A FRAMEWORK FOR MULTIPLE-PARTICIPATION IN ENERGY COMMUNITIES

Ivan Mariuzzo, AIT Austrian Institute of Technology GmbH, University School for Advanced Studies IUSS Pavia, University of Pisa, +39 348 27 61 060, ivan.mariuzzo@phd.unipi.it
Dr. Bernadette Fina, AIT Austrian Institute of Technology GmbH, Giefinggasse 4, 1210 Vienna, Austria
Stefan Stroemer, AIT Austrian Institute of Technology, GmbH, Giefinggasse 4, 1210 Vienna, Austria

Overview

Energy Communities (ECs) have been proposed by the *Renewable Energy Directive* (REDII) (EUR-Lex, 2018) and the *Electricity Market Directive* (EMD) (EUR-Lex, 2019) as a new paradigm for energy systems. Based on the REDII and the EMD, some European Union member states have already enacted legislation for renewable energy communities and citizen energy communities at a national level. With the first energy communities being implemented, the scientific focus as well as the legislation develop constantly. So far, a significant number of studies investigate the optimal planning (Gjorgievski, Snezana , & Georghiou, 2021) of individual communities by considering economic, ecological, and social aspects. However, the Austrian legislation already goes one step further and foresees the possibility of participating in multiple ECs simultaneously (Fina & Fechner, 2021) from 2024 onwards. Therefore, it is necessary to investigate opportunities for new members interested in joining multiple energy communities. In this respect, it needs to be determined how a potential participant would impact energy and economic indicators of already existing ECs without worsening their economic performances. Such a scientific study is yet to be conducted.

Method

In this work, an optimization model is developed with the aim to determine which ECs a potential new participant should join and how such potential participation affects the existing communities. An important constraint is that the economic situation of the existing ECs and their participants is improved, or at least, not worsened. Simultaneously, some financial benefits should also be proposed to the new participant to increase the attractiveness to join an EC. To assess the described problem, the following approach is applied:

1. A pre-defined set of ECs is chosen according to different settlement patterns (e.g. city area, rural area);
2. For each EC, energy consumption and generation are defined by introducing a pool of consumers, prosumers and community-owned assets (e.g., community battery storage, photovoltaic plants, wind turbines, etc.);
3. The new participant is characterized in terms of energy consumption and the availability of a renewable generation unit and/or a storage;
4. The proposed framework establishes which subset of ECs represents an economically viable membership proposal for the new participant. This means that the optimization model determines how many of the available ECs the new participant should join, in order to maximize economic benefits. Still, the economic situation of the existing EC may not be worsened.

When a new participant plans to join one or more ECs, the energy balances of the latter are potentially affected by a new source and sink of energy, represented by the participant. Hence, allocation of the new participant is here modelled by associating binary variables to these terms to decide joining which EC is profitable or not. Additionally, there is the constraint that only a certain number of ECs can be joined simultaneously: The binary variables' sum needs to be lower than or equal to the maximum number of ECs that the participant is willing to be allocated to. Further constraints are adopted to optimally allocate a participant's fraction of energy to be purchased and/or sold to the different available ECs. The problem is then solved by minimizing all occurring costs in an economic objective function.

Results

Results show that the decision which ECs to join depends upon different factors. On the one hand, the purchasing price for energy agreed on in the individual ECs as well as the selling price play an important role. From an economic point of view, a new participant would rather join the ECs with the lowest purchasing price, and the highest selling price (which is only relevant if the new participant owns a generation unit). The combination of selling and purchasing price is then

decisive for the participant's optimal decision. On the other hand, the composition of the existing ECs is important as well. For example, given an EC with low purchase price but lacking of installed generating units, it would make more sense to join a community which is less economically attractive but with sufficient amounts of generation to be shared amongst its members. In certain cases, results show that a novel participant does not join any EC (e.g. because the existing communities' economic situation is worsened). Also, there can occur situations where it is determined optimal to only sell to certain communities, and purchase from others.

Conclusions

Results show that the proposed framework is efficiently solved determining the optimal subsets of ECs that a participant can join. The performed analysis also highlights how energy prices agreed on in the community as well as ECs' size and composition -- in terms of participants and available local generation -- play an important role in the allocation process. Indeed, while a new consumer can consider lower purchasing cost, a prosumer joining more than one EC can further benefit from selling energy at higher prices in comparison to a conventional feed-in tariff. This promotes better energy sharing inside all communities and, thus, an increased local self-consumption of renewable energy.

References

EUR-Lex. (2018). *Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG

EUR-Lex. (2019). *Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019L0944

Fina, B., & Fechner, H. (2021). Transposition of European Guidelines for Energy Communities into Austrian Law: A Comparison and Discussion of Issues and Positive Aspects. *Energies, 14*, 3922. doi:https://doi.org/10.3390/en14133922

Gjorgievski, V. Z., S. C., & Georghiou, G. E. (2021). Social arrangements, technical designs and impacts of energy communities: A review. *Renewable Energy, 169*, 1138-1156. doi:https://doi.org/10.1016/j.renene.2021.01.078