Rule-based energy simulation studies on different energy community compositions

Active end customer-/prosumer participation

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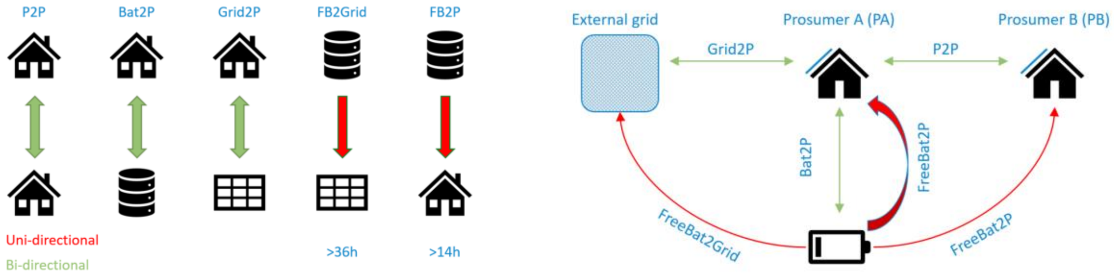
Motivation and research question

It is an ongoing open question if and how energy communities are going to play an important role in our future energy system. Besides ongoing regulatory processes and discussions there is a need to investigate how energy communities can and should be operated in an energy and economy efficient way. Another need is to figure out, when the concept of energy communities can be applied on a group of customers since it represents a composition of consumers, generators and prosumers. Our work addresses these questions by comparing results of simulative studies between different compositions of such energy communities. The shown work represents an extension of [1] as part of the research project Blockchain Grid.

Methodology

In our work, the entity energy community is defined through the participating consumers, generators and prosumers, a central community energy storage and a set of rules for possible virtual energy flows. Figure 1 shows the defined rules for these energy flows and the interconnections of participants where “P” are peers like consumers, generators and prosumers, “Grid” is the external grid which covers the residual load, “bat” is the central community storage and “FB” is a specific functions which is caused by the discharge strategy of the community storage. Summarized, the community can manipulate the virtual energy exchange by doing the common exchange with the external grid, peer-to-peer trading amongst participants and interactions with the central storage. The performed simulative study is done with a rule-based approach. This means that the presented 5 community rules could be executed in any order, resulting in 32 combinations. For this study, the most relevant 11 combinations are examined. Each combination is used as setting parameter for an annual simulation run with a 15 minutes time resolution. The different resulting energy flows with different settings are compared afterwards. Besides the energy analysis an economic analysis is also done by applying defined tariffs on the virtual energy flows. The simulative study is done for 2 different energy communities which vary in their compositions of participants. An overview is shown in Table 1.



(a) (b)

Figure 1: (a) Individual possible energy flows inside the community (b) Interconnection of defined rules and participants

	Setting I	Setting II
Number of customers	12	120
Number of consumption objects	12	125
Annual consumption	184.954 kWh	960.638 kWh
Number of generation objects (PV)	9	20
Annual generation	57.777 kWh	124.263 kWh
Storage capacity	100 kWh	100 kWh
Battery reservation time	14 hours	14 hours
Battery release time	36 hours	36 hours
Simulation duration	365 days	365 days
Time resolution	15 minutes	15 minutes

Table 1: Overview of investigated community settings

Results and conclusion

Nine different combinations of rules (scenarios) are investigated in annual simulative studies for both energy community settings, resulting in 18 annual simulation runs. Energy flows between the external grid, energy storage and participants are analyzed and compared in detail and the impact of the community structure with different rules is discussed. Results provide recommendations, when different compositions of energy communities should favor different rules since the results show, that it is sometimes better to just focus on peer-to-peer trading or storage utilization instead of both. Figure 2 e.g. shows how the community internal photovoltaic (PV) generation utilization varies within different communities and rules. The grid-to-peer scenario (G2P) mainly represents the reference scenario, in which everything is covered and absorbed through the external grid as it is common nowadays. Compared to that, a scenario which makes use of all rules (see Figure 1) could increase the community internal PV usage up to 40-50%. Figure 3 shows how the community consumption coverage via internally produced PV energy varies among different scenarios.

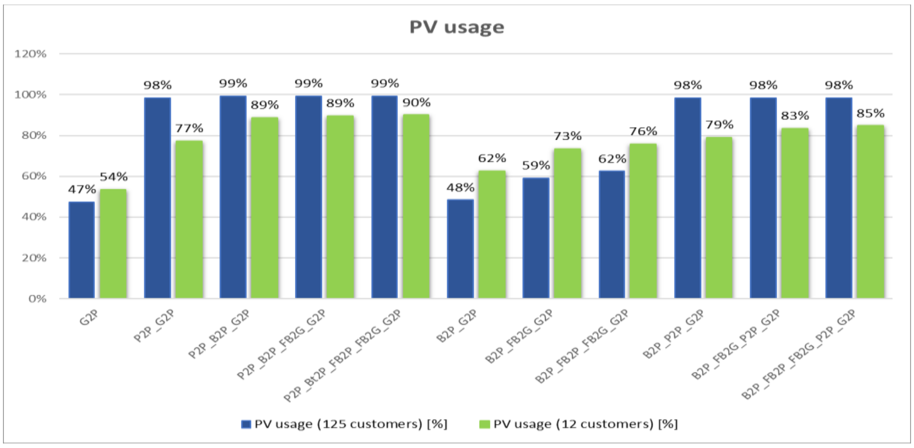


Figure 2: PV usage on community level: Comparison of simulation scenarios.

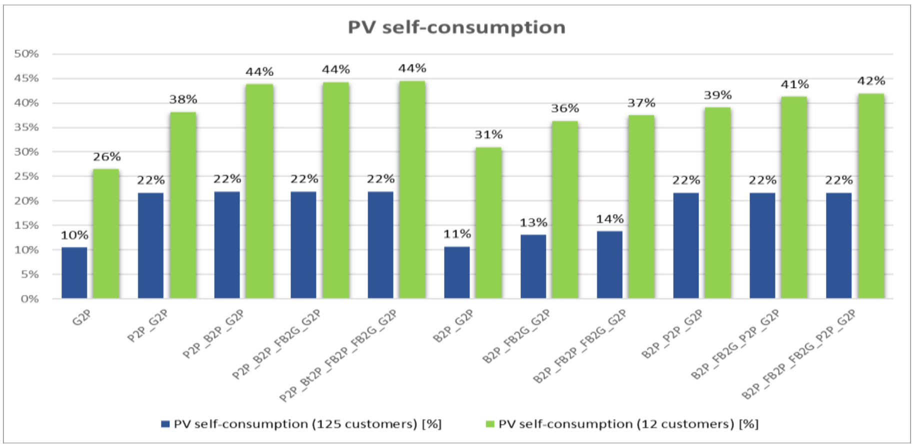


Figure 3: PV self-consumption on community level: Comparison of simulation scenarios

The size, composition of participants and their coherent customer types and temporal behavior, mix of generation and consumption, battery storage size and operation strategy and used rules for the virtual energy flows of an energy community are the most important factors to do an in-depth assessment. Further analysis of different energy communities and how rules scale need to be further investigated to allow concrete planning of energy communities. Shown results between two communities already show the individual treatment of different kinds of energy communities.

Literature

[1] M. Stefan, P. Zehetbauer, S. Cejka, F. Zeilinger, G. Taljan:
"*Blockchain-based self-consumption optimization and energy trading in Renewable Energy Communities*";
Poster: CIRED 2020 Berlin Workshop, Online; 22.09.2020 - 23.09.2020; in: "*Proceedings of the CIRED Workshop 2020 (Online)*", (2020).