# The Role of Battery Storage Systems in Solving Stability Issues in Sector-Coupled and Renewable Low-Voltage Grids

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## Research Motivation

Energy transition with 100% renewables will require massive decentralized photovoltaic systems (PV) and electrification of the heat and transport sector. This changes the way of operating low voltage grids (LV), as bidirectional energy flows and increased supply and demand peaks can be observed. These challenges need to be quantified and better understood. Battery storage systems (BSS) offer a promising solution.

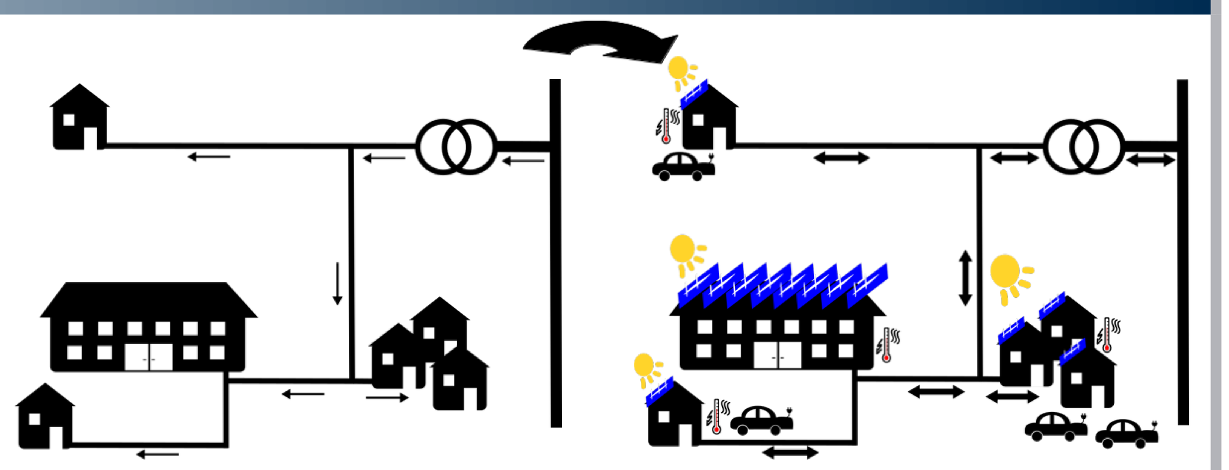

Fig. 1: Sketch of LV-grid - scenario Conv (left) and scenario PV+EV+HP (right)

## Scenarios and Grids

Examined scenarios where grid issues may increase:

1. Conventional (Conv): Only household load exists. No PV, EVs or HPs are installed.
2. Full-electrified (EV + HP): Every household owns one HP and one EV.
3. Max. PV extension (PV): Full technical potential of roof-tops is used for PV systems.
4. Full-electrified & max. PV extension (PV + EV + HP): Merge of scenario 2 und 3.

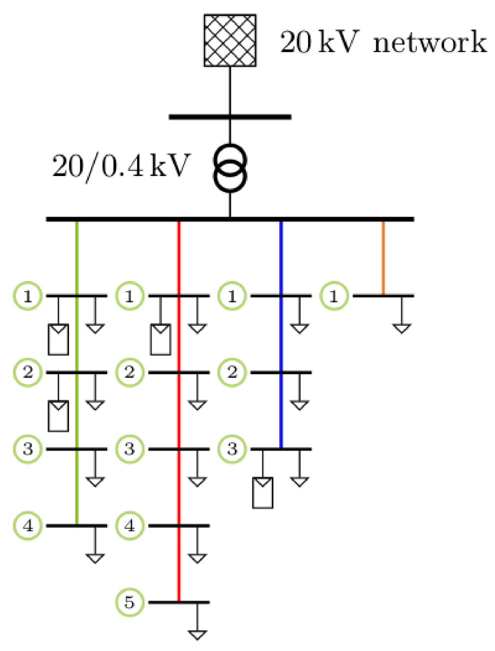


Fig. 2: Schematic diagram of a small rural SimBench grid

## Research Approach

This poster focuses on grid issues in LV-grids with a high share of PV-systems and sector-coupled consumers, such as heat pumps (HP) and electric vehicles (EV). In order to provide reliable recommendations for maintaining the grid stability, it is crucial to understand the specific problems caused in different types of renewable and sector-coupled low-voltage grids. The most relevant performance indicators are **voltage stability, line loading and transformer loading**. **Five representative synthetic rural and suburban grid types** [Meinecke et al., 2020] and **four energy transition scenarios** were simulated.

The developed model is based on pandapower, an open source tool for power system modeling [Thurner et al., 2021]. A **1 min time resolution** is applied to depict short changes in PV-generation and consumption. **One summer week** with the highest negative and **one winter week** with the highest positive residual load is simulated in order to map two extreme time periods of the year.

## Simulation Results - Analysis of Grid Issues in LV-Grids

- Pure electrification creates comparatively minor problems (column 2: EV + HP). These grid issues occur in winter.
- Predominantly photovoltaic systems lead to voltage band violations and line overloads (column 3: PV). These grid issues occur in summer.
- With the combination of PV and EV + HP a slight compensation can be observed (column 4: PV + EV + HP).
- Grid issues occur mainly in rural grids with large expansion, long lines and a high potential for roof-top PV.

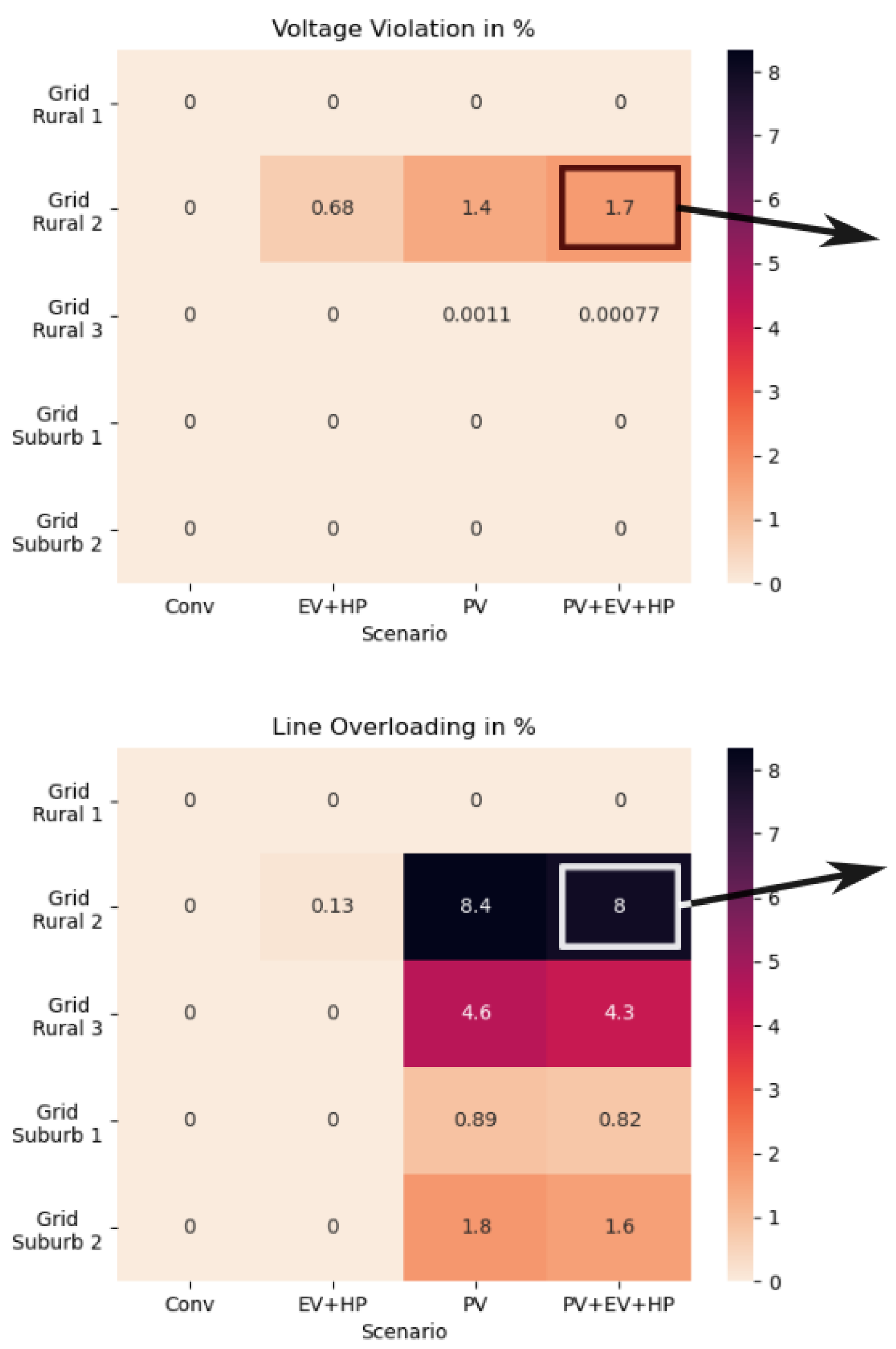


Fig. 3: Voltage violation and line overloading within the examined grid types and scenarios

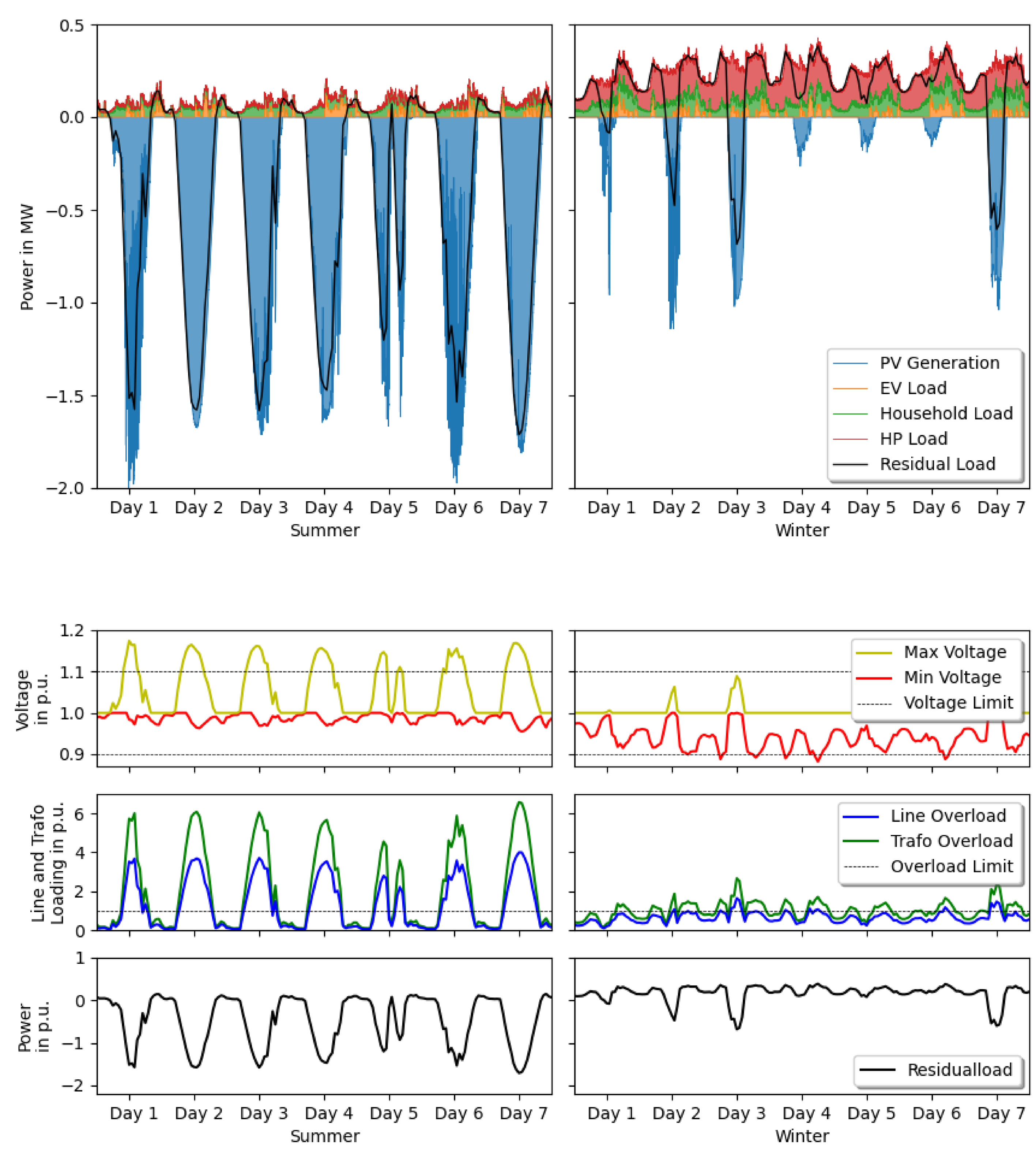


Fig. 4: Scenario PV+EV+HP and SimBench Grid Rural 2

## Conclusion and Outlook

- It can be observed that grid issues arise both from additional sector-coupled consumers and from a strong expansion of photovoltaic systems. This suggests that battery storage systems could offer a promising solution balancing the effects of electrification and pv feed-in.
- The fact that HP and EV also lead to grid congestions leads to the assumption that a smart management of consumers may be useful.
- The results indicate that the use of BSS in distribution grids should be taken into account. BSS are able to encounter a massive grid expansion in the lower grid levels by allowing consumption and generation to take place as locally as possible.

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## Bibliography


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