Impact of Energy Communities on Distribution Grids

CITIES demonstration project

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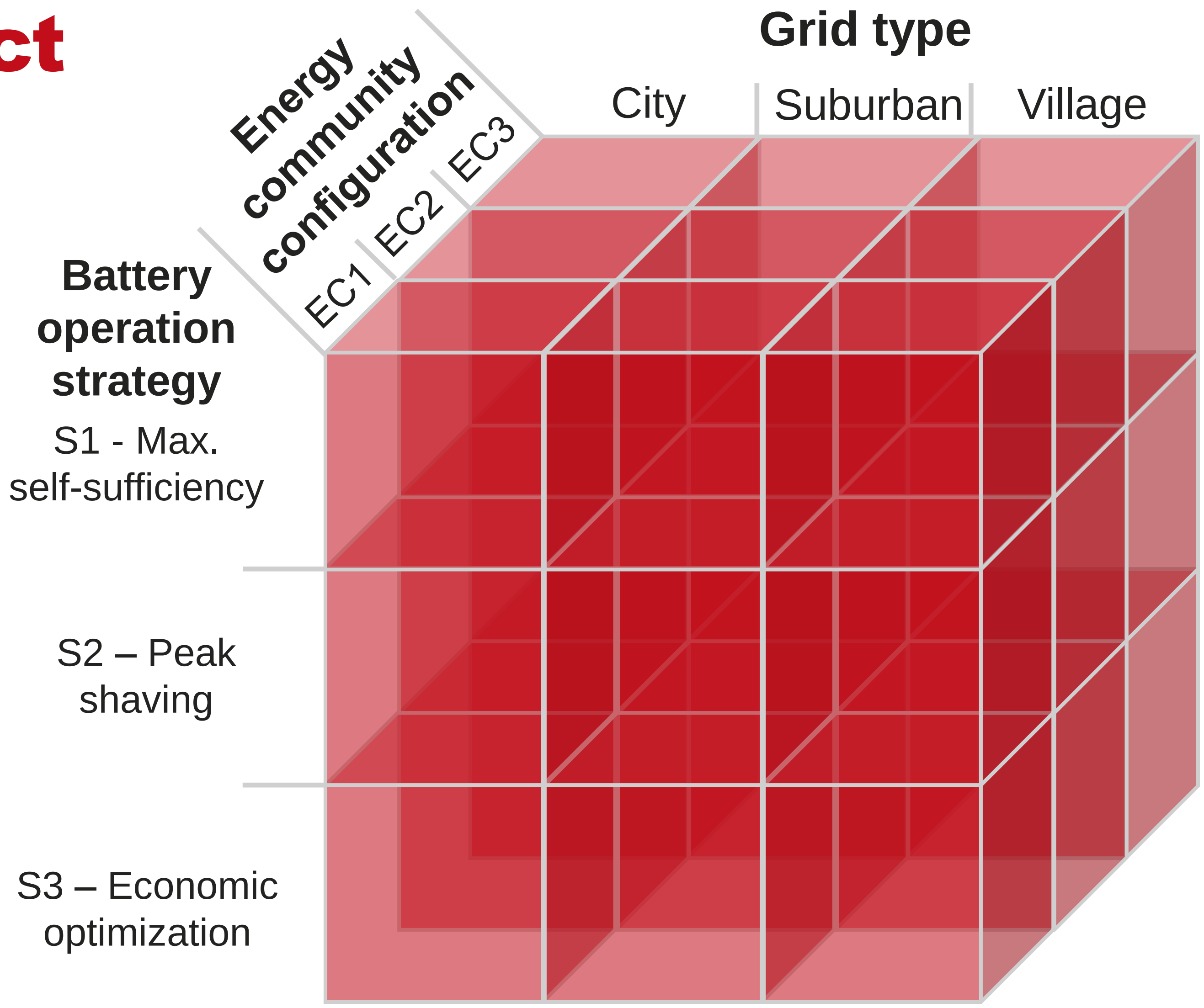
Why energy communities?

- 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?

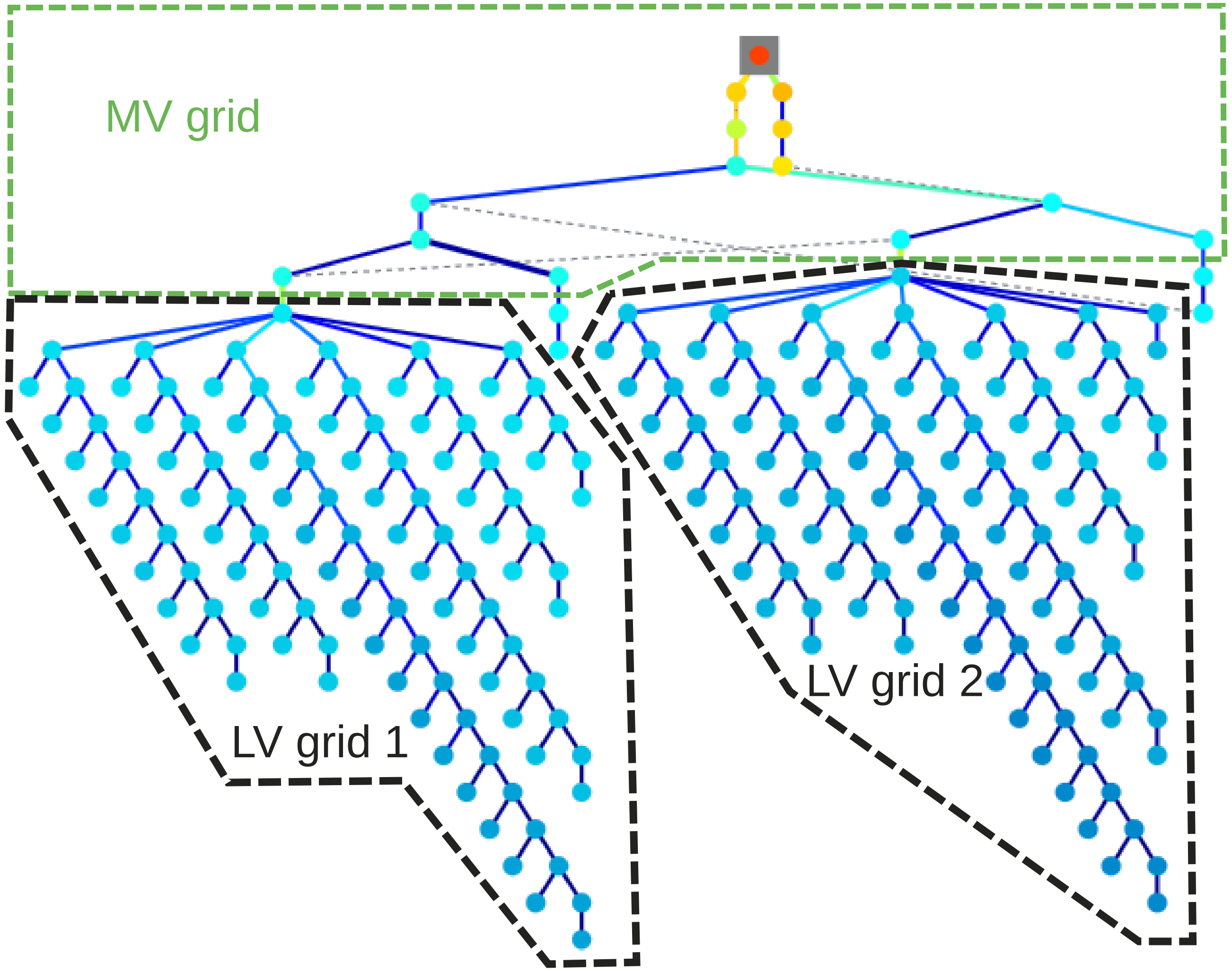
How to assess the impact of ECs?

- 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**



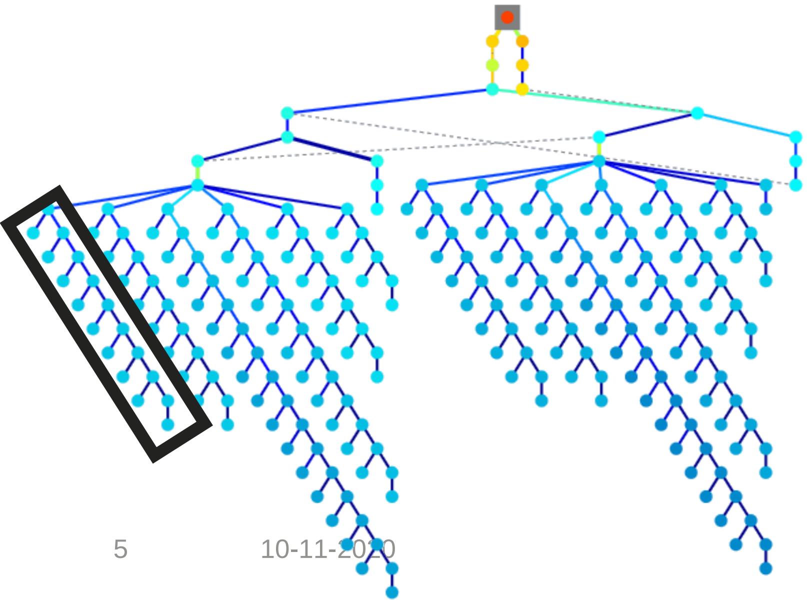
Distribution grids

- **Medium voltage:** Cigre MV grid
  - Task Force C6.04.02: “Benchmark Systems for Network Integration of Renewable and Distributed Energy Resources”, 2014
- **Low voltage grids:**
  - Representative LV grids for Germany
    - Georg Kerber, ”Aufnahmefähigkeit von Niederspannungsverteilnetzen für die Einspeisung aus Photovoltaikkleinanlagen”, Dissertation, 2011
  - **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

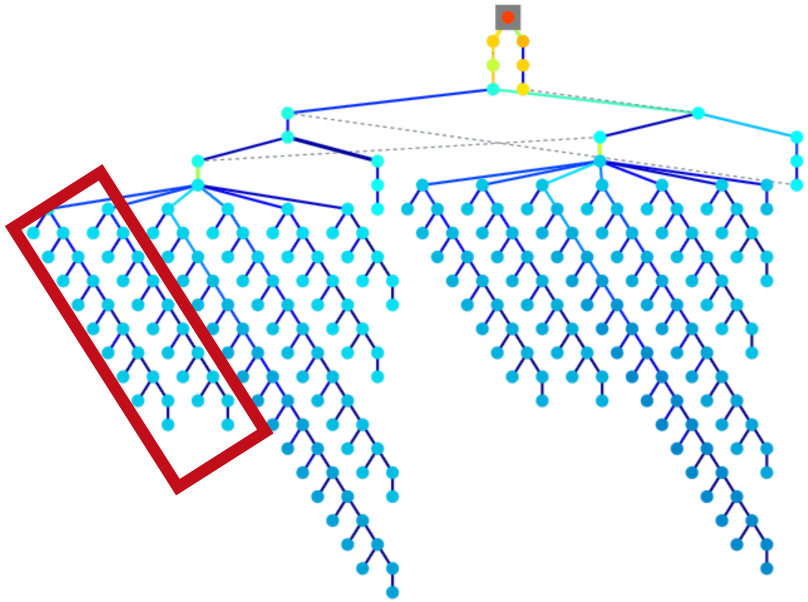


Investigated energy community configurations

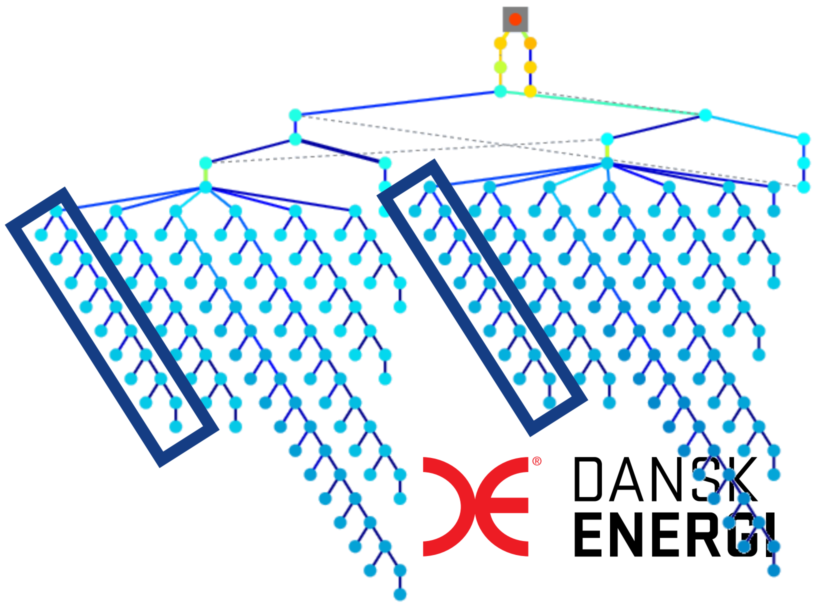
- **EC1: One LV feeder**
  - All member located on one feeder



- **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**?

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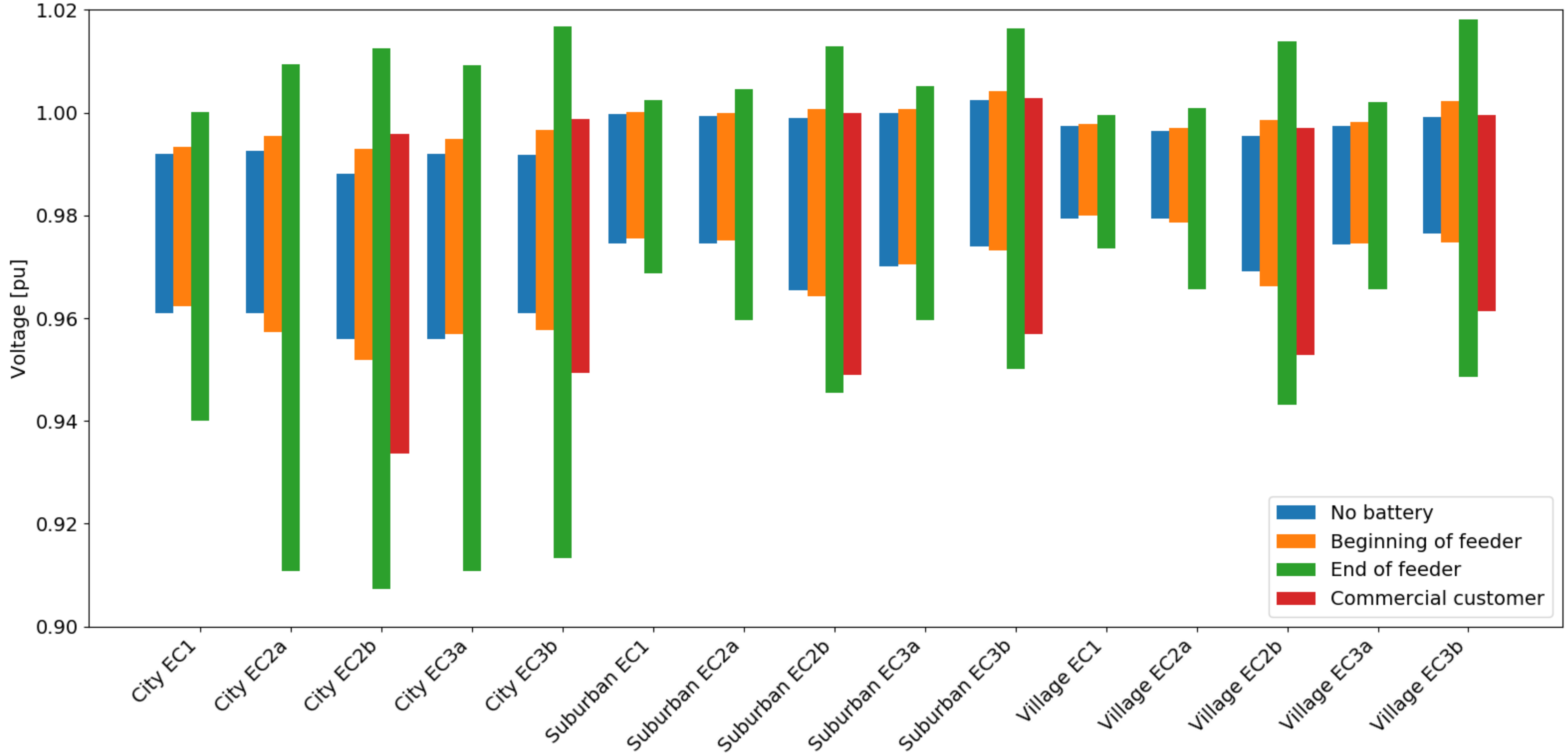
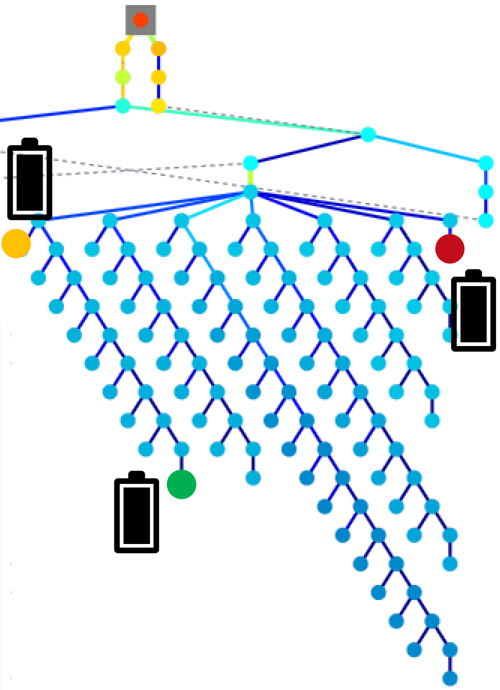
Insight #1: Battery location plays a significant role with respect to grid impact

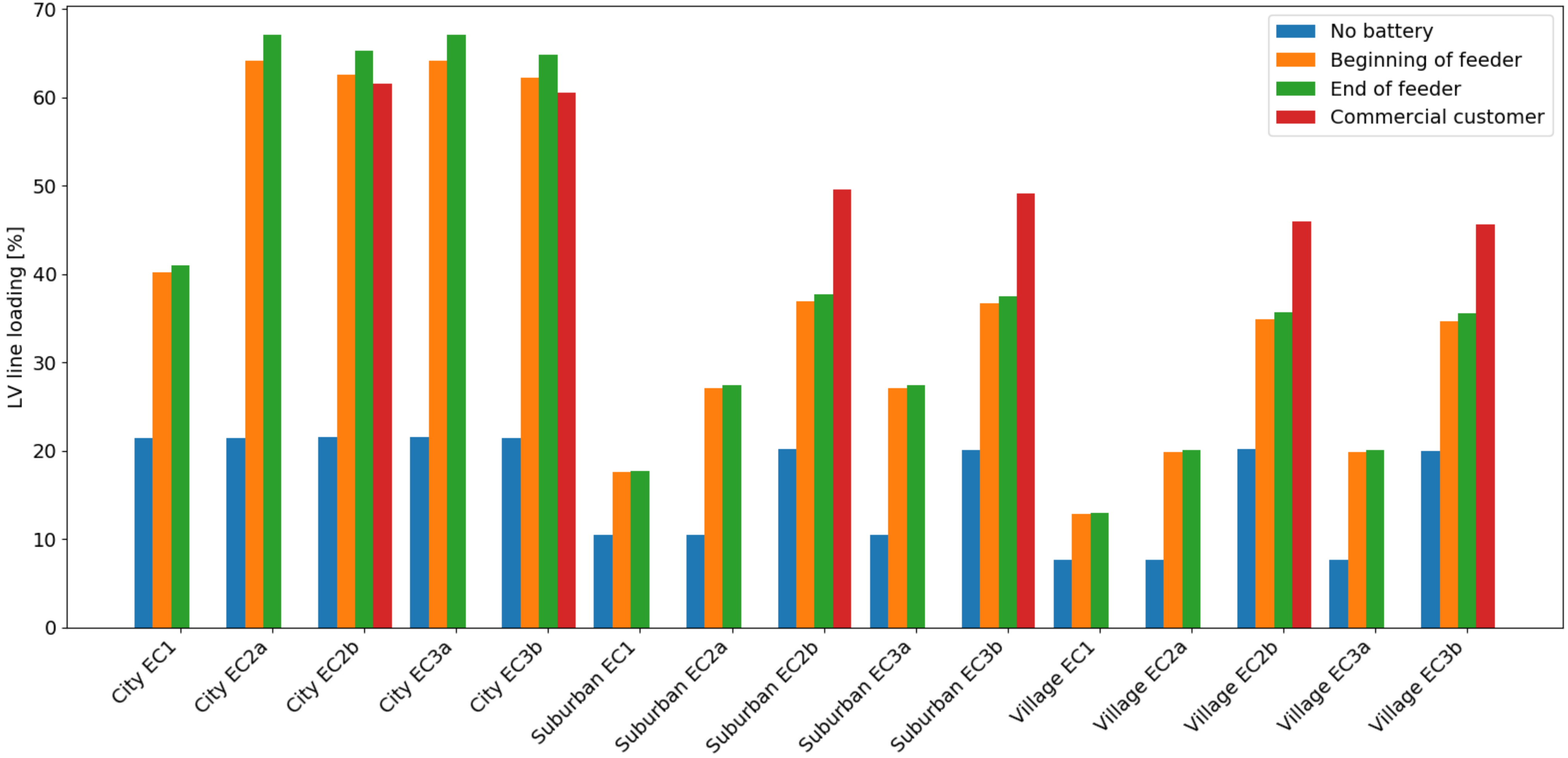
Example: S1 – Self-sufficiency – Impact on maximum and minimum bus voltage





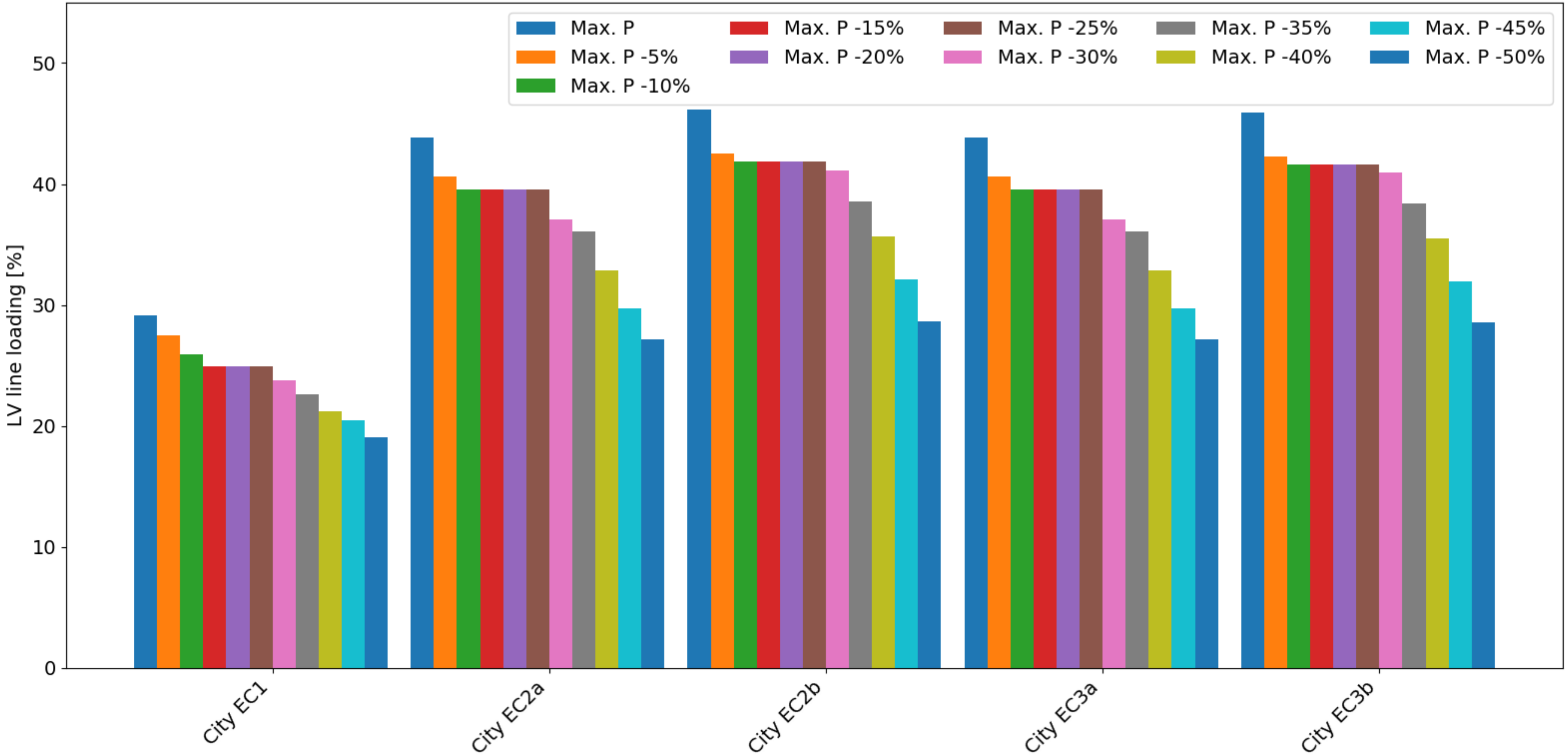
Insight #2: City grid likely to be impacted most

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

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