Impact of Energy Communities on Distribution Grids

CITIES demonstration project

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Why energy communities?

- Ambitious CO$_2$ reduction plans in the EU and Denmark
- Raised awareness about climate change
- Growing interest for creating local energy system solutions and Energy Communities (ECs)
- Often the aim is to optimize consumption of locally and sustainably generated electricity
- For that purpose, a local energy storage unit, such as a communal battery, maybe integrated

How will an energy community with PVs and a communal battery affect the distribution grid?
How to assess the impact of ECs?

- How is voltage and component loading impacted by integration of a communal battery?
- Three different distribution grid types
- Different energy community configuration
- Three different battery operation strategies

<table>
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<th>Battery operation strategy</th>
<th>City</th>
<th>Suburban</th>
<th>Village</th>
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<td>S1 - Max. self-sufficiency</td>
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<td>S2 – Peak shaving</td>
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<td>S3 – Economic optimization</td>
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Distribution grids

- **Medium voltage**: Cigre MV grid

- **Low voltage grids**:
  - Representative LV grids for Germany
  - **City**: short feeders; loads are a dominantly multistory apartment buildings with a few detached houses
  - **Village**: short feeders; loads are detached houses
  - **Suburban**: longer feeders; loads are detached houses
Investigated energy community configurations

- **EC1: One LV feeder**
  - All member located on one feeder

- **EC2: One MV/LV transformer**
  - Members on two or more feeders
  - EC2a: only households
  - EC2b: households and one commercial customer

- **EC3: Multiple MV/LV transformers**
  - Members across multiple MV/LV transformers
  - EC3a: only households
  - EC3b: households and one commercial customer
Battery operation strategies
Dimensioning of the PV & battery system + operation profile

General criterion: costs

Investment costs
PV & battery

Operational costs
Power consumption
Power sales
Grid tariffs, fees, taxes

Dimensioning strategies: additional constraints

S1 – Self-sufficiency: constraint power sales
*Power generated from PV fully consumed in community (no power sold)*

S2 – Peak shaving: constraint peak consumption
*Not more than 95%, 90%, … , 5% of peak consumption allowed*

S3 – Economic benefit: no additional constraints
*PV and battery sized to minimize costs and maximize profits for the community*
Approach for grid impact assessment

- Time-series power flow simulation
  - Household consumption profiles
    - Based on measurement data of 30,000 customers for a year
    - Representative profiles extracted for different consumer categories
  - Optimal battery operation profiles
    - Based on operation strategies S1 - S3
  - Simulation period: 2 summer weeks and 2 winter weeks

- Assessment of:
  - Minimum and maximum voltage
  - Maximum loading of cables and transformers

Three questions are investigated:

1. Does the location of the battery have an impact on the distribution grid?

2. How much can ECs contribute to peak-shaving?
   - What is economically and technically feasible?

3. How do the three battery operation strategies impact the distribution grid?
Insight #1: Battery location plays a significant role with respect to grid impact

Example: S1 – Self-sufficiency – Impact on maximum and minimum bus voltage
Insight #2: City grid likely to be impacted most

Example: S1 – Self-sufficiency – Maximum LV line loading
Insight #3: Impact greatly depends on battery operation strategy

Example: S2 – Peak-shaving
Preliminary conclusions

- Development of a **setup to investigate the impact of Energy Communities** considering
  - Different battery operation strategies
  - Various energy community configurations
  - Different types of distribution grids

- **Insights on grid impact**
  - **Insight #1 - Location of the battery:** coordination between grid operator and energy community is essential
  - **Insight #2 – Different grid types:** City grid likely impacted most
  - **Insight #3 – Battery operation strategy:** Impact on the grid greatly depends on the operation strategy