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Eco-environmental scheduling of multi-energy communities in local electricity and natural gas markets considering carbon taxes: a decentralized bi-level strategy

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Abstract-

Multi-energy communities (MEC) integrated with renewable resources are known as a cost-effective and highly efficient solution to meet the diverse energy needs of subscribers. The increasing integration of MECs with electricity and natural gas networks has made it necessary to design new frameworks to optimize their energy management and then facilitate their participation in competitive energy markets. Hence, this article presents a bi-level optimization strategy for the decentralized coordination of MECs in competitive electricity and gas markets, in which the system operator adopts a robust technique to deal with operational uncertainties. The daily planning of MECs is performed in the upper level, while in the lower level, the planning of electricity and natural gas networks takes place. An adaptive alternating direction method of multipliers (ADMM) algorithm has also been introduced to settle the electricity and natural gas markets in a decentralized space while considering the CO2 footprint tax. The proposed strategy is implemented on a system containing a modified 69-bus IEEE distribution electricity network (EN) and a 65-node natural gas network (NGN). The results obtained from the case studies show that the proposed adaptive ADMM algorithm reached the optimal point in 113 iterations less than the original version, reducing the solution time by 48.01 %. The results prove that the proposed strategy has been able to coordinate the decentralized MECs with the least data sharing in the competitive electricity and gas markets. Additionally, it effectively utilizes the capabilities of renewable-based assets, storage systems, and smart EV charging to reduce the CO2 footprint, alleviate congestion, and improve the voltage and gas pressure profiles, while leading to reduced market clearing prices.

Index Terms- Multi-energy community; Renewable energy sources; Carbon footprint; Electric vehicles; Alternating direction method of multipliers; Energy markets

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