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Global Energy Challenges and Innovations in Energy Storage

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Abstract Energy storage represents one of the most crucial global energy challenges of the 21st century. While the generation and transmission of energy has been largely managed, more or less efficiently, and with a varying degree of success, the issue of energy storage (especially when it is required to store energy for a substantial amount of time) has been largely underestimated. Hydro storage remains the dominating means of electrical energy storage with various batteries occupying just a small part of the energy storage spectre.

This paper focuses on the issues of innovations in energy storage as one of the key energy challenges for the 21st century. With the growing deployment of renewable energy sources (RES), the importance of the energy storage is gaining special importance.

Keywords: energy storage; innovations; energy policy; batteries; renewable energy; sustainability; economic development

JEL Classification: C32; Q4

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Abstract Energy storage represents one of the most crucial global energy challenges of the 21st century. While the generation and transmission of energy has been largely managed, more or less efficiently, and with a varying degree of success, the issue of energy storage (especially when it is required to store energy for a substantial amount of time) has been largely underestimated. Hydro storage remains the dominating means of electrical energy storage with various batteries occupying just a small part of the energy storage spectre.

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1 Introduction

Energy the renewable energy sources (RES), such as wind turbines or solar panels, generated during off peak periods and stored in batteries, could be discharged during peak periods. This is different from using non-renewable sources (such as natural gas turbines) which are pricier and trickier (Balitskiy et al. 2016). Moreover, environmental advantages from the energy storage can be offset by the environmental disadvantages. For example, it may be unnecessary to curtail wind farms at night since the generated energy can be stored (Jacobsen 2016).

Electrical energy can undergo conversion into numerous varying forms for storage (Lisin and Strielkowski 2014; Strielkowski and Lisin 2016; or Varanavicius et al. 2017). Common practices include conversion and storage as: gravitational potential energy with water reservoirs, compressed air, electromechanical energy in batteries and flow batteries, chemical energy in fuel cells, kinetic energy in flywheels, and magnetic energy in inductors and electric field in capacitors. The use of large scale energy storage systems such as pumped hydro storage (PHS), which involves storing electrical energy as gravitational potential energy of water, involves pumping water from a lower reservoir to an upper reservoir during off peak periods. It also has a fast response time of less than a minute in spite of its large power volumes and energy management which makes it suitable for controlling electrical network frequency and providing reserve generation (Díaz-González et al. 2012).

Compressed Air energy storage (CAES) involve energy being stored as compressed air in as underground storage cavern. It is therefore based on the use of conventional gas turbines. Due to very minimal self-discharge within the system, they have been regarded as the long-term competitors of PHS (Lu et al. 2004).

However, it is the battery storage system that attracts the attentions of today’s energy specialists and economists. This paper focuses on the present and the future of the battery energy storage systems and innovations in the energy storage in the face of global energy challenges faced by the humankind that is attempting to follow the path of sustainable economic development in the conditions of global warming and drastic climate change.

2 Battery energy storage systems

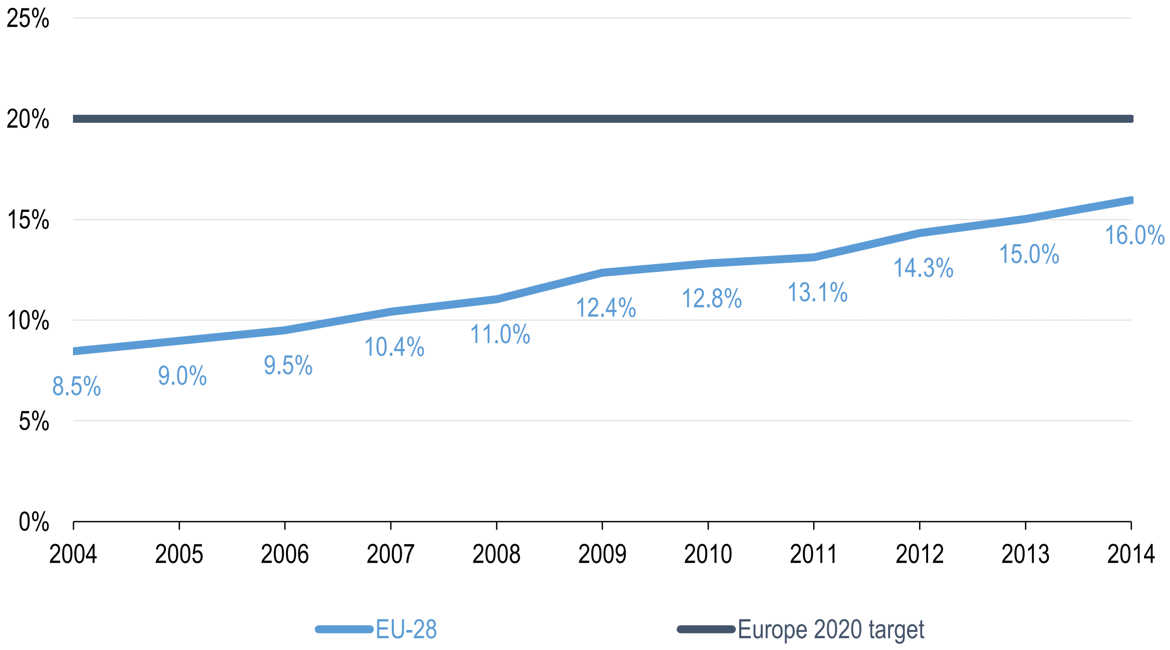
One of the most familiar energy storage technologies is the battery energy storage system (BESS). BESS uses a set of various sets of multiple cells that are interconnected in series, parallel or in both sequences in a bid to acquire some value of voltage or capacity (Divya and Østergaard 2009). This energy is stored in form of electrochemical energy. Electrodes which are usually made of conducting materials are put in an electrolyte contained in a special, sealed container thus supplying an external load (Winter and Brodd 2004). Through the electrolyte, exchange of ions occurs between the electrodes while electrons flow through the external circuit. This method incorporates using power battery modules which produce lower voltages which after being connected in a series, parallel or both sequences, achieves the desired electrical output and behaviour. Normally, a BESS is made up of power batteries, the Control and Power Conditioning System (C-PCS) and the protection plant for the whole system (Suberu et al. 2014).

They have a life cycle of 1200 to 1800 cycles which varies based on the depth of discharge, a round trip efficiency of 75 to 80 percent and a lifespan of 5 to 15 years often depending on the operating temperature (Dufo-López 2015). They are best used for energy storage over long durations. However, they often display poor performance at high and low ambient temperatures and have quite a short life span. They also require water maintenance over time especially the flooded type. Effort has been directed into converting nickel-cadmium and lithium-ion batteries into preferred options for higher power uses especially in terms of their costs. Nickel-cadmium batteries consist of alkaline rechargeable batteries often categorized according to its application (Hadjipaschalis et al. 2009). This involves its sealed form often used on portable electrical equipment and its flooded form used in industrial applications. This type of battery has quite a lengthy cycle life of more than 3500 cycles and requires low maintenance. They are however toxic due to the use of heavy metals which pose health and environmental hazards and often suffer from memory effect. Lithium-ion (Li-ion) batteries on the other hand have common application in modern electronic gadgets such as portable phones and electronic devices requiring low power applications. Li-ion batteries have high energy density of around 170 to 300 W h/l and specific energy of between 75 to 125 W h/kg. They also have fast charge and discharge capabilities as well as having high round trip capabilities of 78 percent within 3500 cycles. These batteries cannot be used for power backup systems due to their life cycle being dependent on the depth of discharge (Young et al. 2013).

3 Economic implications of energy storage

Energy storage is a favoured applied science of the future for great purposes (Ciamician 2012; Strielkowski et al. 2015; Strielkowski et al. 2016). Multiple individuals perceive affordable storage as the lacking connection between alternate renewable energy, such as the wind and solar and daily dependability (Lisin et al. 2015a; 2015b; 2015c). This is crucial for the sustainable economic development (Kalyugina et al. 2015). Businesses are interested in the possibility for storage to satisfy other demands such as reducing gridlock and ironing out the fluctuations in power that happen independently of renewable-energy production (Streimikiene et al. 2016; or Strielkowski and Bilan 2017). Significant mechanical businesses acknowledge storage an applied science that could change cars, turbines, and customer automatics.

Figure 1. Share of renewable energy and RES targets in the EU-28



Source: Eurostat (2016)

The transformative prospect of power storage has been just around the corner, and presently, storage aggregates a small drop in a vast sea (Gallagher 2009; or Strielkowski 2016; 2017). A record 221 megawatts of storage capacity installed in 2015 this was more than three times as much as in 2014—65 megawatts, which was itself a significant increase over the preceding year (Fertig and Apt 2011). More than one hundred and megawatts of the year 2015 total was used by a private local transmission corporation, PJM Interconnection. PJM serves all or section of Illinois; Delaware; Kentucky; Indiana; Maryland; New Jersey; Michigan; Ohio; North Carolina; Tennessee; Pennsylvania; Virginia; West Virginia and Washington, DC. Furthermore, 221 megawatts are not much in the setting of a full US production capacity of more than a million megawatts.

Energy storage installations and project for the top 10 countries. It becomes apparent that although China has most of the installed capacity, it tails the United States and Japan in the number or projects (DOE Global Energy Storage Database, 2016).

Research discloses a considerable near-term possibility for stationary power storage. One speculation for this is that prices are dropping and could be close to $200 per kilowatt-hour in the year 2020; this is half today's rate, and $160 per kilowatt-hour or less in 2025 (Lundmark and Bäckström 2015). Another is that identifying the most effective aspects and highest-potential consumers for storage has shifted to be a preference for a distinct set of organizations comprising power providers, grid engineers, battery producers, energy-storage integrators, and enterprises with built connections with prospective clients such as energy-service companies and solar developers. This is particularly important with regard to the growing share of renewables and RES targets set by the EU (Eurostat, 2016). Innovations in energy storage are crucial in helping to accommodate this growth (Figure 1 above). Setting up plans and identifying clients are needed. It means seeing how power is utilized and how much it costs, as well as the cost of storage. Too frequently, though, businesses that have access to information on power use have an inadequate knowledge of how to assess the economics of storage; those that recognize this economics have inadequate access to actual-world data on energy usage. Furthermore, there has been an inclination to equate the data when executing analyses. Aggregating estimates, nonetheless, is not beneficial when evaluating possibilities for power storage since identical structures next door to each other could have completely divergent models of power use. Inferences formed based on averages, consequently, do not have the accuracy required to recognize which consumers would be helpful to serve.

4 Conclusions

One can see that energy storage has economic reason for specific utilization. This point is sometimes ignored given the importance on charges, payments for some storage designs, and noneconomic or tough-to-measure financial grounds for storage (such as elasticity and protection against power interruptions). In addition, market shareholders need to obtain the complete data that could enable them to distinguish and prioritize those consumers for whom storage is helpful. Given the complexity of power storage, deployment is more reasonable to support a push versus a pull economics pattern, supporting entrepreneurial businesses that find inventive ways to obtain and utilize these data

The most significant relationship is this: the large-scale distribution of power storage could upset market as accustomed for several electricity businesses. In advanced nations, for instance, central or bulk production traditionally has been used to meet immediate demand, with ancillary assistance serving to smooth out inconsistencies between output and load. Energy storage is well adapted to give such additionally services. Ultimately, as prices drop, it could move past that role, producing more and more energy to the grid, replacing plants. Energy storage has the possibility to upend the business structures, both economic and physical, that have established energy businesses for the last century or more.

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