Paper – Abstract

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Paper – abstract

The worldwide understanding for a need of green energy likewise creates a worldwide need for electrical energy storage and opens challenges for batteries in this regard. VARTA Microbattery focuses on the Lithium Ion Technology. Even though this battery technology is today one of the most expensive ones, its cost will decrease by achieving the economy of scale. Besides other challenges which the Li-Ion batteries must face, cost effectiveness will be one of the highest priorities in the R&D work. With the right priority setting Li-Ion battery technology has big potential in the upcoming market for energy storage. The presentation summarizes the challenges for batteries in this new market.

Paper – Long version

Varta Microbattery is an international operating battery company. Its Head Quarter is located in Ellwangen, south Germany. VARTA Microbattery is having subsidiaries in Asia and America and branch offices all over the world. Varta Microbattery produces over half a billion batteries a year.

For the last three years the management of VARTA Microbattery has repositioned the company and defined a growth strategy up to the year of 2015. This strategy implicates the enlargement of the business focus from the core business of micro batteries up to the new emerging markets, such as e-mobility and battery energy storage systems. In the field of e-mobility, VARTA Microbattery, in conjunction with Volkswagen, is developing a competitive Li-Ion battery cell for vehicle traction. VARTA Microbattery is well-known for its Li-Ion know-how and is a founding member of the Kompetenznetzwerk Lithium Ionen Batterien (KLIB)[1]. The Li-Ion technology is used in the field of e-mobility, as well as in sorts of battery energy storage systems for the alternative energy change. Also the Li-Ion batteries had extraordinary success in the field of portable applications. Without these batteries one can hardly imagine cellular phones, notebooks or camcorders with today's long-lasting application times..

The switch to regenerative energies becomes even more important as the world is getting short of fossil fuels[2]; while there is also a need to reduce CO2 emission[3]. The world nowadays is based on continuous availability of electricity. But since the latest nuclear disaster at Fukushima nuclear power plant, nuclear power plants are no longer accepted by many governments and their people. This creates the need of energy storage systems.

Within the last few years, renewable energies such as wind energy, solar energy and bio gas have developed strongly especially in Germany. Also Hydro Power plants are used for years to produce electricity. In Germany, the installed output of these sources did increase between 1990 and end 2010 from 5 GW up to over 50 GW[4] Green energy is not providing energy continuously – the sun is not shining 24/7. The balance between power production and consumption must be ensured every second, but in reality the production of renewable energies is decoupled from consumption. There are different ways to solve this problem. One way could be to extend the existing grid infrastructure[5]. In order to synchronize electricity production, electricity usage could be controlled by an intelligence which is connected to a smart meter[6]. This may find its limitation in some applications such as TV watching or cooking. Therefore, in a second approach, energy should be consumed when it is needed and finds its solution in energy storage. Energy storage can be divided into two categories. First, the centralized big storage systems e.g. pump hydro power,

[1] klib-org.de
[2] Association for the Study of Peak Oil&Gas
[3] Europäische Kommission: Fahrplan für eine kohlenstoffarme Wirtschaft in 2050
[4] AGEE-Stat: Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland
[5] dena-Netzstudie II
[6] Demand Side Management in Haushalten – Methoden zur Potenzialanalyse und Kostenabschätzung

compressed air power or hydrogen storage. The Second category is the decentralized energy storage, where mostly battery storage systems are used. In our opinion, all options must be used to solve the energy problem.

When a huge necessity for storage capacity really exists, then various storage systems will be needed and will be in competition with each other, depending on availability, application, technology and cost. The most common ways of energy storage are listed below. Pump storage facilities are a mature technology, but are limited in their placement; while Compressed air reservoirs are relatively new, but also limited to special geological conditions. Due to its relatively low efficiency, and its enormous theoretical storage capacity, Hydrogen is suited for long term storage. Batteries' advantage is its high flexibility of placement: batteries can be placed in all surroundings and are independent from any condition of landscape. Another advantage is the batteries' efficiency, which is typically between 75% and 95%. At the moment, battery energy storage is relatively cost intensive. Battery storage is not suited for all applications due to the capacity limitations in the technology; its main field of application is in a storage range from 1 kWh and several MWh[7].
All together, the pros outweigh the cons, so energy storage through batteries can definitely be seen as one possible solution.

At the moment, four battery technologies are in consideration: lithium ion, lead acid, sodium sulfur, and Redox flow[8]. Each technology has its own advantages and disadvantages. The lead acid battery technology is mature and relatively inexpensive in comparison to the other technologies. However, it has limitations in its lifetime, between several hundred and one thousand cycles. Redox flow batteries have an unmatched theoretical capacity, but the technology is relatively new, and much research is still needed to prove this technology. The Redox flow technology has the lowest energy and power density of all these technologies. Sodium sulfur battery technology requires high temperatures to work; the electrodes are molten sodium and molten sulfur. As a consequence of its high operation temperatures, it has a low efficiency. And finally, lithium ion batteries have the highest energy and power density of all the listed battery technologies. As a result of these facts, this technology has a huge potential for the future, especially when a large amount of energy is needed in a small area. At the moment the cost for Li-Ion based battery energy storage systems is higher than the other mentioned technologies. But the cost for the Li-Ion battery cell will of course decrease by achieving the economy of scale. Studies conclude that lithium ion technology has the highest cost reduction potential of all battery systems. Synergy with the current e-mobility battery development will help drive further innovation and cost reduction for the lithium ion battery technology.

For battery storage systems based on lithium ion technology, there are four main challenges that must be considered: capacity, safety, lifetime, and costs. In regards to capacity, while the power density and energy density are large for lithium ion technology, a huge number of cells are needed to reach a reasonable capacity for a

[7] Prof. Sauer: Optionen zur Speicherung elektrischer Energie in Energieversorgungssystemen mit regenerativer Stromerzeugung
[8] FhG: Energietechnologien 2050 - Schwerpunkte für Forschung und Entwicklung

battery pack. Due to these facts, the battery storage system is suited for decentralized energy storage. The energy will be stored in the same location in which it was produce, for example, on location with a photovoltaic system. In principal, it's also possible to build Gigawatt-hour battery storage systems, by building a virtual storage plant. In this vision, a huge number of small battery storage systems are connected by a communication network and controlled by a central intelligence.

The second challenge to consider the safety of the lithium ion based system. The lithium ion technology has a small operating window in which the battery can be used safely. However, steps have been taken to minimize these risks in order to make use possible. Research in cell chemistry has allowed for the extension of the operating window, through new electrode material and improved electrolyte. A protection circuit is integrated into the battery pack, to control voltage and current, and to monitor temperature. And finally, battery management systems are utilized for systems of series connected battery cells. There are two types: Passive and Active. Passive battery management systems bypass with a resistor (loss of heat), while Active battery management systems transfer charge from strong cells to weak cells.

The third challenge is the lifetime of the battery. There are two modes of aging: calendric and cycle aging. Calendric aging occurs due to the time the battery is in use. In cycle aging, the battery is aged due to the battery being used and the cycle count increasing. The level of current draw, as well as the duration of said current draw, has a large influence on the cycle life of a battery. The temperature and depth of discharge also have an influence on the cycle aging of the cell. High temperatures can cause the cell to degrade faster. Conversely, not using the full capacity of the battery can extend the cycle life (depth of discharge). For example, a cell was cycled until 94% of its original capacity degraded. For 100% depth of discharge, the cell was capable of 500 cycles. When the depth of discharge was 80%, the cell maintained 2500 cycles[9]. It was possible to increase the lifetime by a factor of five by reducing the depth of discharge only 20%. Another way to increase the lifetime is to improve the electrode materials, such as lithium titanite anodes, which are more robust than graphite. This is due to the lack of solid electrolyte interface of the lithium titanite, where this is present on the graphite anode. The downside of the lithium titanite is that it provides approximately 1V of cell voltage less.
A lot of research has to be done to reach the target of >20 years and >7000 cycles, ultimately reducing the life cycle costs of the technology.

The final challenge is the cost of the battery storage. The costs today are on the level of 500-1000 €/kWh (cell level). The target costs are on the level of 150 €/kWh (cell level) to make economic sense. This means that the cost effectiveness depends on the battery cell cycle lifetime. Therefore this must be on top of priority for the development work. Different options should be taken into account to achieve these targets.
1. An incentive program from the government, similar to the photovoltaic market, would stimulate adoption, thus bringing the price down over time.
2. Research for cost reduction

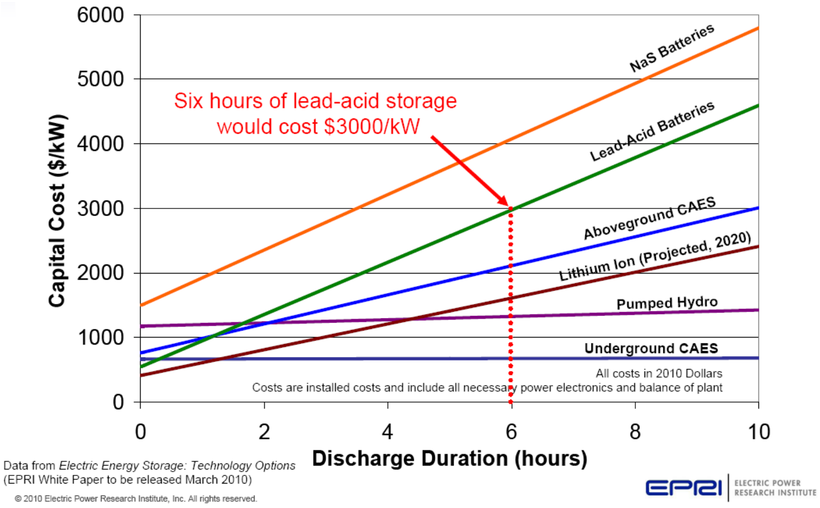
[9] Prof. Jossen: Basiskurs Batterien

3. Utilizing synergies with the EV batteries, thus providing economies of scale.

While there is some work to still be done, battery energy storage is a viable option for supporting the integration of renewable energy.

Kostenprognosen

Energy Storage Plants:Estimated Capital Cost Comparisons



* Compressed Air Energy Storage (CAES)

Where Will Lithium Ion Costs Go?