HOW TO MAKE A SOLAR PV-BASED ENERGY COMMUNITY ECONOMICALLY ATTRACTIVE IN BELGIUM?

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ABSTRACT: Over the last years, the concept of energy communities has gained popularity. They are increasingly perceived as a citizen empowerment opportunity, and a mean to involve them in renewable energy deployment. Yet, deployment of energy communities remains limited. Among the explanatory factors of this observation, one can cite the lack of appropriate legislation, but also the lack of knowledge (of citizen but also professionals) around new forms of business models, with an ensured added value for all stakeholders.
The research results presented here have been obtained through the work conducted in R2EC (Regional Renewable Energy Cells) ERANet project, which intends to evaluate revenue model(s) for an energy community (EC) created in a neighborhood of the municipality of Flobecq (Wallonia, Belgium). The objective is also to evaluate to which extent this model could be replicated in similar settings, elsewhere in Wallonia.
Results show that the local regulation defining renewable energy communities should be adapted, as it is currently too restrictive and prevents sufficient economic value creation to make shared energy generation concepts viable. Peer-to-peer exchange, currently excluded from regulatory frameworks, was identified by our research as a non-optimal business model given the current context in Wallonia (i.e., net-metering).
Keywords: Economic Analysis, Modelling, PV System

1 AIM AND APPROACH

The purpose of this paper is to identify the most promising revenue models for the investigated case study, a neighborhood in the municipality of Flobecq (Wallonia, Belgium), that could be replicated in similar settings. To conduct the analysis of the selected business cases, various elements were defined. Key ones are presented in the rest of this section.

1.1 The participants of the energy community

The participating households have been defined based on two main parameters. Namely:

- Presence (and size if any) of individual PV system on their roof
- Annual electricity consumption, including the consumption for space heating and domestic hot water if covered by electricity (e.g., electric boiler or heat pumps) as well as for electricity car charging if any.

These different parameters allowed to define categories of households. Each category being defined by a certain value or value range for the two abovementioned parameters.

This categorization permits to make conclusions with regards to the interest in participating in an energy community for a large, yet manageable, number of households, based on their production and consumption profile

Note that the profiles of the participants and the household categories have been defined based on actual historical data received from the local DSO (ORES) with the consent of inhabitants of the municipality.

1.2 The composition of the energy community

The created techno-economic model allows to model energy communities in the frame of different evolution scenarios for the studied municipality. These scenarios refer to the level of PV penetration, and the electrification rate.

The PV penetration level is directly linked to the share of households inside the studied energy community equipped with an individual PV system. The electrification rate level is directly linked to the share of households inside the studied energy community having a heat pump and/or one or more electric vehicle(s).

For each considered scenario of PV penetration (Base Case (BC), Accelerated (Acc.) and Massive (Mass.)) and electrification rate (Base Case (BC), Accelerated (Acc.) and Massive (Mass.)), the energy communities pools are constituted accordingly (See Table I).

Table I: Deployment of PV, EV and HP in the different considered scenarios.

PV penetration scenario	Share of households equipped with PV
BC	≈ 35
Acc.	≈ 55
Mass.	≈ 70

Electrification scenario	Share of households equipped with an EV
BC	≈ 1
Acc.	≈ 10
Mass.	≈ 20

Electrification scenario	Share of households equipped with a HP
BC	≈ 2
Acc.	≈ 13
Mass.	≈ 20

Regardless of the considered PV penetration and electrification scenario, a sport center which hosts the 200 kWp common PV system is included in the theoretically energy community.

1.3 Distribution keys

To determine the order of priority by which the energy community members can have access to excess PV production, a distribution key must be defined. A dynamic distribution key was tested here. In other words, at each given point in time, residual production is distributed proportionally to each member's residual demand.

1.4 Applied business models

Two different main business models have been considered.

The first one is based on peer-to-peer exchange. Electricity produced by the different individual PV systems of the community is exchanged inside the community. Any individual PV system owner can sell electricity they did not self-consume at a price higher than the wholesale market price, but lower than the variable retail price so that neighbors buying this electricity have an economic incentive to do so. Based on current observed conditions for EC, the assumption is made that individual PV system owner can no longer be eligible to the local support scheme (net-metering) if they participate in the community. This concept is currently not allowed in the regulation in Wallonia. Nevertheless, it is still relevant to mention as with the end of the net-metering, such concept could become possible as part of the regulation.

The second business model is based on shared generation. Electricity produced by a collectively owned, larger, rooftop PV system is used inside the community. Any member of the community can buy electricity from this PV installation at a price slightly lower than the variable retail price. A community manager (external or internal to the community) bears the investment cost in the PV system, the operation and maintenance costs and the energy community management costs. Each kWh sold to an EC member generates a revenue for the EC manager, amounting to a value higher than the wholesale price. Individual PV system owners behave as they would without the community according to local support schemes.

1.5 Energy flows within the community

For each member of the energy community, annual 15-min time series for their individual PV production profile (if any) and their consumption profile are simulated for 20 years, based on historical real data.

In addition, different "energy" business models related to the energy flows can be studied. These "energy" business models define whether some energy exchanges between EC members are allowed or not, i.e. peer-to-peer.

Combining these elements, the analysis allows to determine for each member of the community: (1) How the coverage of its annual consumption is distributed between individual self-consumption, self-consumption from the common PV system and the grid; and (2) How its individual production (if any) is distributed between individual self-consumption, distribution to other energy community members (if possible) and injection to the grid.

1.6 Cash flows

The quantification of the cash flows relies on the association of a value to each of the energy flows determined above. The value associated with each energy flow is function of the considered business model. The latter defines how value is created in the energy community and by whom this value is captured. In particular, the business model defines the price at which the electricity produced inside the community is sold and bought.

1.7 Final KPIs

There are several aspects and indicators which can allow to identify whether creating an EC is attractive or not, and what are the most influencing factors. The first aspect is economic. It consists in evaluating, for each EC participant (i.e., in the studied case: the participating households, the sport center and the community manager) the NPV (Net Present Value) for all energy community-related expenses and revenues. A positive NPV would indicate that the participant's situation has improved with the EC compared to the case without EC.

In addition, or as an alternative, this economic assessment can be conducted at the scale of the EC. In this case the assessment is conducted on the sum of all energy community-related expenses and revenues (i.e., in the studied case: for the participating households, the sport center and the community manager combined). The drawback of this collective assessment when conducted alone, is that it does not allow to identify if the created value is corned by a few participants only or if it is distributed relatively evenly.

Other indicators such as the total environmental footprint for all energy-related uses, the average individual or total collective self-consumption and self-sufficiency can also allow to assess the attractiveness of the EC.

2 MAIN ASSUMPTIONS

2.1 Energy flows

Theoretical ECs of 100 households and 1 sport center are formed. Different proportions (Base case (BC), Accelerated (Acc.), Massive (Mass.)) of individual PV systems, electric vehicles (EVs) and heat pumps (HPs) are considered (See Table I). Electricity exchanged within the EC follows a one-to-many scheme and comes from a 200 kWp PV system ((S) in Figure 1) installed on the sport center's roof when an EC is considered.

In addition, a fully proportional distribution key is considered. [1]

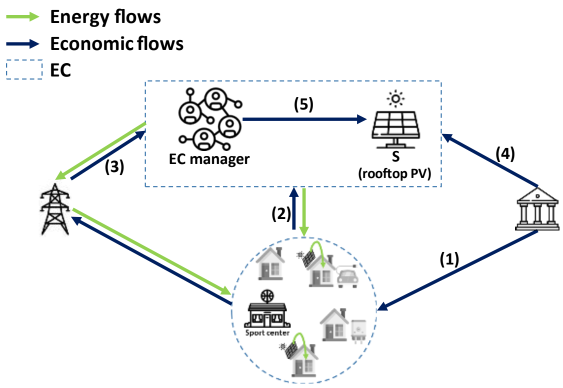

Figure 1: Schematic overview of energy flows between the different entities and economic flows between the different stakeholders in the energy community under the shared generation business model.

2.2 Economic flows*

There are multiple revenues and cost streams in the modelled energy community. Consuming electricity from S enables savings on the electricity bill amounting to the GEC (2,5 c€/kWh) ((1) in Figure 1) [2]. Injecting electricity from S to the community enables revenues amounting to the energy component (7c€/kWh) ((2) in Figure 1). Injecting electricity from S to the grid enables revenues equal to the wholesale electricity price (4,5 c€/kWh) ((3) in Figure 1) [3]. Producing electricity from S enables revenues amounting to green certificates value for 10 years (4,2 c€/kWh) ((4) in Figure 1) [3]. Covering investment in/maintenance of the 200 kWp PV system (0,8 €/Wp – 8 €/kWp.a) ((5) in Figure 1).

Energy community-related costs such as the investment in the control devices and the annual management costs are treated separately as they are associated with a high level of uncertainty because of the limited EC deployment observed yet.

*Early 2021 data

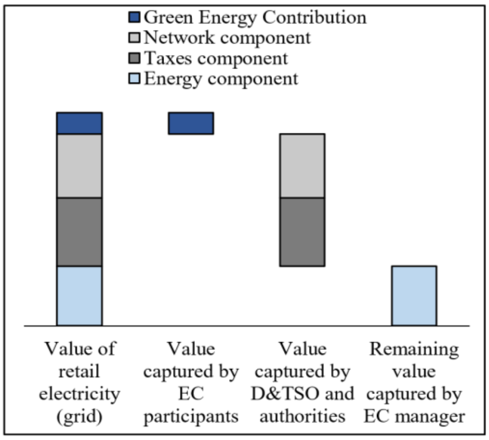

Figure 2: Visual representation of the different revenue streams for the EC participants and for the EC manager from PV electricity produced and exchanged within the community.

3 RESULTS & SENSITIVITY ANALYSIS

First of all, results concerning the peer-to-peer business model are not presented extensively here. Given the existence of net-metering in Wallonia, and the very high economic attractiveness of this scheme for excess electricity (which enables the same savings as self-consumed electricity) and despite the existence of a prosumer tax, the peer-to-peer is currently an unattractive business model from an economic point of view. Moreover, this concept is currently not included in the proposition of regulatory framework for energy communities in Wallonia.

3.1 Main results for the shared generation business model

Presented results are expressed in terms of Net Present Value (NPV) calculated over 20 years and accounting for all revenues and costs associated with the formation of an EC compared to the case without EC (i.e., without 200 kWp system on the sport center).

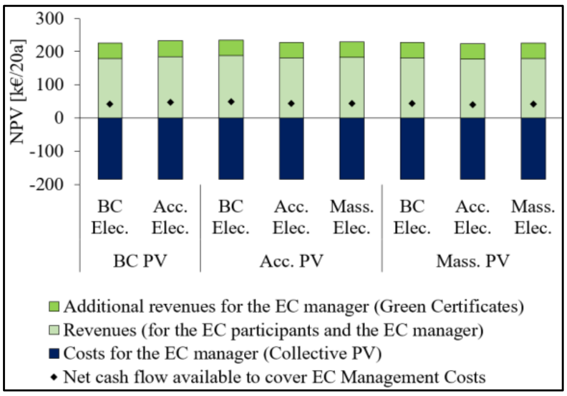

Figure 3: Revenues and costs associated with the formation of an EC and Net Cash Flow available to cover EC Management costs for the different studied EC pools (Note: Discount rate used to discount the households cashflows (respectively the EC manager's cash flows) is 2% (respectively 4%)

Assuming that the energy community manager only targets break-even, the yielded NPV is positive in all cases. With these revenues, some energy community-related costs still need to be covered such as the investment in the control devices and the annual management costs. Therefore, a sensitivity analysis is conducted in Table II. This shows that under the three most optimistic assumptions, all cases reach break-even when factoring in EC-related costs. Under 3 additional moderate assumptions, some cases become profitable, while the remaining assumption do not allow to reach break-even. On the 18 EC management costs combinations, only a third are sufficiently low so that break-even at the scale of the whole EC can be reached.

Table II: Sensitivity analysis on total EC Management costs (monthly management costs and investment in a control device for each participant)
(Note: A: assumptions which allow All studied cases to be competitive, S: assumptions which allow Some studied cases to be competitive, N: assumptions which allow None of the studied cased to be competitive.)

		Control device (CAPEX) [€/device]					
		Changed after 10 years			no change		
		1000	500	250	1000	500	250
Management	50	**N**	**N**	**N**	**N**	N	**A**
Costs	25	**N**	**N**	**S**	**N**	**N**	**A**
[€/month]	0	**N**	**N**	**S**	**N**	**S**	**A**

3.2 Influence of consumers' profiles on revenues:

Figure 4 shows that there is strong correlation between higher electricity consumption and higher revenues. This is highly explained by the chosen distribution key (i.e., fully proportional to electricity consumption). With a hybrid distribution key[1], this would be altered and would reduce the possible rebound effect of encouraging higher electricity consumption among participants. [1] [2]

Furthermore, EC members with individual PV have more limited benefits from the EC because part of their

[1] "A hybrid distribution key is a mix between a static and dynamic distribution key. With a hybrid distribution key, a certain share of the total electricity production at a time t is distributed according to a static distribution key (e.g. proportional to each participant's initial contribution to the collective investment) and the remaining share of electricity production is distributed dynamically (i.e., purely based on consumption at this time t).

consumption is already covered by individual self-consumption. Eventually, EC members with flexibilities (e.g., EVs) can gain more revenues if associated consumption takes place during the middle of the day (e.g., top two grey bubbles), when the solar PV system produces the most.

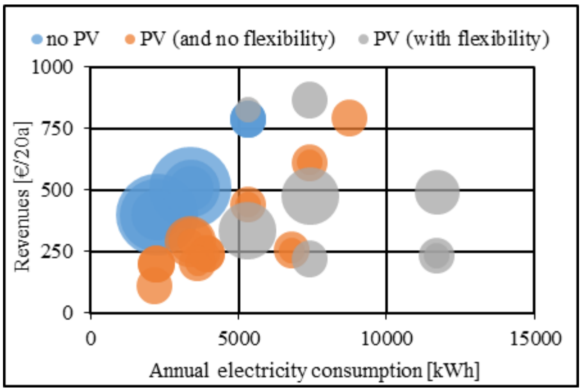

Figure 4: Revenues per type of EC participant (annual electricity consumption, ownership of an individual PV system, ownership of a flexibility (e.g., EV or HP). (Note: Bubble sizes represent the number of participants with this profile)

3.3 Influence of policy framework and electricity prices on profitability

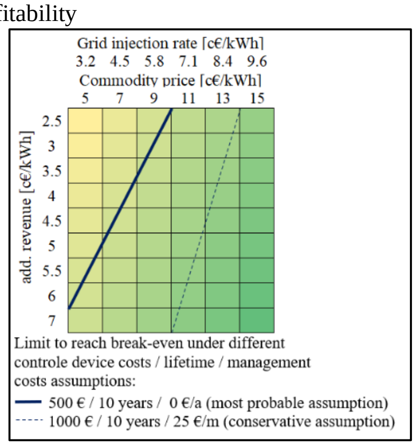

Figure 5: Sensitivity analysis on commodity prices and additional savings.
(Notes: Required combinations to reach break-even under two different EC Management cost assumptions are highlighted with blue lines. Net Cash Flow available to cover EC Management costs range from 10 k€ (top left) to 290 k€ (bottom right)).

From the results of the sensitivity analysis conducted on commodity prices, grid injection rates and additional saving presented in Figure 5, the following remarks can be made:

Even if all combinations to the left of the blue bold line in Figure 5 yield a positive NPV, its value is not sufficient to cover most probable EC management costs, thus not allowing the EC manager to reach break-even.

Unsurprisingly, higher commodity prices and feed-in value increase the profitability of EC. In particular, the higher the gap between these two values, the higher the incentive to self-consume electricity within the EC rather than injecting it to the grid.

Additional revenues which include possible exemptions on the electricity bill (e.g., existing exemption on the GEC or potential exemption on network tariffs) but also EC-specific incentives and can significantly enhance the economic attractiveness of ECs.

4 CONCLUSIONS

The local regulation defining renewable energy communities in Wallonia is currently too restrictive and prevents sufficient economic value creation as it only foresees the exemption of the Green Energy Contribution (GEC) for electricity exchanged within the EC.

Additional revenue streams such as further exemptions (e.g., partial exemption on network tariffs), or EC-specific incentives (e.g., higher green certificate allowance) would greatly enhance the economic attractiveness of ECs in Wallonia.

Investigating ECs' profitability in Wallonia under alternative configurations (e.g., with the inclusion of individual or shared storage, with a hybrid distribution key, with a more diversified consumer profile pool (e.g., commercial consumers) or under a different regulatory framework (e.g., analyzing the attractiveness of P2P after net-metering phase-out in 2024) would be of interest and provides perspectives for future work on this topic.

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