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Performance Evaluation of Advanced Energy Storage Systems

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Abstract:
Energy systems are progressive and revolutionary for their alternative resources, technical developments, demands, effectiveness and environmental effects. The recently published research's goal is to assess and evaluate the systems that are already in operation and those that will be in the future. Energy can be stored as electrical energy such as supercapacitors (SCs) and superconducting magnetic energy storage (SMES) etc., mechanical energy such as pumped hydro energy storage (PHES), compressed air energy storage (CAES) and flywheel energy storage (FES) etc., chemical energy, electrochemical energy such as batteries and fuel cells etc., and thermal energy. Performance of these energy storage systems (ESSs) have been evaluated in terms of energy density, power density, power ratings, capacitance, discharge-time, energy-efficiency, life-time and cycling-times, and costs. Supercapacitors provide highest power density (>10,0000 W/l), while hydrogen fuel cells provide highest energy density (500-3000Wh/l) among other EESs. Batteries also provide high energy density(200-500Wh/l). The energy efficiency is found highest in SMES system (95-98%), and lowest in TES system (30-50%). Moreover, batteries and supercapacitors have the cycle efficiency above 90%. PHES and CAES seem to be the most cost-effective energy storage systems reviewed in this analysis in terms of $/kWh. In addition, power-based capital cost of supercapacitors is lower (100-300$/kW) compared to energy-based capital cost of supercapacitors (300-2000$/kWh). In comparison with power-based capital costs, the energy-based capital cost of batteries is lower, which is 150-400$/kWh for Lead-acid battery, and <300$/kWh for Li-ion battery. This essay may help researchers in choosing the advanced energy storage technologies for relevant purposes.