

Assessing value of renewable-based VPP versus electrochemical storage: Multi-market participation under different scheduling regimes and uncertainties

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Abstract-

To explore clean and cost-effective alternatives to Electrochemical Storage Systems (ESSs), this study focuses on Renewable-based Virtual Power Plants (RVPPs) that employ Dispatchable Renewable Energy Sources (D-RES), Concentrated Solar Power Plant (CSP), and demand flexibility as primary sources of flexibility. In this context, the paper compares the participation of RVPPs and grid-scale ESSs in energy and reserve markets, evaluating their technical performance, market strategies, and economic outcomes. To ensure a fair comparison, scheduling is analyzed over representative sample days that capture seasonal operating regimes, and the associated uncertainties are explicitly modeled. An uncertainty-aware scheduling and bidding framework is developed, explicitly capturing price, generation, and demand uncertainties. It also incorporates a tailored algorithm for sizing the ESS so that its market performance aligns with that of the RVPP. Simulations cover both favorable and unfavorable scenarios, reflecting seasonal energy limits for dispatchable resources, varying forecast errors for nondispatchable resources, and alternative uncertainty-management strategies. The results provide operators with quantitative guidance on the relative value of each approach.

Index Terms- Renewable-based virtual power plant; Electrochemical storage system; Energy market; Reserve market; Uncertainty

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