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Two-stage robust optimization strategy for VPP participation in the energy and reserve markets considering intertemporal carbon trading

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Abstract-

This paper proposes a coordinated strategy for Virtual Power Plants (VPPs), including both renewable and conventional units, to participate in the Day-Ahead Market (DAM) and Secondary Reserve Market (SRM), while incorporating intertemporal Carbon Trading Market (CTM) constraints. The model enables the VPP to leverage differences in CTM prices across multiple sample days by strategically selling excess carbon credits or purchasing required credits on sample days with more favorable prices. A two-stage robust optimization framework is developed to account for multiple uncertainties in market prices, renewable energy production, and demand consumption. The proposed scheduling strategy encourages the VPP to prioritize low-emission resources and limit the use of polluting units, contributing to both profitability and emission reduction. To evaluate the effectiveness of the proposed approach, simulations are conducted for a 220 MW VPP supplying 80 MW of internal demand under various uncertainty-handling strategies and carbon credit allowance levels. The findings show that the proposed model enables more flexible carbon trading, with CTM-related profitability increasing by 29.0–55.3%, and carbon emissions reduction improvement up to 8.9% compared to daily carbon trading.

Index Terms- Virtual power plant; Carbon trading market; Energy market; Secondary reserve market; Robust optimization

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