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Performance Evaluation of a Novel Solid-State Battery in Renewable Energy Grid-Connected Systems

As the global energy structure transitions toward low-carbon systems, large-scale integration of renewable energy poses new challenges to power system stability and energy management. Renewable energy sources, such as wind and solar, are inherently intermittent and variable, which can cause frequency and voltage fluctuations in the grid and impact system reliability. Energy storage technologies play a critical role in grid-connected renewable energy systems by balancing energy supply and demand, performing peak shaving and valley filling, and providing ancillary services such as frequency and voltage regulation. Recently, solid-state batteries (SSBs) have attracted significant attention due to their high energy density, long cycle life, and superior safety. Compared to conventional liquid electrolyte batteries, SSBs offer notable advantages under high-temperature, high-rate, and long-term operating conditions, making them highly suitable for integration with renewable energy systems.

To evaluate the performance of SSBs in grid-connected systems, it is necessary to analyze their charge-discharge efficiency, cycle life, power response characteristics, and compatibility with renewable energy variability. Experimental studies and numerical simulations can reveal the dynamic behavior of SSBs under different operational strategies and load conditions, providing reliable data for system optimization. Performance evaluation not only highlights the technical advantages and limitations of SSBs but also offers theoretical guidance for system design, capacity planning, and control strategy optimization.

This study aims to systematically evaluate the performance of a novel solid-state battery in renewable energy grid-connected systems. The research includes battery characterization experiments, system modeling, renewable energy and load fluctuation analysis, and optimization of energy storage operation strategies. By analyzing system performance under different operating scenarios, the study assesses the effectiveness of SSBs in enhancing system stability, energy utilization efficiency, and economic performance. The findings are expected to provide theoretical and practical support for the large-scale deployment of solid-state batteries in renewable energy systems and contribute to the development of low-carbon smart grids.