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Abstract The high penetration of renewable energy, characterized by strong randomness and volatility, has increased the difficulty of maintaining supply–demand balance in power systems. Consequently, distribution networks face challenges such as enlarged peak–valley differences and line overloads. Traditional planning methods based on peak load are insufficient to meet the requirements for power quality and reliability. Therefore, enhanced planning strategies leveraging flexible resources are required. However, existing approaches often neglect the role of flexible resources in power flow regulation and inadequately capture source–load uncertainties. Although Integrated Energy Systems (IES) have been recognized for their capability in peak shaving and valley filling, most studies rely on centralized optimization and overlook strategic interactions among stakeholders. To address these issues, this paper proposes a distribution network planning model that incorporates IES participation based on a Stackelberg game framework. First, an IES integrating electricity, heating, cooling, and gas is established. Then, considering source–load uncertainties, Information Gap Decision Theory (IGDT) is employed to model uncertainty, and an IGDT-based optimal scheduling model is developed to evaluate the regulation capability of the IES over different time periods. Finally, the regulation demand of the distribution network is quantified and integrated into the planning process, enabling coordinated optimization between the network and IES.

Keywords Source–Load Uncertainty, Integrated Energy System, Stackelberg Game.