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Emerging renewable-based electricity grids under high penetration of cleaner prosumers: unraveling the flexibility issues using a four-layer decentralized mechanism

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Abstract-

The rise in distributed renewable generation and active prosumers has heightened power exchanges in Distribution Systems (DS), causing congestion issues. This paper presents a four-layer optimization model for Distribution System Operators (DSOs) to efficiently manage network congestion through smart prosumers. The first two layers involve an iterative bidding process in the energy market to maximize social welfare during settlement. The third and fourth layers address congestion in the market, employing an adaptive Alternating Direction Method of Multipliers (ADMM) algorithm for decentralized coordination between DSOs and smart prosumers, including Microgrids (MGs), Energy Hubs (EHs), and Electric Vehicle Parking lots (EVPLs). Layer 1 optimizes market player bids, layer 2 maximizes social welfare, layer 3 handles congestion using various strategies, and layer 4 reschedules smart prosumers based on DSO's requests. Implemented on a 118-bus DS in GAMS, the model demonstrates the efficacy of the proposed adaptive ADMM in ensuring player privacy and market efficiency. Additionally, integrating the market-based mechanism with Distribution Feeder Reconfiguration (DFR) optimally utilizes smart prosumers, resulting in a 46.85% reduction in net DSO costs. This practical implication underscores the model's effectiveness in addressing network congestion challenges and providing economic benefits for DSOs.

Index Terms- Renewable energy resources; Active distribution network; Flexibility issues; Microgrids; Energy hubs; Electric vehicle

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