Output Firming

Firming of intermittent renewables, especially wind, is an issue that utilities are growing increasingly concerned about. The concern is manifesting itself in three ways:

- At high levels of wind penetration, electricity generation may exceed demand or may interfere with the running of baseload plants, such as nuclear.
- Inability to forecast variations from wind power at a resolution of seconds and minutes will sometimes lead to rapidly changing levels of generation – a particular concern is where wind *increases* push every turbine on a windfarm over its cut-out windspeed, meaning generation can drop by tens or hundreds of megawatts in seconds.
- Forecasted changes in wind generation (over tens of minutes and hours) will put a premium on flexible and peaking generation.

These issues are manifesting themselves in a number of markets, including Texas, Ireland and Japan. The Japan Wind Development Company is installing 34 MW of batteries at its 51 MW wind farm in Rokkasho (Figure 4).

Figure 4
WIND FIRMING IN JAPAN

Japan Wind Development Company, 2007

Ancillary Services

Historically, vertically integrated utilities provided their own ancillary services, but today market reforms have opened up the provision of these services as regulators try to drive down costs. Storage technologies can be well suited to provide several of these services – in fact, provision of ancillary services may well provide the greatest financial opportunity for emerging storage technologies in the coming years.

Frequency regulation offers perhaps the best opportunity. Beacon Power, a flywheel manufacturer, is stepping up to take full advantage of this. It plans to con-

Delta Energy and Environment
Research, Analysis & Strategic Solutions

June 2008

Delta Research Brief

struct 20 MW flywheel plants in the U.S. to provide a frequency response service to the system operators.

Provision of primary reserve is another example of an ancillary service. Energinet.dk, the Danish TSO, is evaluating a VRB system flow battery at Riso for just this application. The TSO sees this option as a potentially cheaper alternative to purchasing this service from a conventional power plant.

What Should Utilities Do?

Delta classifies these storage technologies as "emerging" because they are approaching commercialisation or have recently been commercialised. However in most cases they are still expensive, and do not offer a compelling economic proposition. Utilities shutting their eyes to these technologies may feel that they are not missing anything of significance.

Careful consideration of a utility strategy may result in a decision to do nothing now. But we believe that drivers for storage can only become stronger – not weaker - and that the long-term future for storage looks very rosy. The electricity network in the U.S. will become more and more constrained and the bureaucratic hurdles associated with laying new transmission lines will remain prohibitive. The European network may be strong, but ever-increasing penetration of renewables is quickly causing serious problems. And importantly, the cost of storage technologies is falling.

While there are alternatives to solving some of the challenges, the promising results from current installations suggest that there will be a clear place for these technologies in the electricity networks of the near future. How big a place and how near a future is not clear-cut, but utilities that engage now will be well placed to be nimble in their response as opportunities open up in the future. And in some applications, such as provision of ancillary services, first movers will gain a significant advantage over their competitors.

For further information on how Delta can assist you in the electricity storage sector please contact Jon Slowe (+44 141 227 3982).