The NextBMS Project: Improved Battery Models for Enhanced Utilization, Safety and Performance of Batteries

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As detailed electro-chemical battery models are usually computationally expensive, current battery management systems (BMS) mostly rely on semi-empirical battery models (e.g., equivalent circuit models) due to limited computational capabilities. However, these models are only valid in the design space where they were characterized and they cannot be used to observe internal processes of the battery. Additionally, State-of-the-Art (SotA) BMS usually use simple measurement of battery voltage, current and temperature to estimate internal battery states. Nevertheless, critical phenomena, like e.g., Li-plating or SEI-growth cannot be detected at early states using this method.
The NextBMS project [1] aims at solving these problems and heading towards optimal battery utilisation by enhancing the overall battery performances, lifetime, reliability, and safety of battery systems. This is achieved by elaborating and implementing solutions at three technical layers: (1) advanced physics-based and adaptable battery models; (2) advanced data acquisition combining sensor-based solutions at battery system/module level and model generated values; and (3) new control algorithms with advanced state estimators and data-based algorithms to increase utilisation while ensuring safety and reliability of the advanced BMS system. NextBMS develops scalable physics-based models for battery management with data transferability between detailed electro-chemical models and computationally efficient equivalent circuit models [2]. The latter features physio-chemical consistency, which means that the parameters and states have a physical meaning, to assure straight-forward utilization of the model while achieving high prediction capabilities in terms of internal battery states and aging phenomena. This approach enables to directly map the electrochemical processes, material properties and geometric parameters of the battery directly into the model topology and the model parameters (Figure 1). A combination of hardware sensors and virtual sensors (coming from the proposed models) is used to increase the amount and quality of information concerning the internal states of the battery. This allows the BMS to estimate internal states of the battery accurately and reliably, and to predict the remaining useful lifetime of batteries more accurately and detect possible failures due to internal processes (e.g., due to battery aging phenomena) earlier than it is possible with SotA solutions. Thus, the proposed solutions lead to an increase in battery utilization, safety and performance at the same time. The entire NextBMS project will be accompanied by a thorough battery testing campaign to prove the validity and performance of the proposed bundle of measures.

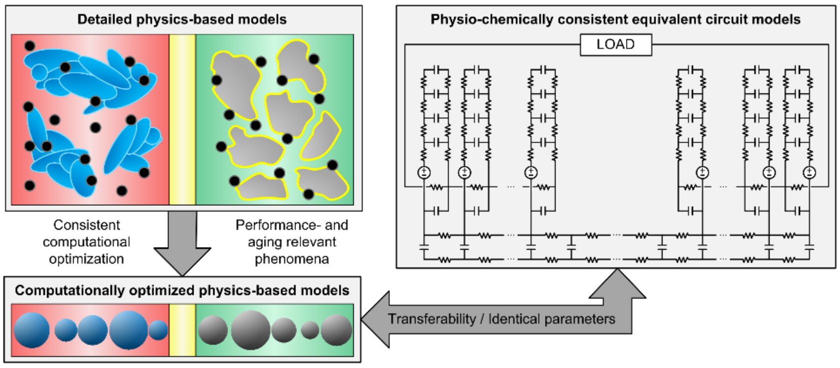

Figure 1: Schematic overview of transferability between different types of battery models [2].

References:
1. NextBMS. (2023). Retrieved from https://nextbms.eu/
2. Katrašnik, T., Mele, I., & Zelič, K. (2021). Multi-scale modelling of Lithium-ion batteries: From transport phenomena to the outbreak of thermal runaway. Energy Conversion and Management, 236(May). https://doi.org/10.1016/j.enconman.2021.114036