BPVA British Photovoltaic Association

*This whitepaper has been developed for the BPVA members covering a number of important questions in the energy storage industry.*

## Why is energy storage such a hot topic at the moment and why is or can it become so important?

Energy storage will be essential in our future energy infrastructure. To be specific, energy storage will help the electrical grids of today to be more stable and flexible, so that they can manage:

- A surge in peak demand
- An increase in the amount of variable renewable energy
- Minimise renewable energy curtailment, therefore reducing reliance on the import of fossil-fuels and increase the return on investment of renewable energy generation.
- In the long term, the prevalence of non-electrical energy uses such as transport and heating will necessitate the use of energy storage systems.

Energy storage is by no means a novel idea; it has seen success in responding to the variation in demand with generation, and in providing associated services. Pumped Hydro Storage systems have been proven to work so well that they constitute close to 99% of all energy storage systems globally. The introduction of environmentally-conscious policies to concurrently lower carbon dioxide emissions and increase the security of energy supplies will heavily influence the market rules and drivers for energy storage. Energy storage is an indispensable part of our energy future, especially if we wish to meet ever-increasing levels of primary energy derived from renewable sources.

Some of the capabilities of energy storage that make it so important are:

- Time-shifting electrical energy
- Acting as a generator and supplying energy to the electrical grid
- Acting as a demand and pulling energy from the electrical grid

With these in mind, energy storage systems hence have the potential to help us in:

- Maintaining the security of the power supply of the electrical system
- Maintaining power quality
- Cost reduction: both direct and environmental costs through the increasing derivation of primary energy from renewable sources and thus the widespread replacement of fossil-fuels.

Energy storage enables the matching of demand with power generation over different timespans, from minutes to months. Energy storage can also be expected to offer valuable services in the entire energy architecture: from electrical generation, transmission and distribution to the end user.

## How can energy storage empower renewable energy in general and solar power in particular?

Energy storage can assist renewable energy generation in contributing to associated services. Currently, companies of renewable distributed generation play no part in the associated services markets, with the exception of a few countries like Denmark and Ireland. For distributed generation that relies on renewable energy sources, performing frequency control means storing some reserve power, hence throwing away an aspect of the down regulation of non dispatch-able renewable energy sources, also known as curtailment. Therefore, when distributed generation companies are

required to contribute to primary frequency control, energy storage can be seen as an alternative way of supplying control power, rather than a self-imposed degradation of primary energy conversion.

To reinforce renewable energy integration into the grid, energy storage can ease the dispatching of variable distributed generation just like conventional generation assets, and firm up capacity. Further, it can also help decentralized generators minimize upstream disturbances, just as users of distribution networks must. During periods when the power generated is unable to be fully transferred into the networks, energy storage can help keep the extra energy in reserve, and extract them later, thus doing away with using fossil-fuels to meet later demand.

Energy storage is also the final piece of the puzzle that will allow renewable energy sources to function reliably in microgrids. Although microgrids are still far from being the protagonist of the renewable energy storage film, with energy storage, renewable energy can really play a significant role in supplying energy to in rural communities. Because countries in the developing world do not have reliable sources of energy, microgrids have played a larger role in supplying energy to isolated communities. In Africa, S&C is already becoming a big player. In India, utilities are also looking at microgrids. Even in Australia, microgrids are fast becoming the energy source for remote regions.

## What are the latest developments in energy storage technology and what future developments are to be expected?

Specifically developed for the demanding requirements of both small and large-scale stationary energy storage applications, aqueous hybrid ion batteries seem to offer a combination of high performance, low cost, operational safety, and sustainability. The technology developed by Aquion Energy recently received $35 million funding from investors such as Bill Gates. The combination of

aqueous electrolyte with abundant raw materials can yield energy at a low cost and with high levels of safety, as required for grid applications. Indeed, the costs of aqueous hybrid ion batteries are as competitive as the more mature lead-acid batteries, but with 5,000 life cycles and 100% depth of discharge.

We are also seeing companies put a new spin on flywheel storage. Recently, Silicon Valley inventor Bill Gray unveiled his new Velkess flywheel, which will store energy at a price of $1,333 per kilowatt - as price competitive as pumped hydro and compressed air. With an 80% efficiency, the Velkess can charge fully within five hours, and store 15 kilowatts of power, enough for one day in the average household. Gray managed to cut costs by using cheaper fiberglass rather than steel or carbon fiber. The Velkess can store electricity at only $300,000 per megawatt-hour, a tenth of its competitor's costs. The Velkess' design also seems to allow for safety within the house, so that the device doesn't heat up excessively or break down completely. It can also be scaled for large industries or businesses.

In compressed air energy storage, an innovative design that features the use of double-walled pressure vessels seem to promise to overcome limitations in size and capacity. The technology by e-Storage Solutions makes use of composite cylinders that are filled with self-consolidating materials to result in energy being stored economically at grid-scale. The new design will allow savings of up to 70% compared to conventional systems. Another company, LightSail Energy employs a fine, dense mist of water spray to prevent wastage of heat created during air compression. This technology has the potential to increase efficiency in compressed air energy storage.

There have also been advances in the nascent field of microgrids. EnerDel debuted its Mobile Microgrid Storage System with the U.S. military last month. The device was lauded by the military personnel for its portability and easy deployment. The Mobile Microgrid Storage System is setting standards for its power capabilities, clean integration from standard commercial off the shelf

components, compact nature and fuel efficiency. EnerDel's system demonstrates the extensive features of microgrids in rural or troubled spots away from the central grid. The budding microgrid sector has won and held the attention of the energy industry, with the Microgrid Forum in Europe and Asia bringing together industry experts for a 3 day conference.

New applications of thermal energy storage systems (concentrated solar power) are also expected. Some thermal energy storage applications that will soon see deployment are:

- Heating and cooling of structures using solar power
- Using industrial heat sector to improve efficiency and lower energy consumption in the industrial manufacturing processes
- In power generation involving thermal conversion, such storage systems may allow conventional power plants to gain added flexibility and to reinforce Combined Heat & Power implementation, storing heat production for later use.
- Storage of heat in tandem with district heating systems for up to several months
- Providing heating to residential buildings, while a demand side management system supplies electric energy from renewable sources for electric storage heaters and heat pump
- Installation of expansive solar thermal systems for cooling, heating, heat processing and power generation including concentrated solar power
- Using heat stored from electric heating elements as a quick balancing service in the electricity grid

## How do you see the future of energy storage and its impact on the global energy market/ electricity grid?

The outlook for solar energy is bright, with some estimates putting market revenues at $19 billion by 2017. A recent report by IHS Inc. predicts that the market will experience dramatic growth over the

next four years, from under $200 million in 2012. That is some 7 gigawatts of storage, or 2 gigawatts every year till 2017. IHS also predicts 70 percent of the world's installed storage will occur in Germany. But while Germany is leading the way in renewable energy storage installations, many other countries are following. If Germany's recent subsidies prove successful, other countries will look to replicate that. IHS argues that even without the subsidies, the decline in market prices of residential storage will cause the market to grow in countries like the UK.

In the global flywheel energy storage market, Research and Markets recently released a report forecasting that it will grow at a Compound Annual Growth Rate (CAGR) of 12.35 percent between 2011 – 2015. One of the key factors contributing to this market growth is the increasing investment in smart grid construction. The Global Flywheel Energy Storage market has also been witnessing increasing investment in energy storage technology. However, the lack of familiarity with flywheel technologies could pose a challenge to the growth of this market. According to the report, it is predicted that by 2035 the global energy demand will increase tremendously, but the energy consumption pattern is likely to vary in each country.

The current demand for energy is expected to more than double globally by 2020. It is not possible to meet the future demand with the existing power generation capacity. The storage of energy will help to maintain a backup to cater to the high future demand. Large-scale grid energy storage systems will meet this need and flywheel energy storage systems will enable this grid power storage to take place. Consequently, the growing energy demand may increase the growth of the global flywheel energy storage market.

## When will energy storage become operational in a way that it will be economically profitable?

Energy storage has a variety of applications today, such as price arbitrage, energy balancing, provision of black-start services, and transmission and distribution deferral. In assessing the business case for each of the storage applications, companies should have an understanding of the full technological picture before making an investment. For example, there are presently six competing technologies in lithium-ion battery storage. Because each technology involves the use of different raw materials and components, companies should perform a comprehensive analysis prior to committing to a technology.

According to a Boston Consulting Group report, companies should also study and put a figure on the relevant end market. A careful examination of growth factors, important trends, and market drivers is important for companies to reasonably estimate the market demand, beginning from the relevant applications. Generally, investors should beware of getting involved prematurely, when the technology is expensive and renewable energy generation is low, and also too late, when the market is already saturated and there is no good market gap left to occupy. BCG also predicts that by 2030, the energy storage market will need $230 billion in additional cumulated investments.

It is important to note that given the right conditions, energy storage can already be a profitable investment today. Cost degressions for stationary batteries will substantially increase profitability across a wider range of applications.

Today, batteries have already gained a foothold in the energy storage market for various mobile and stationary power applications. Figures from BCC Research put the market at $15.3 billion in 2009 and $16.7 billion in 2012. Market revenue forecasts predict a surge of $5 billion by 2017, with a compound annual growth rate of 4.6% between 2012 and then. These figures will propel the battery

industry to the higher reaches of the technology-driven electrical and electronic sectors, in terms of size and growth rate. BCC Research also identified the different areas in advanced battery sector that could see dramatic growth usually characteristic of new industries. Some of these high-potential-growth areas are utility-load levelling systems and wind-power energy storage.

There is more good news for the advanced battery enterprise, with Pike Research recently projecting a staggering 200-fold increase in global capacity within the next 9 years. This will bring the few hundred megawatts of today past the 10,000 mark by 2022. In addition, the business revenues for advanced batteries in utility-scale energy storage will just about double every year for the next 4 years, totalling almost $8 billion by 2017. And over the subsequent 5 years, growth can be expected to stabilise to a still-impressive compound annual growth rate of 31%, with total revenues of $29.8 billion in 2022.

## Conclusion

According to our research and conference delegates' feedback, it appears that energy storage will first be widely deployed in the short term electricity balancing market. And over the next 5 years, the need for more balancing power is likely to emerge. There is also a caveat – currently, only a small number of energy storage applications can justify market-based business cases. This could explain the so-far limited deployment of energy storage technologies in the market.

From where the industry stands, the outlook over the next two decades is positive. It is probable that energy storage will only grow in significance as a part of the electrical grid. Over the same timespan, ancillary services and energy arbitrage based on stored energy could conceivably penetrate deeper into the energy market – a result of the wider deployment of renewable supply sources with the simultaneous phasing out of fossil, dispatchable generation capacity. We also predict that energy storage applications will bridge the electricity system and its neighboring sectors in the energy market. Future supply from the power grid will likely target private and industrial heat demand, with the transport sector moving towards a sustainable electricity supply.