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Keywords Load shedding, Network reconfiguration, Power system restoration, Resilience improvement, VPP

Abstract This paper proposes a risk-oriented optimization framework for coordinating multiple virtual power plants (VPPs) within a reconfigurable distribution network to enhance system resilience under extreme natural disasters. The problem is formulated as a bi-level optimization model, where the upper level minimizes the overall operational cost of the distribution network. In contrast, the lower level maximizes the profit of individual VPPs. To ensure computational tractability, the bi-level model is transformed into an equivalent single-level formulation using Karush-Kuhn-Tucker (KKT) conditions and solved efficiently with the GUROBI solver. Uncertainty is also addressed through a non-parametric approach based on info-gap decision theory (IGDT), which enables both risk-averse and risk-seeking decision-making under severe uncertainty. The proposed framework is validated on IEEE 33- and 69-bus test networks. Results indicate that system disturbances considerably increase operational expenses, largely driven by the need for load shedding to preserve system security. The proposed coordination strategy, which integrates feeder reconfiguration with optimized VPP dispatch, effectively mitigates these costs during severe events. Furthermore, the method improves voltage regulation and enhances system voltage stability under disturbances. In terms of computational performance, the proposed method delivers faster solutions, offering a clear advantage over metaheuristic methods and enabling real-time restoration applications.

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