WELFARE IMPLICATIONS OF RENEWABLE ENERGY COMMUNITIES. INDIVIDUAL VERSUS COLLECTIVE APPROACH

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Overview

Decentralized solutions of resource consumption build on the theory of commons to define governance rules for resource usage and remuneration (Olstrom, 2010). This paper identifies the energy surplus as being the common to be regulated within a community by means of decentralized sharing rules, and by the State with supporting schemes. Collective self-consumption is described analytically by the relationship between taxes, feed-in-tariffs and market prices to highlight the main attractiveness of communities that is the energy in excess from the other participants. Yet the welfare improves only if the excess of energy is sold within the community below the market price, and outside the community at feed-in tariffs that are not regressive with the community size. By using French solar data and user profiles for residential and tertiary sectors, the model shows divergent interests when based only on the long-run cost of the common: the tertiary sector records net benefits if household selling price is below market rates, while households find no financial motivation to join the community compared to individual self-consumption. The welfare improves if the sharing rule of the common includes also the opportunity cost, which adapts in this way the current one-size-fits-all policy to the performance of the community.

Methods

Several theories can be used to study the concept of commons, such as transaction costs, game theory, and institutional arrangements within decentralized communities. The energy generated within the community has the features of common good as long as the property rights on the energy resource are well defined and rules of governance can efficiently manage conflicts (Ostrom, 2010). The public choice theory finds fertile ground with application to electricity communities, by adding communication: smart meters allow tracing flows such as to reduce overharvesting of common-pool resources against penalty, where the common pool is the energy generated by the community. The initial financial investment of participants forming the community allows framing the properties of rivalry and exclusivity of the common good: the community gives exclusivity to its members and any use of the resource diminishes the use by another member, thus generates a reward to its owner and a cost or penalty to its user; the common pool cannot be overharvested because it is automatically managed by smart meters and it is restricted to the surplus of the resource only.

First we separate individual self-consumption from collective self-consumption. Simple self-consumption is related to the single end-user who produces renewable energy for self-consumption and for market selling (Iazzolino et al., 2021). We assume an end-user installing solar panels who consumes in priority energy from panels, and sells the electricity in surplus and buys electricity from the market in the absence of solar input, automatically. The self-consumption prosumer *i* defines the utility based on yearly cash flow CFI_i that is the revenue from selling the electricity in surplus (*ES*) at feed-in tariff rate (*T*), minus the bill of the electricity withdrawn from the network (*E*) at market rate including taxes (*p*) net of the electricity self-consumed (*ESC*), minus the cost of solar panel evaluated at the average value (*lcoe*) of the energy produced each year (*PV*), net of costs of network fees and abonnement (*AI*):

$$CFI_i = ES_i \times T - p \times (E_i - ESC_i) - lcoe_i \times PV_i - AI_i \qquad (1)$$

The energy withdrawn from the grid diminishes with the energy self-consumed which makes decreasing the revenues of the grid operator from taxes τ included in the market price, *p*. To keep constant these incomes (Clastre et al., 2019), variable charges are passed on the fixed fees (*AI*). At *A0* the abonnement level before self-consumption, the following identity ensures the grid operator budget neutrality:

$$\tau \times p \times E_i + A0_i = \tau \times p \times (E_i - ESC_i) + AI_i \qquad (2)$$

The difference between abonnement levels being $\Delta A = AI_i - A0_i$, we obtain:

$$\tau \times p \times ESC_i = \Delta A_i \qquad (3)$$

Equations (3) ensures that revenues for grid operator remain constant, and that the welfare of the general consumers remains constant as well, without additional charges due to self-consumption. The abonnement of the prosumer $A1$ will increase with the missing revenues from taxes which are not paid on the energy self-consumed.

Finally, the cash flow is the net gain from selling the energy surplus, plus the bill saving from self-consumption, net of investment cost and abonnement:

$$CFI_i = ES_i \times (T - lcoe_i) + ESC_i \times (p - lcoe_i) - p \times E_i - A1_i \qquad (4)$$

Within the community, other conditions add, such as the prosumer welfare improves if the loss from selling the surplus to the market, at community rate instead of initial feed-in tariff, plus the difference of selling the surplus to the community at an average cost, is compensated by the benefit of buying energy from the community, instead of the market. This rule represents the decentralized rule of governance of the community, with various solutions that can be issued through negotiation among members. It also includes the condition that the welfare of general consumers, outside the community, remains unchanged: any network missing revenue from collective self-consumption is compensated by taxes set on prosumer's selling price. The welfare of the prosumer improves only due to the community operation, and not to lower fees on the electricity withdrawn from the grid. Inside the community, the use of central network is paid by the community members while trading. The intervention of the regulator with taxes set on the use of the central network shows that the relationship among community members cannot be based on institutional arrangements only, but on hybrid forms with market and the State that together ensure economically viable model of communities.

Results

The case study applies to the French solar energy self-consumption, located in the region of Pays de la Loire, and tests different PV size and investment options. The community is made of tertiary building and twelve identical households, calibrated based on the surplus generated by each prosumer. Results show that each actor is interested in the surplus generated by the others: the household maximizes the profit rate at large tertiary solar installation (300 kWp) and low household solar panel size (3 kWp); similarly, the tertiary building maximizes profits at high household solar panel size (9 kWp) and low own solar investment (100 kWp). The trade of energy within the community increases with the scale of the surplus. The simplest financial case for the grid operator is applying similar variable charges to prosumers and to general consumers, and to set increased fixed fees to compensate the missing revenues from self-consumption. For the prosumer, the simplest case is trading with participants having similar power contracts such as to make comparable tax regimes and to play on the surplus flow instead of solar panel costs, hence on the heterogeneity of profiles among similar activities. We obtain a set of solutions sustaining the existence of polycentric governance of the community, where the active involvement of participants is necessary such as to turn the analytical rule into practice and institution.

Conclusions

Decentralisation of renewables involving citizens into both production and consumption of energy comes with new rules of governance based on prior criteria of proximity and social interactions. As the community remains connected to the central grid, these social arrangements are insufficient to operate the community and needs to be complemented by government rules in terms of network fees. The theory of institutions consider that the rationality of communities is to renounce to market rules but not in favour to other merchandising opportunities, i.e. community profits, but as the opportunity of individuals to involve within the energy management and to contribute to solving the social dilemma of climate change and resource scarcity. Yet the diversity of participants asks for a limited size of community such to make the negotiation effective.

Communities connected to the national grid can operate based on their self-governance rules, but the dependence on the consumers outside the community makes them subject to national rules through taxes and values that the society is based on. So far the community models prevent private network establishment by residential users in favour of the exploitation of the public distribution network. Yet community models prove viable as long as they remain connected to the grid, despite high levels that the decision-making of prosumers and communities may attain.

References

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