Electricity Networks Analysis, Research and Development

IEA Implementing Agreement on Electricity Networks Analysis, Research and Development (ENARD)

Annex I Briefing Sheet

"Energy Storage"

Annex I: Information Collation and Dissemination

Introduction

Traditionally, with the exception of large scale pumped hydro schemes, it was believed that electricity could not be stored and any excess generation would be 'lost'. Unlike most industries that can store their end products in a warehouse, electricity requires an instantaneous matching of supply and demand. There are, however, a number of technologies now emerging that are able to store electricity on a scale that is beneficial to the Transmission and Distribution sector. These are in addition to and complement the long established pumped hydro storage which has in excess of 90GW of capacity installed worldwide.

Different systems can be distinguished by how much energy they can store and by their power rating (how much energy they can deliver in a particular time frame).

Technologies

The main technologies being used or developed for energy storage at present are:

- Pumped Storage (or Pumped Hydro)
- Compressed Air Energy Storage (CAES)
- Battery storage (BESS)
- Flow Cells
- Kinetic Energy Storage (Flywheels)
- Super Capacitors

Pumped Hydro Storage is the most established form of large-scale energy storage. As the name suggests, these units pump water from a lower reservoir to a higher reservoir when there is a surplus of electricity. This can then be released at times of peak demand. Such units are expensive to construct in absolute terms due to their size and are dependent on terrain, but can be very effective at storing large volumes of energy and have a competitive $/kW of storage. Presently, the largest pumped hydro station is Guangzhou in China, with 8 x 300MW rated turbines (2,400MW in total).

Compressed Air systems (CAES) use low cost electricity to compress air into large caverns which can then be expanded via a fired turbine unit. Only two schemes have been commissioned to date, namely the 110MW plant in McIntosh, Alabama, and the 290MW plant in Hundorf, Germany. There are, however, smaller related systems (micro-CAES) for more localised applications, such as wind farm support under construction.

There are a number of different types of battery system available, including lead-acid, lithium-ion, and sodium-sulphur designs. Lead-acid battery systems are one of the most developed, however they tend to have a somewhat limited cycle life making them less suited for energy management. There are also concerns relating to the footprint of these systems, especially in urban areas. A number of sodium-sulphur battery systems are currently in operation in Japan and the US, with the largest believed to be a 6MW, 8hr unit for Tokyo Electric Power Company. Lithium-ion systems are currently used in much smaller applications and there are a number of emerging challenges which will need to be overcome for the technology to be scaled up.

Flow cells operate differently from battery systems with the chemical reaction taking place in a reaction cell. Unlike a battery system, energy and power in a flow cell are independent of each other so it is easier to develop modular systems that can be expanded as required. There are currently a number of electrochemistries at different stages of development and deployment including Vanadium/Vanadium; Zinc Bromine; Zinc Cerium; Vanadium Bromine; Soluble Lead ;Vanadium Cerium and Iron Chromium. Additionally, the UK Regenesys™ project was based on Polysuphide Bromide, although this technology is not currently being developed further.

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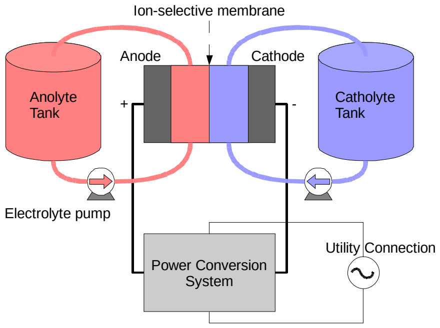
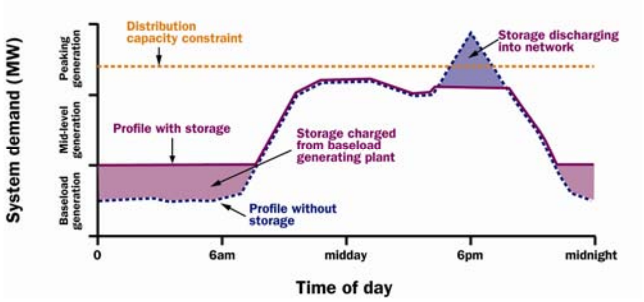


Schematic Diagram of a Redox Flow Cell

Flywheels and Super Capacitors presently tend to have greater application in large commercial or industrial sites to maintain energy supplies, rather than as part of the main electricity network.

Applications & Benefits of Storage

Rarely do generation and demand profiles match exactly. Probably the greatest benefit of Energy Storage is that it can be used to balance these two factors, preserving network integrity. In the short-term, this can be in the form of frequency control, whereas over longer periods this can smooth the demand and supply. For some countries this could mean that some of the peaking plant (often older and less efficient units) currently used to maintain the system could be retired.



Energy Storage to smooth demand and supply
[courtesy of VRB Power Systems Inc][3]

As storage systems are available in different scales, they have the potential to support both transmission and distribution networks. As far as the transmission network is concerned, energy storage can be beneficial for managing sudden shocks to the system, such as a thermal plant tripping. Their ability to respond quickly, combined with their flexibility, makes them extremely attractive to network operators.

Storage also has the potential to deliver reductions in overall CO_2 as the need to retain part-load thermal plant to meet reserve requirements can be reduced. The benefits of intermittent renewable generation can also maximised by smoothing output to facilitate more accurate scheduling and trading.

Energy storage systems can also be used to support distribution networks, especially in areas prone to constraints or facing increased stress, as an alternative to upgrading the infrastructure. Pacific-Corp in the US, for example, have installed a flow cell system in Utah on a 209 mile 25kV network for load-levelling which has deferred the need for a new sub-station.

In countries where energy is traded in hourly or half-hourly periods throughout the day, storage systems can also be utilized for price arbitrage opportunities. Through buying energy during the cheapest periods of the day and selling in the more expensive, storage systems can maximize on any price differentials.

The Future for Storage?

The current focus on renewable generation has the potential to generate new markets for energy storage systems. The majority of renewable power sources, such as wind, solar and tidal, are intermittent in nature and electricity may be generated at times of low demand. Energy storage offers the potential for renewable generation to be maximized, without the need to run thermal plant at part-load, which is less efficient, to be available for any sudden fluctuation in renewable output. In some countries, such as Japan, wind farms are already being installed in conjunction with an energy storage system to maximize their output.

Whether the full benefit of energy storage is realized may demand changes to regulatory structures in some countries. Presently, there are significant differences as to how storage is regulated in the economic regulatory models adopted by different countries. In some countries, such as the US, network operators can own and operate storage. Others, such as the UK, require a separation of control between generators and network operators. Given that energy storage tends to be classified as a generation, this type of regulatory regime is likely to limit how storage might be used.

References

1. Electrical Energy Storage:- Challenges & Market Opportunities; Energy World; Nov. 2004
2. POST Note 306 – Electricity Storage, UK Parliamentary Office of Science & Technology, April 2008.
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