A robust ADMM-enabled optimization framework for decentralized coordination of microgrids

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Abstract-

The integration of renewable energy resources and electric vehicle (EV) fleets with community microgrids (CMG) has increased fluctuations in net load. To address this and ensure safe operation, tapping into demand-side flexibility capacities in local electricity markets (LEM) is essential. Hence, this article presents a multilevel methodology for settling energy and flexibility markets among CMGs, utilizing the potential of Internet-of-Things-enabled appliances (IoT-EA), thermostatically-controlled loads (TCLs), and EVs in smart residential buildings (SRB) to enhance system performance. At level 1, SRBs are modeled using the virtual energy storage system (VESS) concept. Level 2 involves CMG scheduling, and at level 3, the distribution system operator settles the energy and flexibility markets using an adaptive alternating direction method of multipliers (ADMM) algorithm. Strong duality theory (SDT) and Karush-Kuhn-Tucker (KKT) conditions form a mathematical program with equilibrium constraints (MPEC) where market prices are variable for all participants. By unlocking the potential of SRBs, the proposed framework reduces flexibility market costs by 49.67%, network losses by 24.1%, and improves the voltage profile. The results confirm that the proposed market clearing mechanism ensures market efficiency and protects CMGs' privacy.

Index Terms- Distributed optimization, flexibility markets, Internet-of-Things, microgrids, vehicle-to-grid technologies, virtual energy storage systems.

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