DELTA Energy & Environment

Delta Research Brief

Electricity Storage: Will Europe Follow in the Footsteps of Japan and the US?

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2009 will herald the dawn of emerging[1] electricity storage technologies on European electricity networks. A handful of utilities will install these systems on their grids to learn about the various value streams that storage can offer their business. However, it will take time for these benefits to be fully understood and technology costs to become competitive with traditional alternatives for widespread deployment. This paper will analyse successfully emerging markets in Japan and the U.S and then determine if Europe holds similar potential.

THE CASE FOR STORAGE GROWS STRONGER

Today's centralised electricity system is built around the fact that electricity cannot easily be stored; but must be generated when it is needed, creating a myriad of supply and environmental challenges. Constantly fluctuating demand requires fossil plants to ramp up and down. Aging power grids struggle to cope with peak demand and supply. The introduction of non-dispatchable generation such as wind, solar and combined heat and power (CHP) is adding to system operators' headaches of maintaining a constant balance between supply and demand. These are the issues that are increasingly driving a wave of new innovations in how to manage our outdated electricity systems. Electricity storage is emerging as a front-runner in this field.

What does storage offer the Electricity System?

Today, a range of emerging electricity storage technologies offer a means for utilities and network operators to manage these new challenges.

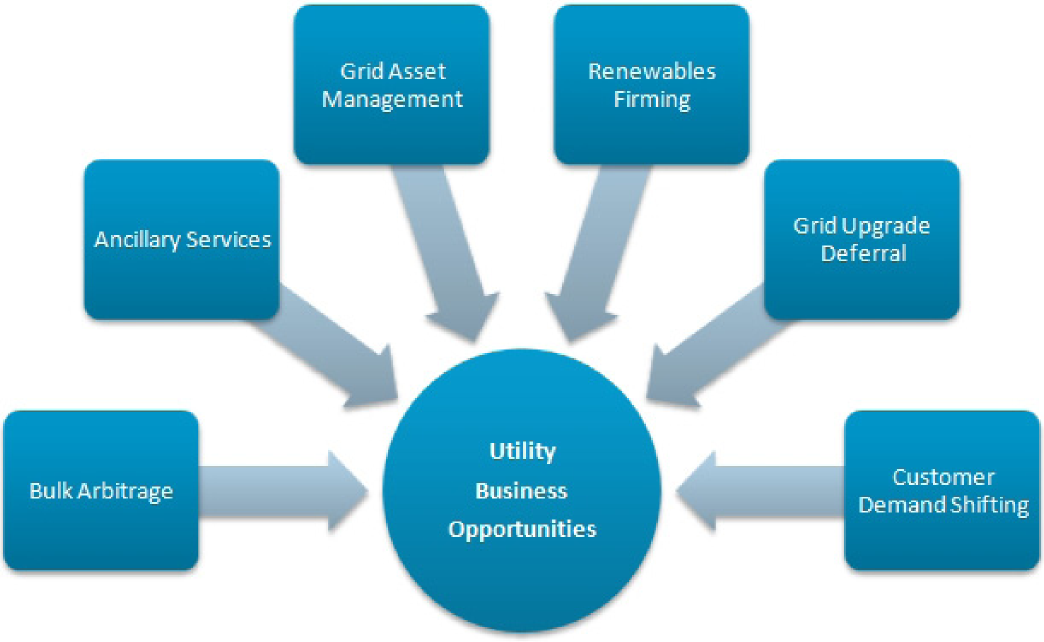
Applications for electricity storage, outlined in Figure 1, include:

- **Storing power from intermittent peaks of wind and solar generation, rather than resorting to costly and time-consuming investment in grid reinforcement;**
- **Firming the output from renewable generation, allowing the generator to sell dispatchable power to day, week and month-ahead spot markets;**
- **Smoothing the most severe demand peaks as peak load on a network increases, allowing the network operator to defer upgrading the network until it is economically viable to do so;**
- **Reliable power storage for areas at risk of outage, while damaged transmission lines are repaired or generation is brought on line;**
- **Night storage of cheaper off-peak power for energy-intensive industrial customers to use during the day.**

[1] This article does not consider the already established pumped hydro market. In many markets, most suitable pumped hydro locations have already been exploited.

Figure 1: Electricity storage offers a range of value streams to today's utility

It is only when an electricity storage solution taps into two or more of these value streams that it begins to make commercial sense. This can prove difficult to achieve, especially to an unbundled utility.



Delta Energy & Environment, 2009

Significantly, the challenges that storage addresses are all exacerbated by increasing amounts of decentralised energy (DE) and renewable generation on an aging grid – an increasingly pressing issue for many North American, Asian and European systems.

However, it is only in two of today's major markets that storage can be found in these utility applications – primarily in Japan, and a fast-emerging market in the US. Why is this? And why not in Europe, the global leader in DE and renewable generation?

> Japan's unique power system, comprised of ten poorly interconnected utility supply areas, makes it an ideal market for storage

JAPAN: THE BIRTHPLACE OF UTILITY-SCALE STORAGE OPERATIONS

Japan is the clear global leader in distributed storage deployment, with around 250 MWe capacity already installed (the vast majority of which is the locally developed sodium sulphur battery from NGK Insulators, as seen in Figure 2).

Japan's situation is a special case. Its power system is comprised of ten utility supply areas with very little interconnection capacity between them, in some cases less than a tenth of the peak demand of the area. Due to this limited interconnection, the utilities are required to keep a balance between supply and demand in their respective territories, an unenviable challenge in a country with large fluctuations in peak demand.

Figure 2: 1.2 MWe NaS battery installed at NGK's own facility

With over 270 MWe capacity installed globally, NGK is the clear market leader in the emerging storage technology market. however, many other technologies are now approaching commercialisation and will soon undercut NGK's current market price.

NGK Insulators, 2008

Japan's nuclear baseload helps drive the case for storage

Japan's baseload power is provided largely by nuclear (over 25% of total supply), and the 10 utilities would like to keep this running as continuously as possible, without ramping up or down to facilitate generation from the likes of wind and solar PV. However, Japan still has quite a way to go to satisfy its Kyoto Protocol targets for PV and wind:

- **PV: 4,820 MW in 2010 (1,422 MW installed by 2007)**
- **Wind: 3,000 MW in 2010 (1,538 MW installed by the end of 2007)**

This is causing the electricity companies considerable concern. Not only due to the large capacity of inflexible nuclear, but the transmission of this renewable generation from areas of generation to demand is extremely difficult through the spinal, poorly interconnected transmission system.

Japan's unique challenges with respect to its power system make it the ideal breeding ground for an emerging technical solution such as storage. The world leader in emerging storage technologies hails from Japan – NGK insulators has been developing its high-temperature sodium sulphur (NaS) battery for over 20 years in partnership with Tokyo Electric Power Company (TEPCO). It now has over 270MW of its battery systems installed globally, the majority in Japan at the sites of TEPCO's energy intensive industrial and commercial customers. The NaS battery is used to store electricity at night to be used on-site during the day, reducing the peak demand on the network and allowing the nuclear baseload to run uninterrupted.

The Future of storage in Japan - business as usual

Delta expects Japan to continue to lead the world in advanced electricity storage deployment. New wind farms will be encouraged to install storage to make their output dispatchable and TEPCO will continue to offer its customers attractive rates to shift their peak demand.

THE US: A RAPIDLY EMERGING STORAGE MARKET

The electricity storage market in the U.S is now nearing the end of the "demonstration" phase, with projects beginning to be rolled out for economically justifiable reasons. This market has been championed by a handful of innovative utilities: one in particular (American Electric Power) has committed to installing 1 GWe of distributed storage on its networks by 2020.

Creaking grid driving storage deployment

The U.S has been increasing its generation capacity for decades, neglecting the decreasing capability of the transmission network to cope with this. However, the era of taking the grid for granted is now over:

- **Old, unreliable and over-strained transmission and distribution lines are struggling to cope with ever-increasing peak demand and unpredictable renewable generation.**
- **Regulators are imposing penalties on utilities who cannot meet their customers' increasingly high expectations of reliable supply.**
- **In some areas, there is an excess of wind generation compared to night-time demand, such that power prices have occasionally gone negative.**
- **Utilities are spending vast sums of money on upgrading distribution feeders and substations to cope with a small number of daily peaks that they cannot handle.**

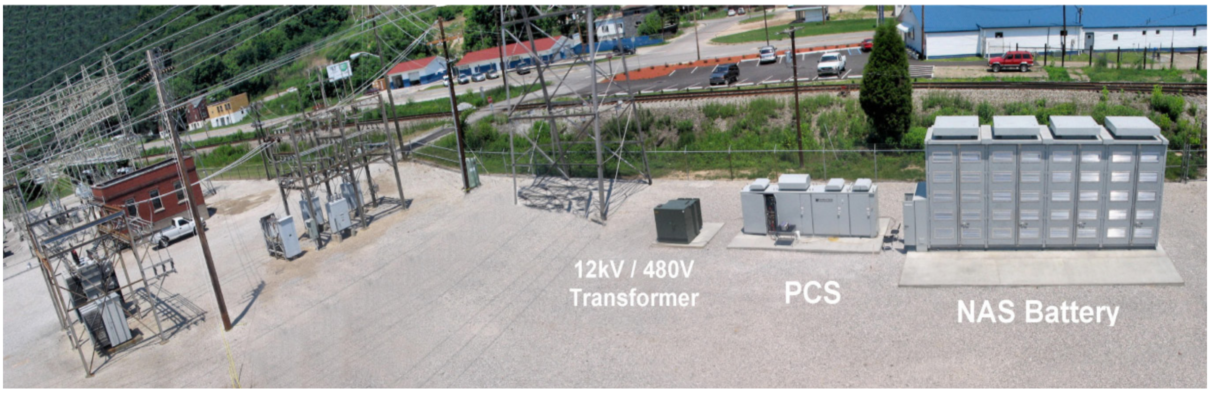
Storage is being deployed to combat these (largely grid related) issues. A handful of utilities have installed pilot projects on their networks, both to solve these challenges but also to see how storage can add value to different streams of their business.

Storage that defers the upgrade of a substation (such as seen in Figure 3) can also play in open frequency regulation markets as well as taking advantage of arbitrage opportunities. An installation that smoothes the output of a wind farm can double as a city-scale UPS system if the local network is unreliable. It is the multiple values of storage that makes it such an exciting proposition for utilities.

A handful of US utilities have installed pilot projects on their networks, both to solve grid challenges and see how storage can add value to different parts of their business

Figure 3: Storage deployed in the US for grid upgrade deferral.

1 Mw NaS battery installed by american electric power (AEP) in 2006 to defer building a substation for 4 or 5 years. aep has since installed a further 6 mw of nas batteries for the same application but with an added function of improving service reliability to customers. it is in this way of adding extra value streams that storage becomes commercially viable.



AEP, 2006

The future for storage in the US – ever increasing rate of deployment

We are looking to the US market in anticipation of a great acceleration in project rollouts. Early movers such as AEP are demonstrating the system benefits that these technologies offer and competitors are sure to take heed. States such as California and New York already recognise these benefits and are offering investment support for certain installations. Delta expects 2009 to be a busy year for storage in the US.

EUROPE – A POTENTIAL STORAGE MASS-MARKET

Where does Europe fit in to the storage picture? Currently, it is a very poor third behind Japan and the U.S. But European momentum is picking up speed and we believe will become a hotbed of storage activity in the next 3 years.

Strongly interconnected electricity network, but strains appearing

There simply aren't the same problems as in Japan or the U.S – strong interconnections between individual electricity networks support stability. Denmark is a prime example of this – it has reached a level of wind (> 20%) and distributed generation (> 50%) penetration greater than anywhere else in the world through its excellent interconnection with Germany and Norway (interconnection capacity of 2,760 MWe which is 77% of peak Danish demand, to be increased by a further1,600 MWe by 2014). Europe's networks are strong, and have been well maintained, unlike in the US.

However, issues are beginning to arise:

- **Bottlenecks are arising in countries where the renewable resource is concentrated in certain areas including Germany, Spain, Portugal and the UK.**
- **There are countries and regions that have little interconnection – Ireland at Greek islands are obvious examples.**
- **Northern Europe is experiencing large price differentials between peak and off-peak generation that could warrant large-scale or distributed storage to perform bulk arbitrage.**

In general, there are challenges and opportunities arising in Europe, largely brought on by the growth of renewables, that increase the attractiveness of utility-scale storage year by year.

Cost has also held back storage in Europe. Emerging storage technologies are expensive when compared to traditional solutions (increasing grid capacity/peaking generation) and it is difficult to justify the cost when the multiple benefits cannot be accrued to just one business unit of an unbundled utility.

However, traditional solutions are becoming much more complicated. There are huge time delays and regulatory barriers associated with grid construction and fossil fuel gensets are subject to emissions standards and volatile fuel prices. Combine this with the fact that storage costs are dropping and these new solutions begin to become attractive.

European utility interest is noticeably growing and Delta's first 'Electricity Storage in Europe' Summit, held in October 2008, gave a sense of how quickly. Representatives from most of the key players attended, not just to sit and learn, but to offer their thoughts and ideas.

Much utility interest already to be seen

Table 1 gives just a few examples of how European energy companies are beginning to engage with electricity storage.

Table 1: Examples of Europeam utility Engagement with Electricity Storage

Utility/Energy Company	Storage Development
Scottish & Southern Energy (UK utility)	Acquired minority stake in Premium Power – zinc bromine flow battery developer. A 150 kWh unit has been delivered and installed as a UPS to test its operability.
Energienet.dk (Danish TSO)	Testing 1 MW, 2 MWh VRB system at Risø National Laboratory for wind and ancillary services applications
Spanish utility (confidential)	Actively searching for ~1MWe battery to install on its network
RWE (German utility)	Investigating feasibility of compressed air energy storage (CAES) facility in Northern Germany for bulk arbitrage
Dutch Government (in conjunction with Dutch utilities)	Exploring creation of "Energy Island" – hollowed out artificial island in North Sea using pumped hydro in reverse. Up to 30 GWh of storage.
Gaelectric (Irish wind developer)	Investigating feasibility of CAES facility in Ireland for provision of ancillary services

Delta Energy & Environment, 2009

More and more utilities are beginning to pay attention to electricity storage market and technology developments. This is particularly the case in regions where grid issues are forecasted, such as Ireland, the UK, Northern Europe and the Iberian peninsula.

We have a high level of confidence that storage will be a significant part of future European power markets. Attention should be payed to centralised (e.g. large compressed air energy storage CAES) and decentralised (e.g. batteries and flywheels) storage – both will play a role. We believe that utilities that make early plays will be best positioned to exploit opportunities and create value, one just needs to look at such players as AEP in the States and TEPCO in Japan to realise this. These innovators are quickly learning how electricity storage technologies can help futureproof their utility business against oncoming challenges.

Delta Energy and Environment launches its Electricity Storage Service in March 2009, providing rigorous research and analysis to help utilities make the right storage choices.

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