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Unintended consequences: The snowball effect of energy communities

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The US Community and Shared Solar initiatives provide four main vehicles to broaden the participation of individuals in the energy transition by giving access to an investment option into solar PV. Shared solar falls under the community solar umbrella, allowing multiple participants to benefit from a jointly produced energy. This US initiative finds its equivalent in the ongoing European discussion about a new legislative package for the electricity market design, called the winter package. The winter package pushes for more customer empowerment in general but provides several new concepts that fall into the category of community solar (local energy community, renewable energy community). Most notably, it introduces the concepts of collective auto-consumption. Some member states have already implemented such geographically limited auto-consumption. The German Mieterstromgesetz allows residents in collective houses to share the generation of the PV panels on the common roof (on-site shared solar). If consumers form such a community they can avoid network charges on the self-consumed energy and they receive a return on the renewable energy surcharge (effectively a tax reduction) like a classical prosumer in a stand-alone building. In addition, if network charges contain fixed or capacity-based components, the community pays this component only once (fixed parts) or for the whole capacity of the community. The community then receives an aggregation benefit due to the mitigation of the overall consumption capacity.

In the German case, the collective owner of the house essentially becomes the electricity provider of the energy community. Since retail markets are open to competition, residents cannot be forced to participate (or they might form more than one community). The first challenge is, hence, in allocating the benefit of collective PV in a way that leads to a stable coalition among the residents. The second challenge is in the determination of the origin of the benefit itself, which might lead to some externalities that have to be accounted for: not paying for the grid component of the auto-consumed energy creates value for the community but can lead to a revenue shortfall for the grid operators, most importantly the distribution companies.

Low-contributing consumers will result in higher tariffs and hence to more consumers investing in PV. This might lead to a snowball effect.

In this paper, we develop a game theoretical approach so as to analyze the stability of energy communities sharing a PV panel with respect to grid tariffs. In particular, we show that reducing the analysis of the emergence of communities to a cost-benefit analysis is unsatisfactory and that adding cooperative-game theoretical considerations to account for stability complicate substantially the formation of communities and that a wise choice of a sharing rule was crucial for communities to materialize. We observe in particular that the cost savings of communities in terms of grid tariffs may translate into a loss for a distribution system operator (DSO). As a consequence, we model an equilibrium between energy communities and the DSO while imposing a grid cost-recovery constraint that allows for potential spillovers among communities through the medium of grid tariffs.

This paper proposes three main insights. First, community formation can lead to a snowball effect through the medium of grid tariffs. This comes as a result of a very simple mechanism. When communities form, they often save on grid tariffs. A grid operator's costs, however, are largely unchanged. In turn the operator may need to modify its tariffs, so as to recover costs. As a consequence, other prospective communities may also form. We then analyze more closely the effects of the precise grid tariff structure on the snowball effect: a second insight is that per-connection fees is the structure most favourable to community formation, while capacity-based or energy-based tariffs lead to more inertia. It is also the structure that best avoids welfare-destructive efforts to reduce payments to the grid operator. This second insight is to be contrasted with the third one. Namely, capacity- and energy-based tariffs are the ones most effective in promoting investments in PV and batteries. From this we derive a simple policy implication: a policy maker willing to promote communities per-se should favour per-connection tariffs, with the risk of increasing coordination costs. If the focus is rather on PV or battery installations, capacity- or energy-based tariffs should be preferred. We however note that such tariffs may induce excessive investment in these technologies, from a social-welfare point of view.

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