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Highlights

- Coordinating conventional Volt-VAr devices with distributed energy resources.
- Incorporating demand response program into the Volt-VAr control problem.
- Utilizing ε-constraint approach to generate Pareto optimal solutions.
- Using IGDT to develop a robust decision-making approach.
- Developing a mixed-integer linear programing framework.

Abstract Distributed energy resources (DERs), such as renewable energy sources (RESs) and energy storage systems (ESSs), are inevitable parts of future power grids. However, the high penetration of RESs may cause voltage violation issues in distribution levels. To this end, the application of the Volt-VAr management (VVM) scheme is highlighted. This paper aims to maintain voltage levels within standard ranges with optimal coordination of different resources at minimum operational costs and voltage deviation. In more detail, this article develops a new VVM in distribution networks to effectively coordinate novel smart grid technologies such as PV inverters, time of use demand response program (TOU-DRP), energy storage systems (ESSs) with traditional devices, including on-line tap changer transformer (OLTC) and switchable capacitor banks (SCBs). Because the coordinated VVM is a bi-objective model that minimizes both operating cost and voltage deviation, it is proposed to use the ε-constraint technique to identify optimal Pareto solutions. To handle the uncertainty related to RESs and load demands, a robust technique based on information gap decision theory (IGDT) is also utilized. The formulation is configured as a mixed-integer linear program (MILP) and solved by CPLEX. It was implemented on the 118-bus distribution network under various conditions. The simulation results clearly show that the coordination of DERs and traditional devices has a significant impact on maintaining voltage levels within permissible ranges while minimizing operational costs. A higher degree of uncertainty radius can also be obtained if DRP participates in the VVM scheme.

Keywords Volt-VAr control; Demand response programs; PV inverters; Energy storage systems; Information gap decision theory (IGDT).

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