Distribution Dynamic Operating Security Space Characterization for Aggregation and Congestion Capacity Evaluation of Virtual Power Plant

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Virtual power plant(VPP) can manage distributed energy resources (DERs) to serve the grid, which should satisfy the power flow constraints. However, the distribution system operator(DSO) monopolies system parameters and VPP cannot directly access them. To solve the coordination problem between distribution operation security and VPP management, the distribution dynamic operating security space (DOSS) is proposed to constrain the DER output power for VPP aggregation and congestion capacity evaluation. First, a hybrid fuzzy modeling method based on the distribution system security region is employed to characterize DOSS, and less information exchange between VPP and DSO is required. Data privacy is well respected, and the computational complexity is also reduced. Second, the enhanced opposite direction searching algorithm and the generalized credibility-based piecewise membership crisp method are applied to achieve DOSS's type-reduction and defuzzification for VPP aggregation. This clarifies distribution security risks on VPP through DOSS's credibility levels. Finally, VPP congestion capacity is proposed to quantify security constraint impacts on the VPP aggregation capacity, which can help coordinate the VPP economic and DSO secure operations. Case studies demonstrate that the proposed methodology can effectively embed the distribution operation security constraints into VPP aggregation and show higher applicability and lower conservativeness than existing approaches.

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