On Distributional Effects in Local Electricity Market Designs—Evidence from a German Case Study

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A number of pilot projects have proven the feasibility of concepts for energy communities that the European Commission has called for in the *Clean Energy for All Europeans* package. Academia adopted these ideas and developed theories describing concepts, market designs, and characteristics of local electricity markets, peer-to-peer trading, and aggregation, proving these approaches to be feasible and to lead to major savings for community members. An investigation of impacts that occur when integrating these concepts into the existing markets on a larger scale or when performing adjustments has not been a main focus of existing research.

So far, a major part of literature in research has elaborated on a wide range of market designs for energy communities and investigated their feasibility as a stand-alone concept. The idea arose from a number of pilot projects – most famously the *LO3 Brooklyn Microgrid* – and aims at allowing end-users to actively participate in the energy market. In this context, an energy community becomes an organizational entity and targets a connection between community members to make profitable use of their resources and to create local value from it.

Reviewing the suggested market designs and concepts, we observe that the existing literature falls short in both analysing the impact of a wide-spread implementation and in evaluating the feasibility of energy communities in the current regulatory framework.

In our study, we propose a simplistic tool to perform analysis of energy communities in the presence of local market concepts/designs, and we present a case study to elaborate the challenges of a roll-out of these concepts. For a quantitative analysis, we develop a mixed complementarity program to model an energy community of heterogeneous energy consumers and producers which can be freely adapted to different market designs and community structures. An equilibrium model in this context finds a Nash equilibrium as solution point under the defined objective, constraints and assumptions.

To show the model's characteristics, we present a case study with three market designs from literature and an attempt to implement these designs under the current German regulatory framework. The case study is built on data for a village in Germany. This community comprises a number of residential energy users and producers as well as a market operator. The residential energy users are clustered into pure consumers and prosumers–consumers that own technology, such as rooftop solar panels or home storage, to produce their own electricity. We simulate the local supply and demand balance for this community subject to minimising costs of electricity in different market designs.

Some local market designs in research suggest to change the tariff structure and exempt local trade fully from any network charges and other levies. These tariffs lead to a mismatch of today's tariffs and network costs as seen in our analysis. We consequently observe that costs of electricity per household based on these designs decrease in the presence of local energy markets and home battery storages. This exemption creates much lower prices on a local market and especially prosuming and storage owning households profit. However, there is a shift of the network costs to pure consumers who are depending largely on the grid supply and most likely represent the group of electricity end-users that do not own a roof or the liquidity for a rooftop solar system.

Including rules on local trading from the German regulatory framework, we need to reintroduce network tariffs on local trading and find that the concept becomes highly uneconomic due to marginal costs of smaller installations being higher than the market price. We conclude that there are two pathways to follow from this point:

- Adjust the regulatory framework in order to allow for cheap local trading activities.
- Introduce a different design for local markets.

The former pathway would risk a redistribution of fixed network costs at the expense of less affluent consumers. The latter, however, leads us to the suggestion of an alternative approach to a market design that does not exempt anyone from network charges or other levies in the German context: instead of solely privately owned technology at a small scale, we propose a scheme under which every electricity end-user can become an active part of energy communities by being allowed to buy a share of a larger installation in close vicinity, that is, a solar rooftop installation on a supermarket operated by a local business.

We see major advantages in sharing a large installation in a close spatial vicinity among community members instead of privately owning small installations as main economic concepts apply in this context. Economies of scale give more benefits to larger installations. A smaller number of players can reduce information asymmetry but also economics of coordination within the energy system. But not only economic concepts play a role here. From a societal perspective, public acceptance can rise in the presence of participation and private ownership, which could lead the operator of a larger scale installation to being a form of *Bürgerenergiegenossenschaft* (citizen energy cooperative) in the German context, a local legal entity representing regional interests and keeping the economic benefits close.

References:

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