Battery Energy Storage System – Benefits and Risks

Batterie-Energiespeichersystem – Vorteile und Risiken

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***Abstract* —** This article describes the benefits and risks of the battery energy storage system. It provides information about the battery energy storage system, the main manufactures and solution providers, and its future market trends. It shows examples of the disadvantages related to battery energy storage system, which will be the challenges for all companies and organizations connected with the power industry in the next 10 years.

***Zusammenfassung* —** Dieser Artikel beschreibt die Vorteile und Risiken des Batterie-Energiespeichersystems. Er informiert über das Batterie-Energiespeichersystem, die wichtigsten Hersteller und Lösungsanbieter, und zukünftige Markttrends. Er zeigt die Nachteile von Batterie-Speichersystem, die in den nächsten 10 Jahren die Herausforderungen für alle Unternehmen und Organisationen mit Bezug zur Energiewirtschaft darstellen werden.

I. Introduction

With the increasing energy needs of households and businesses, the load on the power grid is enormous. Along with reducing carbon emissions, energy and automation industries face major challenges. The short time in which the new systems need to be transformed and implemented leads to both benefits and risks for business and society. Therefore, in the following chapters we will take a look at what a battery energy storage system is, what types of energy storage exist, their benefits and risks?

II. What is the battery energy storage system and its benefits

Battery energy storage system ensures the balance in the power grid. It allows renewable energy to be stored and supplied when needed and it could be used as stand-alone solutions to help with fluctuating power supply and demand. The battery energy storage system also could be a back-up for the instant power supply.

This optimisation of energy output to the grid means that renewable energy and battery energy storage system provide power at both peak and non-peak times, stabilising the distribution network. This also allows investors and stakeholders to realize increased revenue income resulting from limited wastage while reducing costs for consumers [1]. Figure 1 shows a diagram of peak shifting between the charge during the off-peak times and discharge during the peak times.

Energy storage devices are shown on figure 2 which can be used according to discharge time at rated power and system power ratings. It shows the comparison between the power output and energy consumption. The figure 2 also presents the main technologies for storage capacity.

They can be used for uninterruptible power supply (UPS), transmission and distribution (T&D) system support, or large-scale generation, depending on the technology applied and storage capacity. Among electrochemical, chemical, and physical energy storage devices, the technologies that have received the most attention recently fall within the scope of UPS and T&D system support. Representative technologies include reduction–oxidation (redox) flow, sodium–sulfur (Na–S), lead–acid and advanced lead–acid, super-capacitor, lithium, and flywheel batteries. Lithium batteries are in common use today [2].

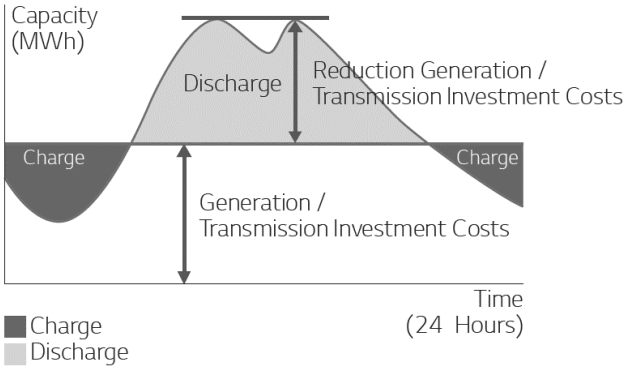

Fig. 1 Peak Shifting [3]

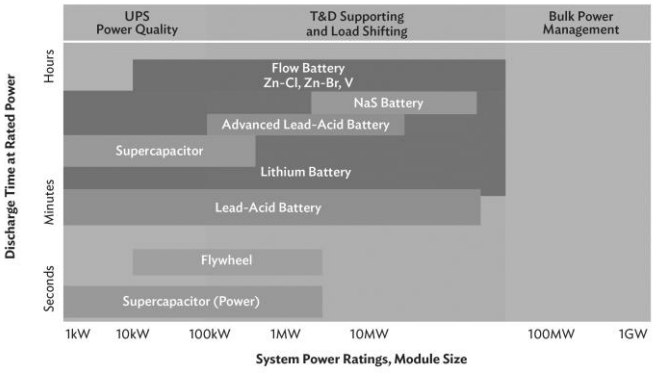

Fig. 2 Comparison of Power Output and Energy Consumption [2]

One of the reason is decreasing price of the Lithium-ion battery pack by 89% from 2010 to 2020, with the volume-weighted average hitting $137/kWh. Underlying material prices will play a larger role in the future, but the introduction of new chemistries, new manufacturing techniques and simplified pack designs keeps prices falling [4].

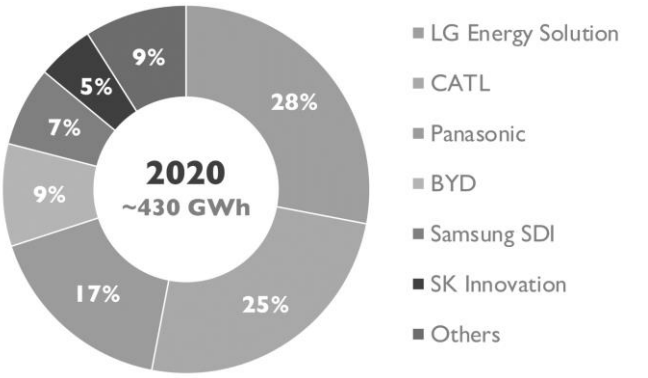

Fig. 3 2020 top battery manufacturers market shares in GWh [5]

Figure 3 shows the split between the main batteries manufactures in 2020. Demand for lithium-ion batteries will increase rapidly in the coming years, hence there will be a big competition between the existing manufactures and the new start up ones. With 28 percent, LG Energy Solution ranks first in the production of lithium ion batteries.

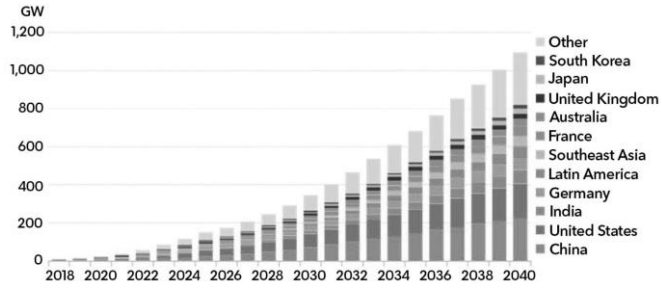

Fig. 4 Global cumulative energy storage installations [6]

Energy storage installations around the world will multiply exponentially, from a modest 9GW/17GWh deployed as of 2018 to 1,095GW/2,850GWh by 2040, according to the latest forecast from research company Bloomberg NEF (BNEF) [6].

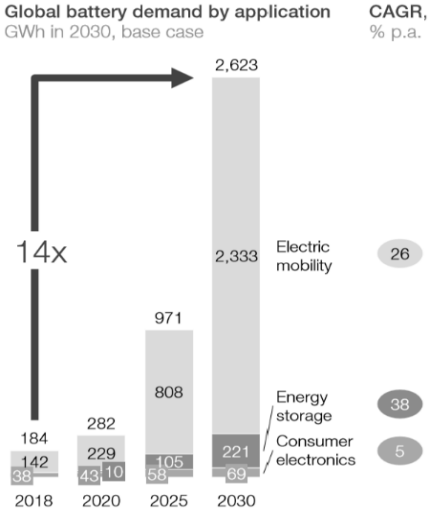

Fig. 5 Global battery demand by application [7]

There is a fundamental transition developing in the power system and transportation sector. Falling wind, solar and battery costs mean wind and solar are set to make up almost 40% of world electricity in 2040, up from 7% today. Meanwhile passenger electric vehicles could become a third of the global passenger vehicle fleet by 2040, up from less than half a percent today, adding huge scale to the battery manufacturing sector. The demand for storage will increase to balance the higher proportion of variable, renewable generation in the electricity system. Batteries will increasingly be chosen to manage this dynamic supply and demand mix [6].

Figure 4 and 5 show the forecast of the global battery demand by the application and region.

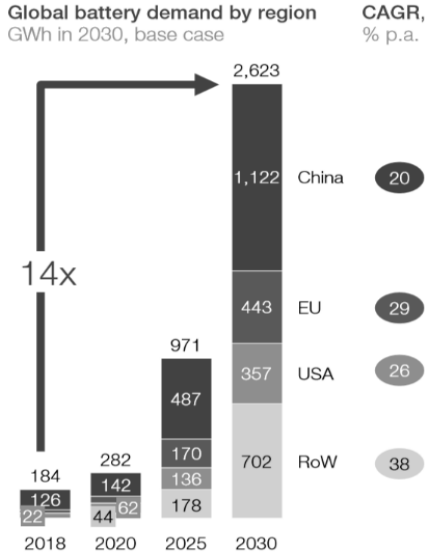

Fig. 6 Global battery demand by region [7]

The companies which offer battery storage system solutions are Mitsubishi Heavy Industries, Tesla, ABB Hitachi, Siemens, Honeywell, LG Energy Solution, Man Energy Solutions, CATL and General Electric. They offer not only battery storage solution but and full automation control and observation.

There are many projects which are fulfilled worldwide:

- 400-MWh Saticoy energy storage project using Tesla Megapacks which is operating now in Southern California;
- The Minami-Soma Substation – 40,000kW energy storage project located in Minamisoma, Fukushima, Japan [8];
- Jinjiang 100 MWh energy storage power station project – China [9].

III. Risks

Along with the benefits that battery energy storage system brings, it also has accompanying risks. The major risk are fire or explosion, augmentation, and developing of a new battery breakthrough storage.

A. Thermal runaway

By storing of a large amount of energy there is a risk that an uncontrolled release of the energy could result in a fire or explosion. In batteries, thermal runaway describes a chain reaction in which a damaged battery begins to release energy in the form of heat, leading to further damage and a feedback loop that results in rapid heating. Left unchecked, the heat generated can cause a fire. The figure 7 shows an example of thermal runaway feedback loop. The only way to stop thermal runaway is rapid cooling of the affected cell(s); another approach is to simply separate the affected battery module and allow the reaction to reach its destructive conclusion in a safe location [10].

Fig. 7 Thermal runaway feedback loop [10]

According to Marsh global risk management company recent survey found insurers of battery energy storage system facilities were most interested in the fire protection features, followed closely by space separation between battery enclosures. To assess emergency response, underwriters look for evidence of detailed dialogue with emergency services and a written protocol for incidents (documented pre-fire plans). Ultimately, early engagement with the company risk adviser is a key to ensuring that company project is well protected, safe, reliable, and well positioned to benefit from a competitive insurance placement for the long-term life of the project [10].

Global battery energy storage system fire events in Europe and North America have highlighted that failures are not unique to a particular manufacturer or design, but that the hazard is inherent in the technology.

The figure 8 shows a battery storage container on fire in South Korea.

Fig. 8 Battery energy storage system on fire [11]

The report of South Korea which investigates 23 energy storage system fires that have occurred since August of 2017 are announced in 2019 that there four causes for the fires:

1. Insufficient battery protection systems against electric shock
2. Inadequate management of operating environment
3. Faulty Installations
4. ESS System Integration

The report concludes that the lithium-ion battery fires results in system losses valued at over $32M USD. The government requested to stop operation of existing systems which resulted the shutdown of 522 ESS units – approximately 35% of the budding market [11].

B. Augmentation

To offset anticipated degradation of a battery system augmentation is a typical strategy. The augmentation is the process of adding additional capacity at select times to the system to ensure it meets a customer-desire threshold for total capacity. Figure 9 shows two strategies for providing a minimum battery capacity, 9MWh in this example. The first strategy does not include augmentation, but instead provides substantial oversizing of the battery. In the second case, the battery capacity is augmented twice in order to retain the required capacity. As a result, the initial battery size is smaller. As part of the system modelling, the company will provide a recommended approach to ensure the capacity that meets the financial needs of the customer [12].

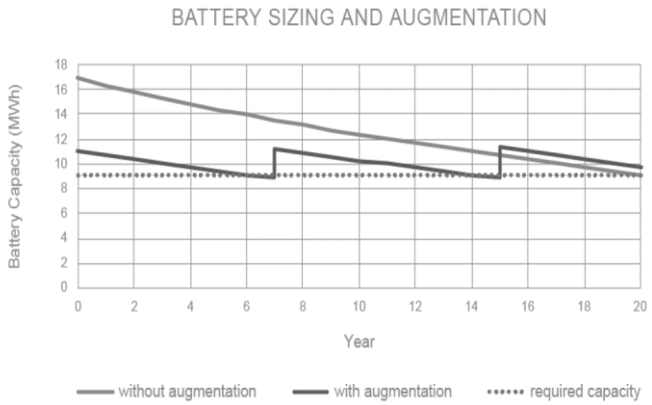

Fig. 9 Battery sizing and augmentation [12]

IV. BATTERY 2030+

BATTERY 2030+ is the large-scale and long-term European research initiative with the vision of inventing the sustainable batteries of the future, providing European industry with disruptive technologies and a competitive edge throughout the battery value chain and enabling Europe to reach the goals of a climate-neutral society envisaged in the European Green Deal [13]. With a total budget of EUR 40,5 million, seven projects will contribute to the implementation of ultrahigh-performance, reliable, safe, sustainable and affordable batteries[14]. The BATTERY 2030+ roadmap will promote a circular economy with reduced waste, small CO2 footprint, and more intelligent use of strategic resources [7].

The mission is to transform the EU's economy for a sustainable future, to make Europe the first climate-neutral continent by 2050 and to live up to the United Nations' Agenda 2030 and Sustainable Development Goals [7].

The chemistry-neutral approach of the Battery 2030+ consist of:

1. Accelerated discovery of interfaces and materials
   - Batteries Interface Genome
   - Materials Acceleration Platform

2. Integration of smart functionalities
   - Sensing
   - Self-healing

3. Cross-cutting areas
   - Recyclability
   - Manufacturability

Thanks to this chemistry-neutral approach, BATTERY 2030+ will have an impact not only on current lithium-based battery chemistries, but also on post-lithium batteries, including redox flow batteries and on still unknown future battery chemistries [7].

V. Conclusion

The lithium batteries are conventional, and until the development of a new technology, the battery storage system will continue using lithium batteries technology for storage and supply to the power grid. Despite of the risks associated with the lithium batteries technology, the benefits for the industries and utilities are the most economically profitable solution which ensures sustainable power supply. Furthermore, this technology will define the future energy market price.

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