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Single-level flexible robust optimal bidding of Renewable-Only Virtual Power Plant in energy and secondary reserve markets

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Abstract-

This paper proposes a novel single-level robust mathematical approach to model the Renewable-only Virtual Power Plant (RVPP) bidding problem in the simultaneous day-ahead and secondary reserve markets. In existing single-level models in the literature, different uncertainties are modeled separately, without explicitly considering their interactions, leading to worst-case energy scenarios. In this study, the flexible worst-case profit of RVPPs due to uncertainties related to electricity prices, Non-dispatchable Renewable Energy Sources (ND-RES) production, and flexible demand is captured. In order to find the flexible worst-case profit in a single-level model, the relationship between price and energy uncertainties leads to non-linear constraints, which are finely linearized. Simulation results show the superiority of the proposed robust model compared to alternatives found in the literature in terms of computational efficiency, without compromising the quality of results. Moreover, ND-RES and demand uncertainties exert a greater influence on the RVPP trading strategy and profitability compared to uncertainties in electricity prices. Specifically, for the studied RVPP, the sold and purchased energy decrease by 52% and increase by 74.2%, respectively, when only ND-RES and demand uncertainties are considered, as opposed to the case where solely uncertainties related to day-ahead and secondary reserve market prices are taken into account.

Index Terms- Renewable-only virtual power plant; Electricity markets; Single-level model; Robust optimization; UncertaintyFlexible worst-case profit

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