MONTE CARLO SIMULATION-BASED ECONOMIC RISK ASSESSMENT IN ENERGY COMMUNITIES

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Overview

In the European Union (EU), energy communities are seen as a pathway towards increased energy self-sufficiency of individual citizens as well as on a larger scale. Moreover, they are deemed a way to foster and implement decentralised renewable energy sources (RES), especially photovoltaics (PV). For that reason, research on energy communities has become increasingly prevalent in recent years. While a number of studies with a focus on the economic viability of energy communities already exist, methods to evaluate the economic risks associated with them have not yet been developed and introduced in literature, even though this aspect is crucial for making sound decisions on investments, operation strategies, and financing options for potential energy communities prior to their establishment.

Methods

In order to realise economically sustainable and viable energy communities, economic considerations that take into account risk aspects are essential. For that reason, a new tool for the economic assessment of energy community operation under the consideration of associated risks is developed in this study. The tool, which is based on the open-source programming language python [1], includes the possibility to appraise an array of uncertainties that determine the risks that impact the viability of energy communities. Monte-Carlo simulation is used for that purpose in the context of energy communities for the first time, thus contributing significantly to the current state of the art. Uncertainties such as the cost associated with installing RES, operation and maintenance costs, interest rate fluctuations, and different operation models can be mapped in the model according to their probabilities. Through that, the outcome of the Monte-Carlo simulation-based risk assessment provides a sound representation of the true behaviour of the uncertainties and the associated implications for the economic risk in energy communities. The chosen approach also offers the possibility to reveal almost all possible outcomes concerning a specified parameter during the implementation of an energy community, which further refines the decision-making process. Moreover, CO_2 emissions and their relationship with the associated risks of different alternatives for the operation of an energy community can be derived, which allows to evaluate the ecological impact of the energy community at hand. The results of the economic evaluation under risks given by the proposed tool thus furnish a well-founded basis for making sound decisions concerning the implementation and operation of a potential energy community.

In order to validate the developed tool, a case study is conducted. The tool is applied to a real site in Austria, comprised of several multi-apartment houses that contain 157 apartments in total. The site consists of a mix of old and new buildings and is a social housing site, which increases the cruciality of a sound economic and risk assessment of a potential energy community prior to its implementation. The current regulatory framework for energy communities in Austria is considered in the case study, however, it should be noted that the tool is not limited to one country, but can easily be applied to other regions through adapting a limited number of parameters.

Results

The application of the tool developed in this study provides insights into (i) the economic viability with regard to associated risks and (ii) the carbon footprint of energy communities for different operation models. As a result, the most cost-effective option for the energy community is identified. By modelling the associated risks for each alternative, an indication of the most risk-averse decision can be obtained, as well as the correlation of the risk with the other considered parameters. The distribution of outcomes for a specified measure, which is the result of the Monte-Carlo simulation, provides a wide range of possible outcomes in addition to their probabilities and therefore

constitutes a well-founded estimation of its real behavior. Furthermore, the least carbon intensive operation model for the energy community is pinpointed by the results on the CO_2 emissions for each alternative. Through that, a sustainable operation of the prospective energy community can be ensured. Moreover, the relationship between the profitability, riskiness, and ecological impact can be determined for each operation model of the energy community, which enables decision-making based on the individual priorities of different stakeholders concerning these parameters.

In this study, the developed tool is applied to a social housing site in Austria, since specifically in this area, funds are limited and the topic of energy poverty is relevant. Concrete results of the considered case are the costs, resulting profitability, associated risks, and CO_2 emissions for different operation models. Results for three different operation models are provided, namely investing in a new renewable generation plant, integrating an existing plant into the energy community, and contracting the installation of a plant to be used in the energy community. In the first operation model, a new plant is financed by the energy community as a whole, i. e. by its members. As a result, risk due to changes in the number of members is created. In the second operation model, an existing plant owned by one of the members of the energy community or the social housing company is incorporated into the energy community either as a full feed-in or excess feed-in plant. In this case, possible risks are posed i. e. through a change in ownership of the plant. Lastly, in the third model, a plant is built by an external contractor, whereby risks are associated with the dependency on the contractor.

Conclusions

Energy communities are expected to be rolled out on a large scale in the coming years, due to their large potential to contribute to a successful energy transition, being crucial for climate change mitigation and decarbonization. The here-presented tool, containing a Monte-Carlo simulation-based risk assessment approach, has proven to be well-suited to model economic risks associated with energy communities, because it has the capacity to mirror the real behavior of specified uncertainty-possessed parameters. In addition, it enables an evaluation of the ecological impact of proposed energy community operation models. Thus, the tool provides a valuable contribution to the establishment of economically and environmentally sustainable energy communities.

References

[1] G. Van Rossum und F. L. Drake, Python 3 Reference Manual, Scotts Valley, CA: CreateSpace, 2009.