Electrochemical energy storage for automotive, stationary and portable application

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From the first battery (Cu-Zn primay cell) development by the Italian Alexandro Volta in 1800 up to the 1980s the battery applications were primarily technology driven. The applications were mainly in the portable (flashlights, transistor), industrial (storage, emergency), and automotive (car starter) area. However, with the increase of environmental and resource problems the development became more and more demand and government driven. National and international battery development programs were launched especially from 1990.

Accompanied by the development of the high-performance Li-ion battery (LIB), which was able to open up new markets (electromobility, stationary energy storage systems) there was a rapid increase in the global battery production. While in 1990 the production capacity amounted only to 5 GWh, already in 2000 we had 10 GWh and 2010 30 GWh. With the further increase of the LIB performance and, above all, the reduction in cell costs (2000: ca. 1,000 $ kWh -1 . 2010: ca. 400 $ kWh -1 , and 2020: ca. 160 $ kWh -1), the Li battery production increased exponentially to about 1 TWh in 2023, where the production capacity was even at 2.6 TWh (after Bloomberg NEF, 2024). Elon Musk predicts 300 TWh in the future to solve the global problem The lecture is concentrating on the state-of-the-art and the future of LIBs and Post-LIB

systems. The today LIB with liquid electrolytes are performance and cost optimized. The performance LIB systems (NMC, NCA, Si/C) can achieve a specific energy of 300…350Wh kg -1 on cell level and the cost optimized LIB systems (LFP, LMFP, LMRO) about 30 % lower. The costs of LFP cells are ~$70/kWh and the NMC cells at ~$100/kWh.

An important parameter in battery development is safety. It is to notice that with increasing specific energy the safety is reduced. Developments to increase the specific energy and to decrease the hazard are all solid- state batteries (ASSB) based on polymer and inorganic (sulfidic, oxidic) solid electrolytes. Based mainly on interphase problems between the solid anode/cathode and the solid electrolyte a market introduction of the inorganic ASSB will be only at the end of this decade. Polymer ASSB with lower specific energy and operating temperatures of > 60 °C exist already (BOLLORÉ). Decreasing costs and a larger resource basic are the driver for Sodium-ion batteries (SIB). Furthermore, SIB have shown a higher safety and longer lifetime. The production of SIB has already started mainly in China.