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Abstract

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SUSTAINABLE BATTERY ENERGY STORAGE SYTEM (BESS) CHALLENGES FOR DISTRIBUTED GENERATION

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Abstract

The transition to sustainable energy systems has highlighted the critical role of Battery Energy Storage Systems (BESS) within distributed generation (DG) frameworks. Microgrids and DG technologies provide substantial technical, economic, and environmental benefits, including improved reliability, reduced power losses, enhanced voltage profiles, and lower carbon emissions. These systems enable decentralized power generation and storage, making energy more accessible and cost-effective. However, the exponential demand for lithium-ion batteries has introduced significant challenges, particularly concerning waste management, energy density, cost, and environmental sustainability. Improper disposal of end-of-life batteries creates risks such as contamination, safety hazards, and an increased carbon footprint, all of which threaten the sustainability of energy systems. Despite being disposed of at approximately 80% capacity, these batteries can still be repurposed for energy storage systems, offering an extended utility of an additional 5–10 years.

Addressing these challenges requires a robust, circular approach to battery lifecycle management. Recycling technologies present an effective solution by recovering critical materials from used batteries, reducing environmental risks, and decreasing dependency on the extraction of finite raw materials. Moreover, developing efficient recycling processes can bolster local economies through job creation while supporting sustainable manufacturing practices. By integrating recycled batteries into energy storage systems, the industry can mitigate environmental impact, reduce costs, and enhance resource efficiency. Additionally, advancements in recycling processes, such as chemical recycling, are essential to reclaim valuable materials and minimize the carbon footprint of battery production and waste management.

To ensure the long-term sustainability of DG and BESS, a comprehensive approach is essential. This includes aligning production, usage, and end-of-life handling with innovative recycling strategies and fostering collaboration between policymakers, researchers, and industry stakeholders. Policies promoting sustainable practices, coupled with research initiatives aimed at improving battery performance and recycling technologies, will support a transition to resilient and environmentally friendly energy systems.

In conclusion, the adoption of BESS in DG systems is a pivotal step toward a decentralized and sustainable energy future. However, achieving this vision requires addressing the environmental challenges associated with battery waste. By investing in recycling technologies and adopting a lifecycle approach, stakeholders can ensure that batteries are utilized optimally and disposed of responsibly, thus contributing to a greener and more resilient energy ecosystem. Collaborative efforts across industries and research institutions are vital to achieving these goals and enabling a sustainable energy transition.