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# Renewable Energy Communities: Optimal sizing and distribution grid impact of PV and battery storage

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## Introduction

To mitigate climate, change the European Union aims at climate neutrality in 2050. Realizing the central role of the energy sector in the climate challenge EU launched the Clean Energy package, stating that the share of Renewable Energy in the energy mix should be at 32 % in 2030 and further that the energy market should be modernized to account for flexibility. To accommodate for increasing RE, the power system is undergoing a paradigm shift that has led to more Decentralized Energy Resources (DERs) in the grid.

As a consequence, the concept of **Energy Communities (ECs)** has been developed as an innovative and cooperative strategy to share renewable energy DERs, minimize their own consumption, and/or to ease the loading of the power grid through utilizing energy flexibility of the active consumers.

## Main research questions

**Question 1:**
What are cost-optimal installed capacities of PVs and community BESS for ECs based on a current regulatory framework?

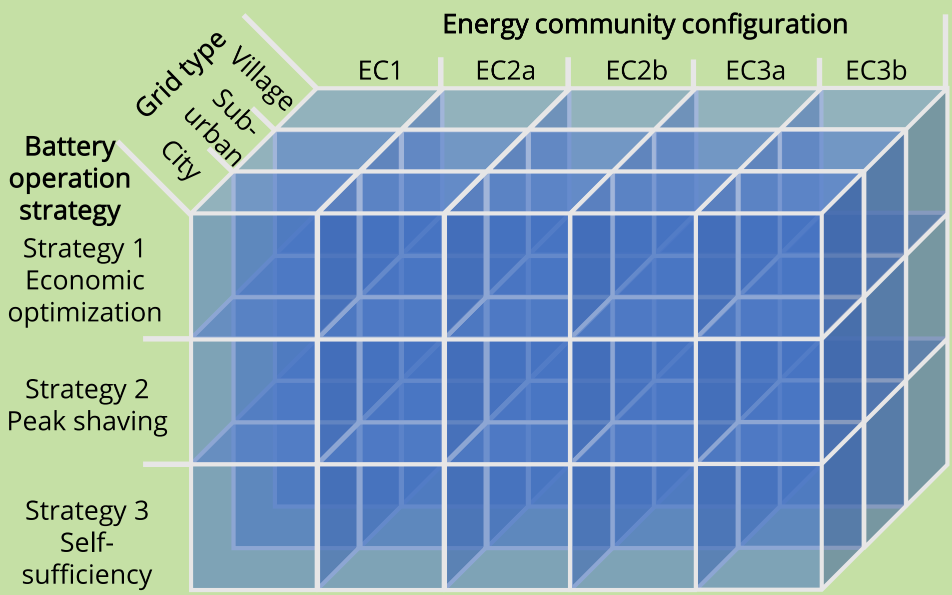
**Question 2:**
How do different operational strategies of an EC and the EC's configuration impact the distribution grid?

**Question 3:**
How do different placements of a communal BESS impact the distribution grid?

## Scenarios

In order to investigate the impact of energy communities (ECs) with PVs and a communal battery 45 different scenarios were investigated. This allowed to account for:

- *Three* different distribution grid type: city, suburban and village
- *Five* different energy community configurations (EC1-EC3b) which include residential customers as well as commercial customers
- *Three* different battery operation strategies (Strategies 1 – 3)

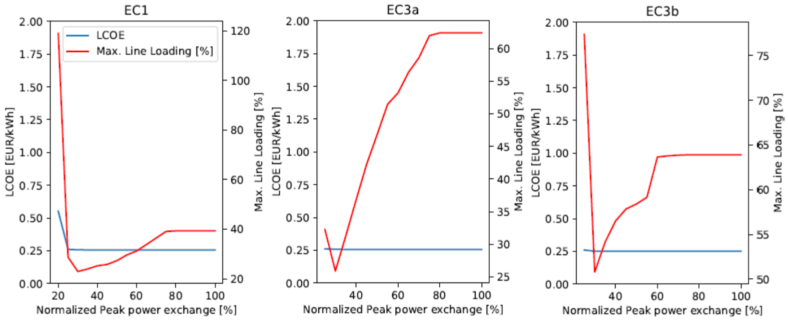


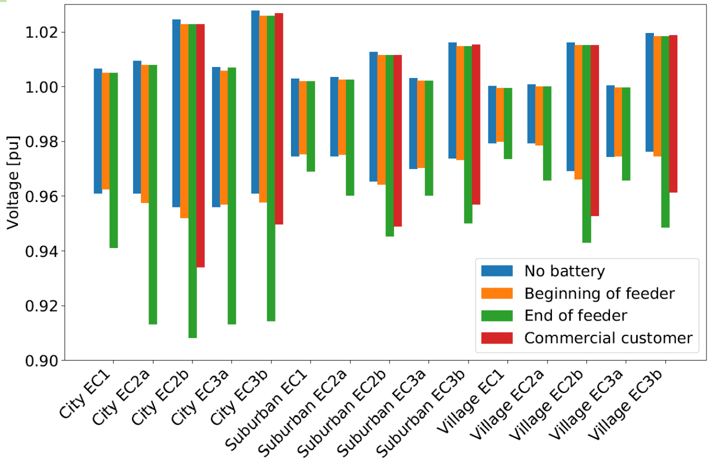
# Results

For each scenario and based on data for an entire year, optimal battery operation strategies for each scenario were derived. The grid impact was then investigated based on power flow computation where the impact on grid component loading and voltage was analyzed. Three key insights were identified.

## Insight #1: The EC's costs are only minorly increased when a battery operation strategy is used aiming to support the DSO and relieve the distribution grid

Strategy 2 revealed that by changing the operation strategy in line with the needs of the DSO (reducing peak consumption), the EC could significantly reduce its grid impact, for only a minor increase in costs. In a green transition, this could to some extent help the integration of more electric vehicles (EVs), heat pumps, and PVs without the need for grid reinforcements. The ECs would provide flexibility by adjusting their behaviour based on the grid conditions.



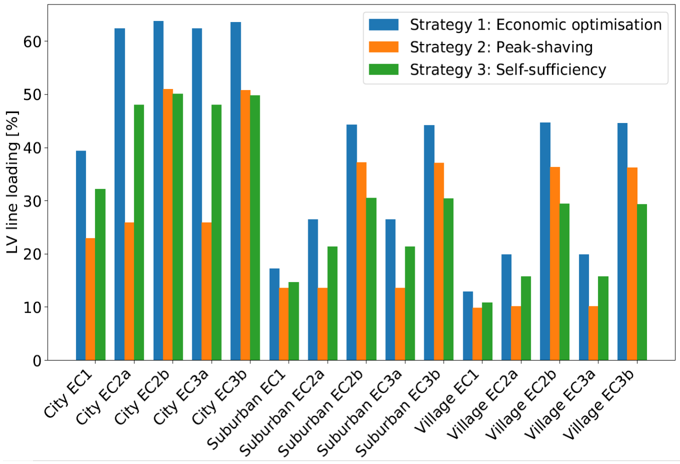




## Insight #2: Battery location plays a significant role for the grid impact

The results showed that battery location has the largest impact on voltage. Located at an unfavorable location (e.g. 'End of feeder'), the battery increases significantly the range of observed voltages leading potentially to voltage violations. Connected to a favorable point (e.g. 'Beginning of feeder'), the battery does not affect the range of observed voltages. This demonstrates the need for communication between the EC and the DSO when an EC is established with a communal BESS.

## Insight #3: Impact greatly depends on battery operation strategy

When investigating different strategies, the results showed that Strategy 1 has the highest impact on LV line loading, since the battery is charged during low price hours, which creates a new consumption peak. Strategy 2 and 3 were decreasing the LV line loading. Due to the higher concentration of consumers, the highest loading could be observed in the City grid. With respect to EC configuration, the impact grows with the total consumption of the EC. The configurations with the largest impact were EC2b and EC3b, which consist of residential and commercial customers.

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