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Editorial

Towards a Smarter Battery Management System

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Batteries play a critical role in achieving a sustainable energy future, enabling the integration of renewable energy sources and supporting electrified transportation and smart grids [1–3]. Advanced Battery Management Systems (BMSs) are essential in harnessing the potential of various battery chemistries. BMSs ensure safety, optimize performance, and prolong battery lifespan through advanced monitoring, state estimation, thermal management, and fault diagnostics [4,5]. Recent advancements in algorithms, sensors, and hardware have significantly enhanced the capabilities and intelligence of BMSs, making them increasingly adaptive and efficient.

The first edition of this Special Issue, "Towards a Smarter Battery Management System", gained remarkable success, with 11 high-quality papers published, covering essential topics related to smart BMS solutions. Inspired by these systems' reception and the continuous developments in the field, this second edition expands upon these critical research areas to further highlight the latest research and perspectives. It covers diverse topics, including advanced modeling techniques, state-of-health (SOH) and state-of-charge (SOC) estimation algorithms, battery balancing technologies, battery durability, second-life applications, and emerging chemistries such as sodium-ion batteries. The issue attracted strong interest, receiving 11 high-quality submissions, reflecting ongoing advancements and diverse research efforts within the BMS field.

Research Papers:

1. Advanced Algorithms for State Estimation

Akram et al. [6] developed a novel SOH estimation model that integrates Distribution of Relaxation Time (DRT) parameters with a Long Short-Term Memory (LSTM) neural networks. This hybrid approach enables the capture of both electrochemical dynamics and temporal trends, significantly improving estimation accuracy and adaptability to various cycling conditions.

LeBel et al. [7] conducted a detailed analysis on the impact of entropy change in lithium-ion battery electro-thermal modeling. By incorporating entropy change into thermal prediction frameworks, the study achieved better alignment with experimental temperature profiles and improved the fidelity of battery thermal models.

2. Battery Testing and Durability

Neupert et al. [8] proposed innovative data-driven load cycle generation methods for battery testing. By leveraging Gradient Random Pulse strategies and advanced Generative Adversarial Networks (GANs), they produced synthetic profiles that closely resemble real-world usage, enabling more robust and flexible battery evaluation.

Tian et al. [9] evaluated the degradation behavior of lithium-ion batteries under frequency regulation conditions. Their findings provided critical insights into how high-

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rate cycling impacts capacity fade and electrochemical stability, which is vital for grid-supporting applications.

Muresanu and Dudescu [10] investigated the structural integrity of cylindrical lithium-ion cells under mechanical compression. Through experimental and simulation-based approaches, they characterized deformation modes and provided recommendations for mechanical protection design.

3. Hardware Innovations

Song et al. [11] introduced a new inductor-based active balancing circuit capable of operating efficiently across a wide voltage range. The proposed hardware architecture reduces balancing time and energy loss, offering practical improvements for high-energy battery packs.

Martínez-López et al. [12] investigated flow dynamics in organic redox flow batteries. By introducing electrode obstacles to guide electrolyte movement, they demonstrated improved concentration distribution and mass transport efficiency, which can boost the performance and durability of flow battery systems.

4. Second-Life Management

Cao et al. [13] assessed the second-life potential of commercial $LiFePO_4$ battery packs retired from electric vehicles. Their study evaluated capacity consistency, balancing challenges, and overall system integration, offering practical strategies for repurposing used batteries in stationary energy storage applications.

Review Papers:

Andrenacci et al. [14] reviewed battery storage developments within European smart mobility contexts, discussing performance, safety, regulatory challenges, and sustainability considerations.

Bača et al. [15] systematically reviewed sodium-ion batteries, presenting a detailed analysis of their properties, advantages, challenges, and suitability for stationary storage applications.

Jose et al. [16] provided an in-depth exploration of artificial intelligence applications in battery recycling processes, emphasizing their role in enhancing recycling efficiency and environmental sustainability.

These contributions significantly advance the field of smart battery management systems, providing essential references for future research and practical applications. Future studies might further address advancements in the software and hardware of intelligent BMSs, the integration of BMSs with emerging battery chemistries, and standardized approaches to managing second-life batteries. We encourage researchers to submit their work to upcoming editions of this series.

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