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A Critical Review on Compatibility of Energy Storage Technologies with Renewable Energy Integration

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The global shift towards sustainable energy necessitates the integration of renewable sources like solar and wind into power systems. However, the intermittent nature of these sources presents significant challenges to grid stability and reliability. This study critically reviewed the compatibility of various energy storage technologies—Pumped Hydroelectric Energy Storage (PHES), Flywheel Energy Storage (FES), and Li-Ion Battery Storage (LIBS)—with renewable energy integration. Each technology's unique characteristics, including energy and power density, efficiency, cost, lifetime, and response time, were analyzed in detail. PHES, with its large-scale storage capacity, offers a cost-effective solution but is geographically constrained. FES provides rapid response capabilities suitable for frequency regulation, while LIBS, despite higher costs, promises flexibility and scalability. The study highlights the crucial role of energy storage in mitigating the intermittency of renewable sources, enhancing grid stability, and promoting sustainable energy. Through a comprehensive analysis, this critical review aims to assist decision-making by providing insights on the effective integration of energy storage technologies in renewable energy systems.

Keywords: *pumped hydroelectric energy storage (PHES), flywheel energy storage (FES), Li-Ion battery storage (LIBS)*