Improving Sustainable Microgrid Design by Considering Effects of Government Subsidies, Peer-to-peer Energy Trading, and Uncertainty: Fuzzy Meta-heuristic Approach

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Abstract. The uncertainty of demand loads and the volatile nature of renewable sources lead to challenges in balancing energy supply and demand. To solve this problem, sustainable microgrid (SMG) with renewable energy has been counted as a reasonable approach to achieve economic goals, reduce impacts to the environment, and satisfy customer demand. However, the installation rate of microgrids is still limited, because of the high initial investment cost. In order to improve installation rate, various studies examined government subsidies on designing a sustainable microgrid, but the effects of government subsidies on electricity prices and financial factors under peer-to-peer (P2P) energy trading have not been investigated in SMG design by previous studies. To fill this gap in the literature, this research develops SMG design by considering various impacted factors such as the effects of government subsidies on electricity selling price, P2P energy trading, time value of money, depreciation, and uncertainty. Objectives that include maximizing total profit, satisfying customer demand, and minimizing total environmental cost are created by a multi-objective mixed integer-linear programming model. To deal with inaccuracy in the original model and uncertainty, the fuzzy approach is first applied to convert the original model into an equivalent fuzzy multi-objective programming model. A genetics algorithm is then utilized to solve the proposed fuzzy multi-objective programming model to decide the optimal decisions on the number, location, capacity of renewable distributed generation sources, electricity flows, price for selling electricity to demand areas and P2P energy trading, and government subsidy rates on electricity selling prices. Numerical experiments are conducted to assess the performance of the proposed model and algorithm. The results demonstrate that the proposed model is more efficient and effective, increasing total profit by 17.26% and reducing total environmental cost by 8.12% compared to the case of no government subsidies and P2P energy trading.

Keywords: Sustainable microgrid design, Government subsidies, P2P energy trading, Uncertainty, Fuzzy multi-objective programming, Genetic algorithms