# Analysis of Operating and Positioning Strategies of Home and Community Storage Systems in Low Voltage Grids in a Sector-Coupled and Renewable Energy System

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# Introduction

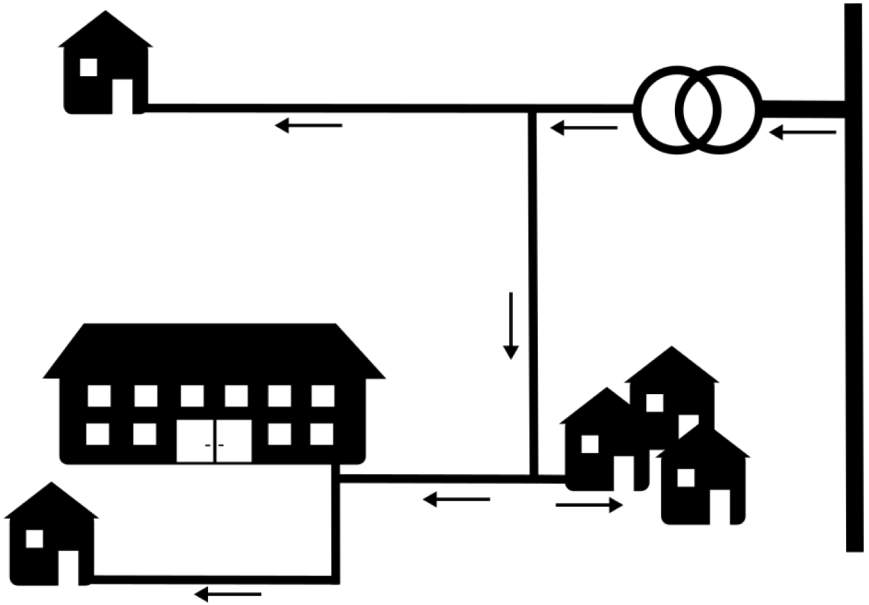


Fig. 1: Low voltage grid in the conventional energy system

## Conventional energy system:

- Central power plants
- Uni-directional power flow

# Introduction

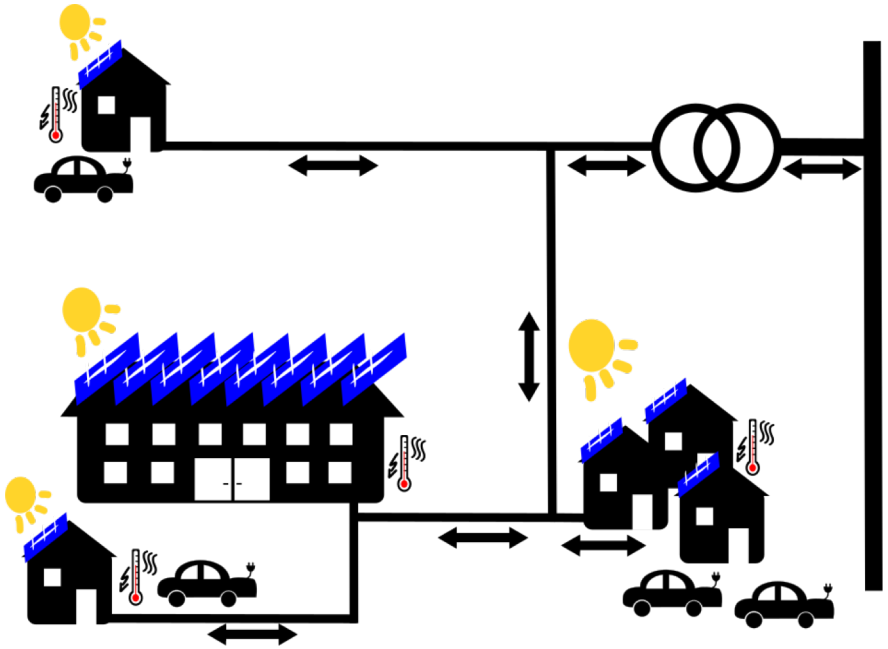


Fig. 2: Low voltage grid in the renewable and sector-coupled energy system

## Conventional energy system:

- Central power plants
- Uni-directional power flow

## Renewable and sector-coupled energy system:

- Decentral power plants
- Bi-directional power flow
- Higher power demand compared to conventional energy system

# Introduction

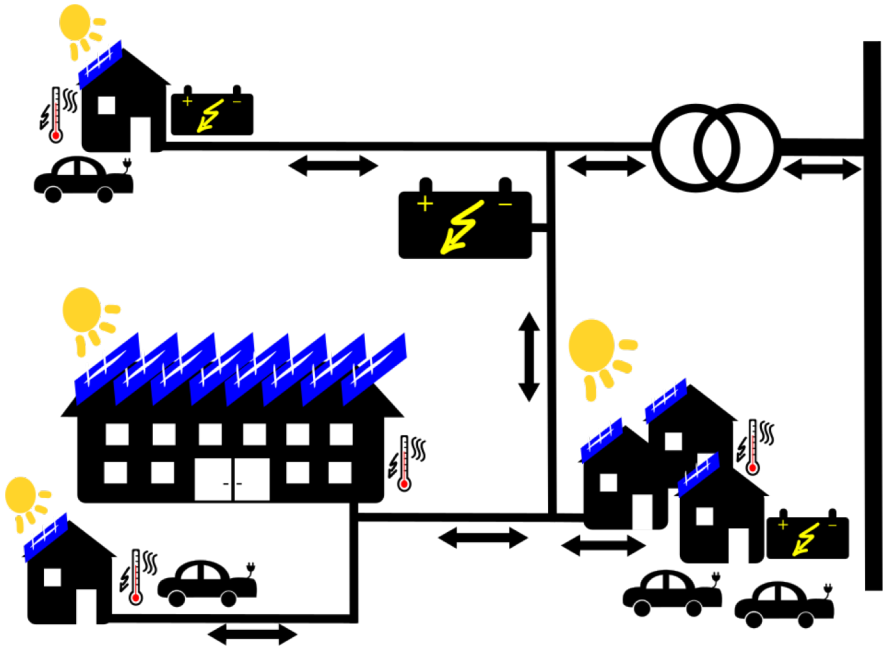


Fig. 3: Low voltage grid in the renewable and sector-coupled energy system with home and community battery storage systems

**Battery storage systems (BSSs):** Balancing of power supply and demand

→ Integration of renewable energy

→ Security of supply

# Research Questions

- How are the grid equipment load and local generation balancing affected by the …
  - positioning strategy
  - operating strategy

  … of BSS in case of a sector-coupled and renewable energy system?

- How do the results differ in rural and suburban areas?

# Methodology: Energy Cell Modell

## Object of investigation:

- 5 low voltage grids
  - 3 x rural
  - 2 x suburban

## Variation:

- 3 positioning strategies
- 3 operating strategies

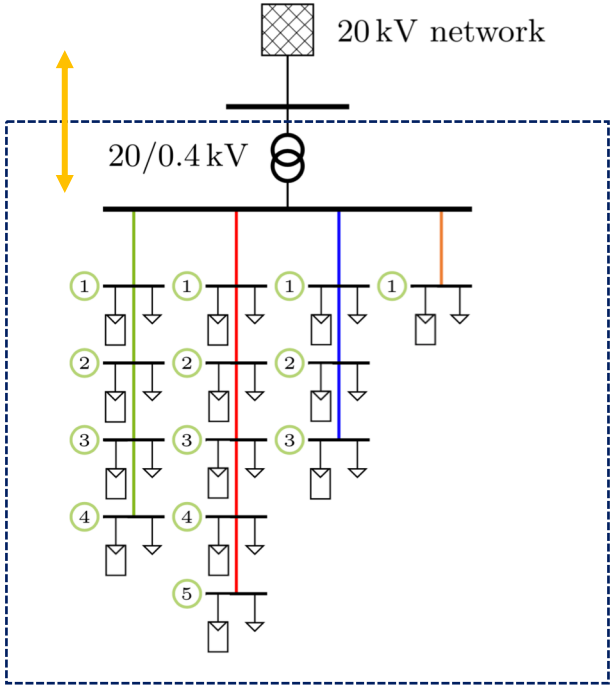
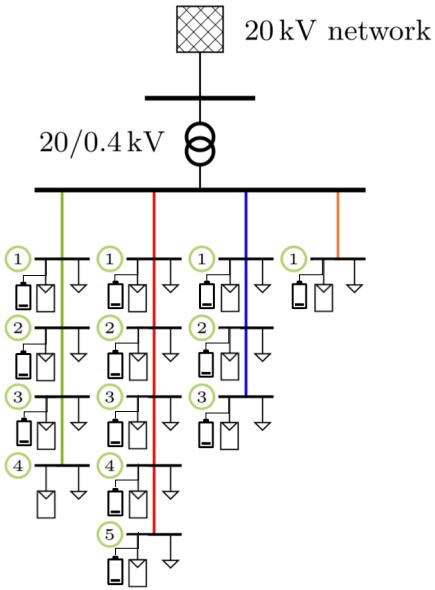


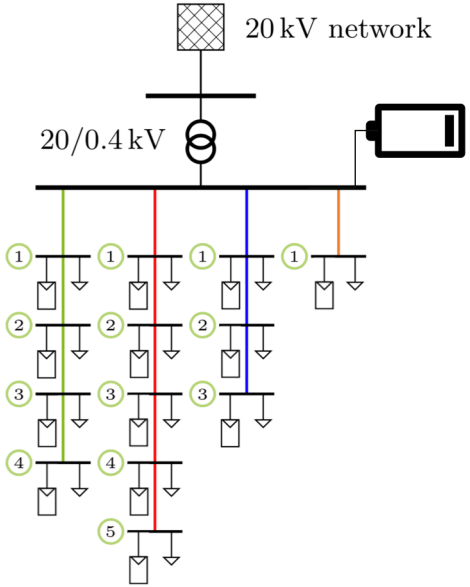

Fig. 4: Energy cell model [Meinecke et al., 2020] (edited)

# Methodology: Positioning Strategies

## Per household




## Low voltage busbar




## End of power line

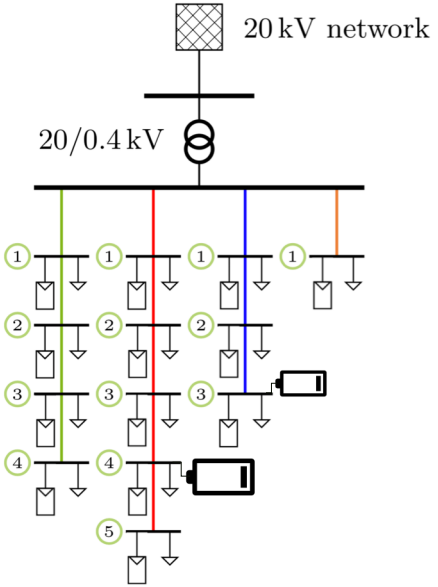



Fig. 4: Positioning strategies for battery storage systems in a low voltage grid [Meinecke et al., 2020] (edited)

# Methodology: Operating Strategies

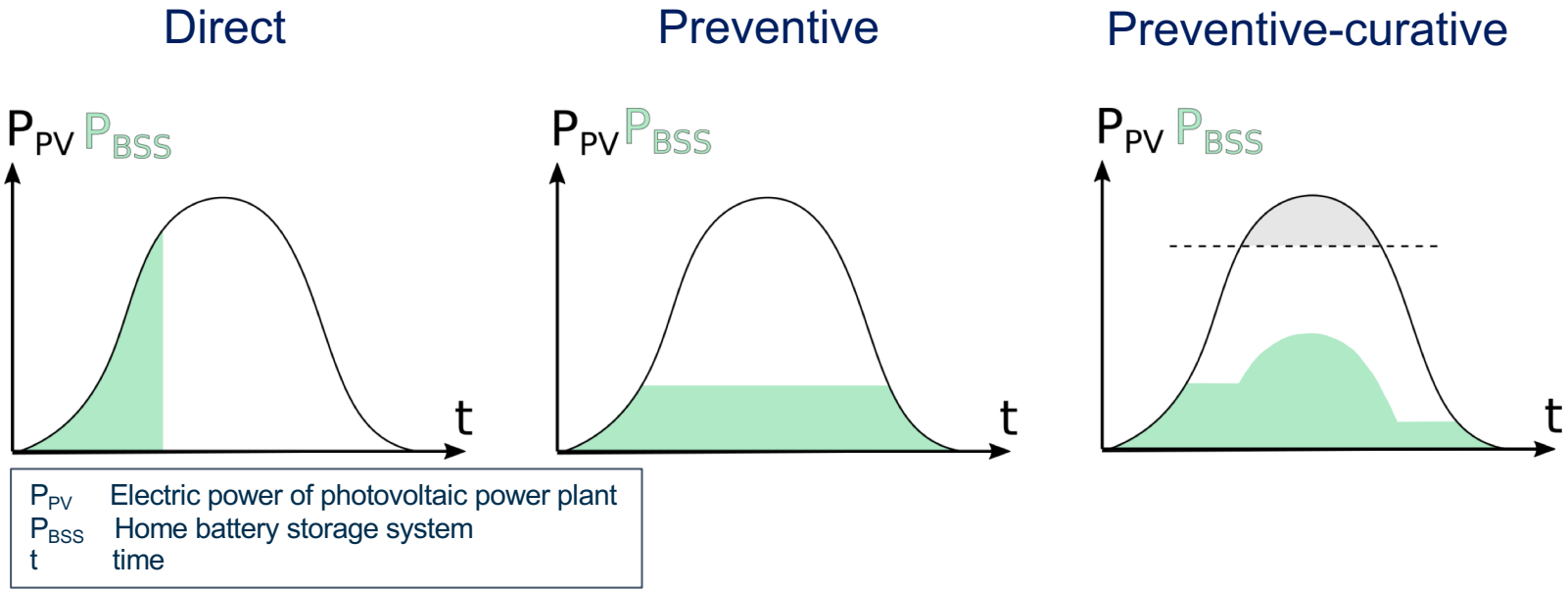



Fig. 5: Characteristic of different operating strategies

# Methodology: Research Scenarios

Tab. 1: Methodology of comparison and respective combinations of positioning and operating strategies

| | Positioning Strategy | Operating Strategy | Methodology of comparison | | |
|---|---|---|---|---|---|
| Scenarios | - | - | | | Reference and BSS scenarios |
| | HBSS | Direct | Operating Strategies | | |
| | HBSS | Preventive | | | |
| | HBSS | Preventive-curative | | Positioning Strategies | |
| | CBSS LVBB | Preventive-curative | | | |
| | CBSS line | Preventive-curative | | | |

HBSS: Home battery storage system
CBSS: Community battery storage system
LVBB: Low voltage busbar

# Methodology: Power Flow Simulation

## Time Parameters:

- One week per season
- Time resolution of 1 min

## Evaluation criteria:

- Network problems
  - Voltage band violations
  - Overload of transformers and power lines
- Losses due to curtailment
- Self-consumption rate, degree of self-sufficiency

# Results

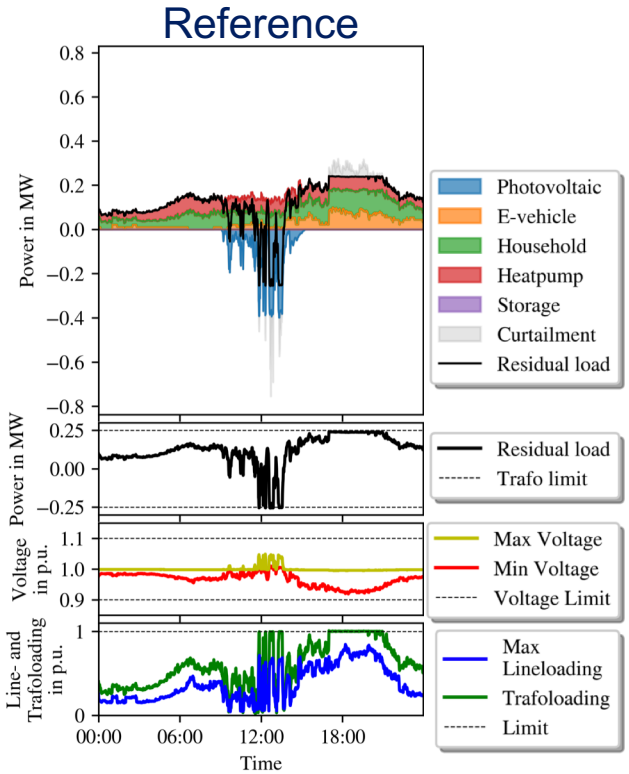
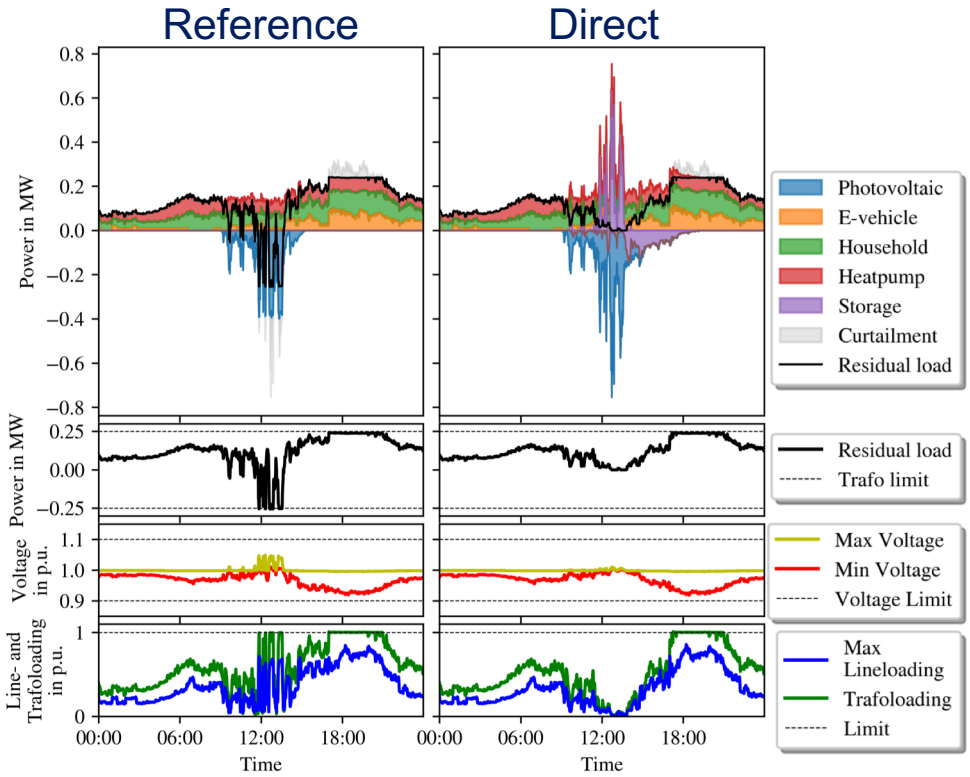



Fig. 6: Reference scenario and scenarios with home battery storage systems and different operating strategies in comparison.: accumulated loads, residual load and grid states on a winter day in a rural low voltage grid

# Results

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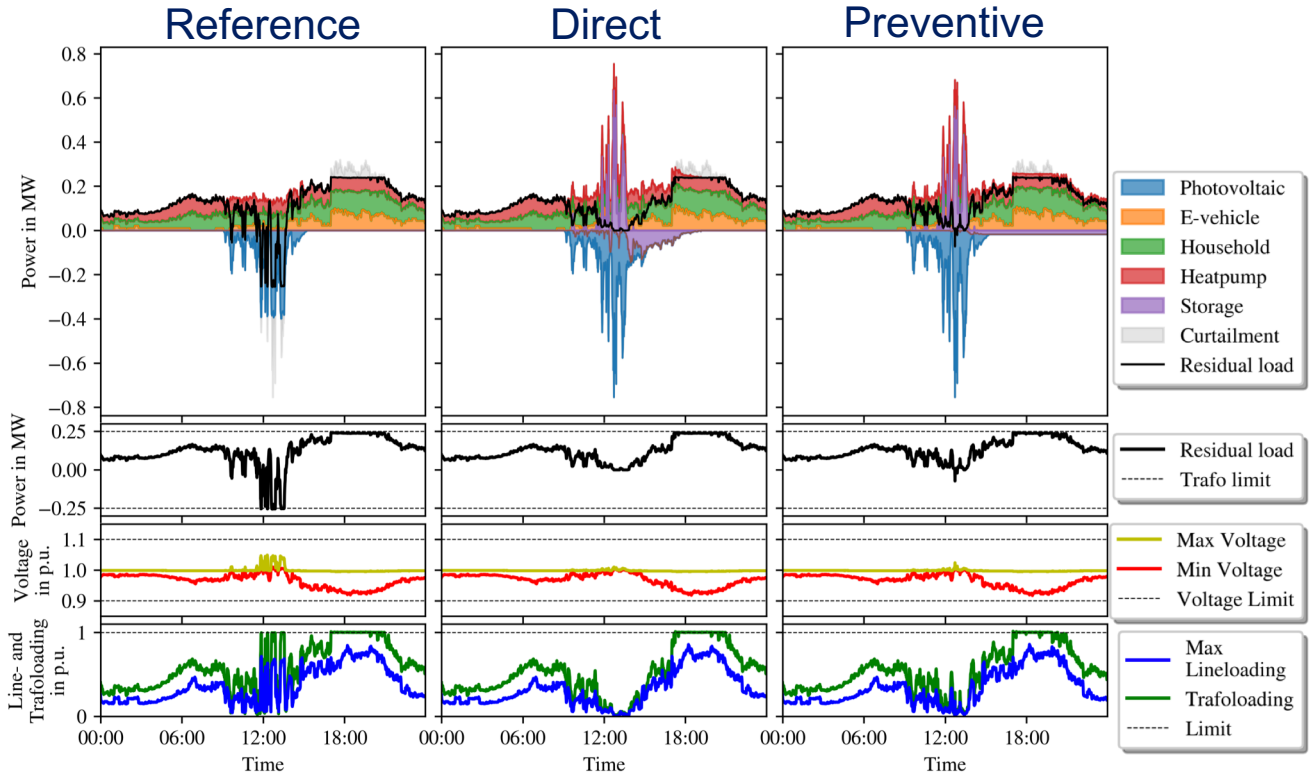


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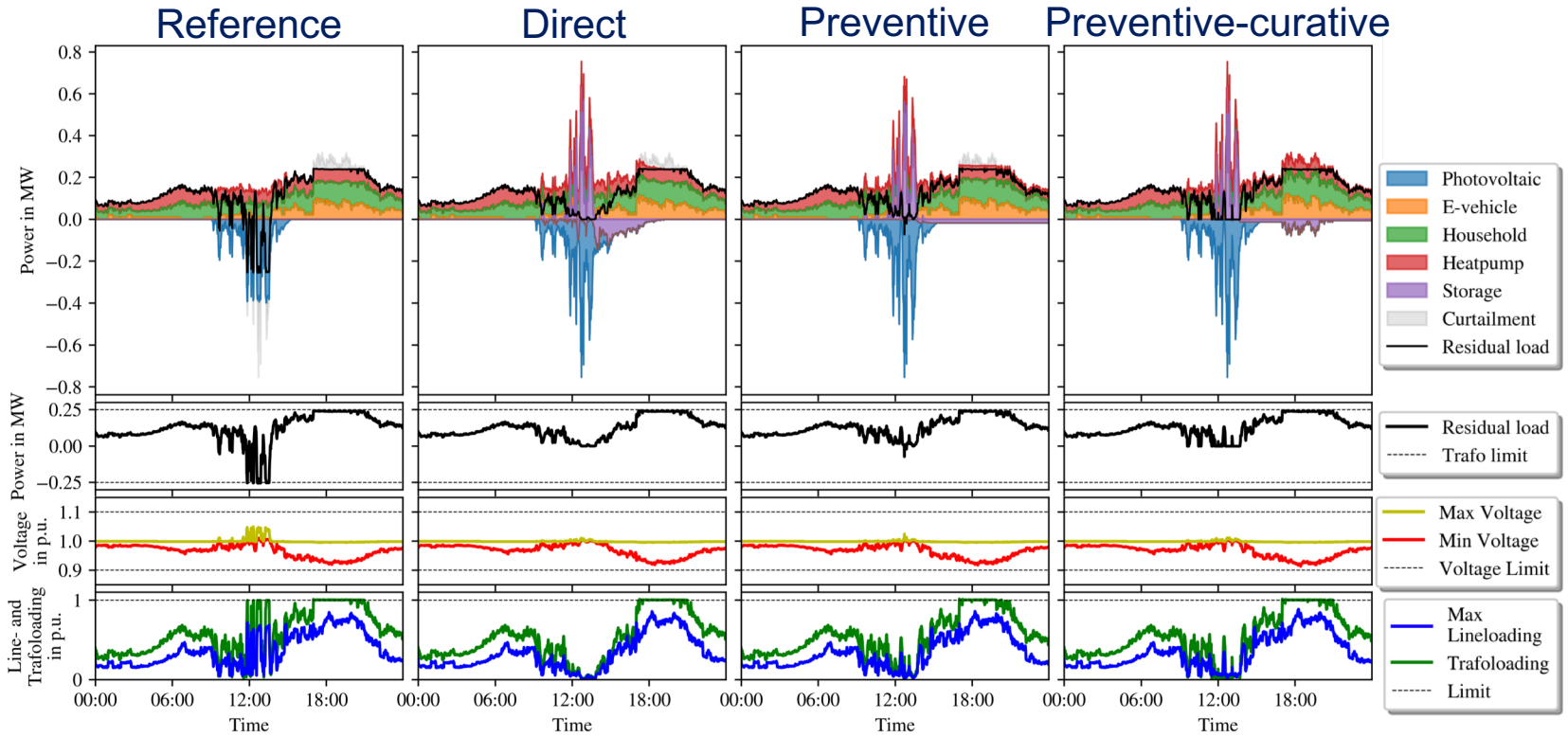


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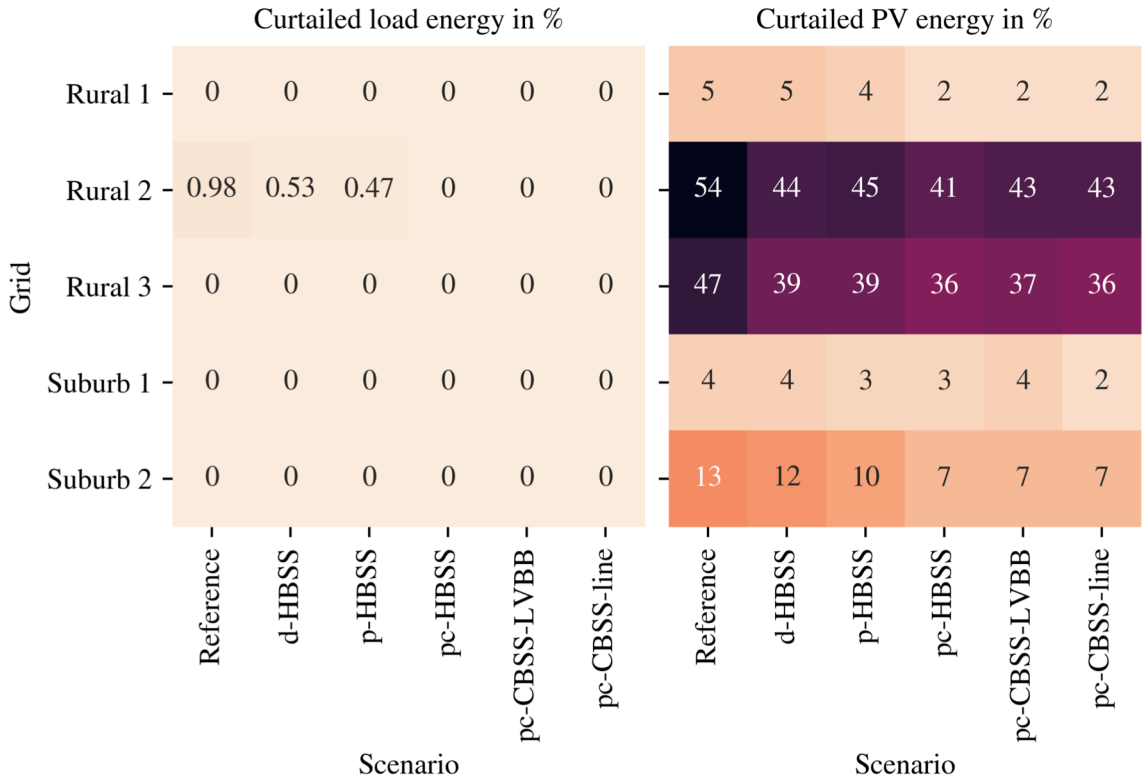
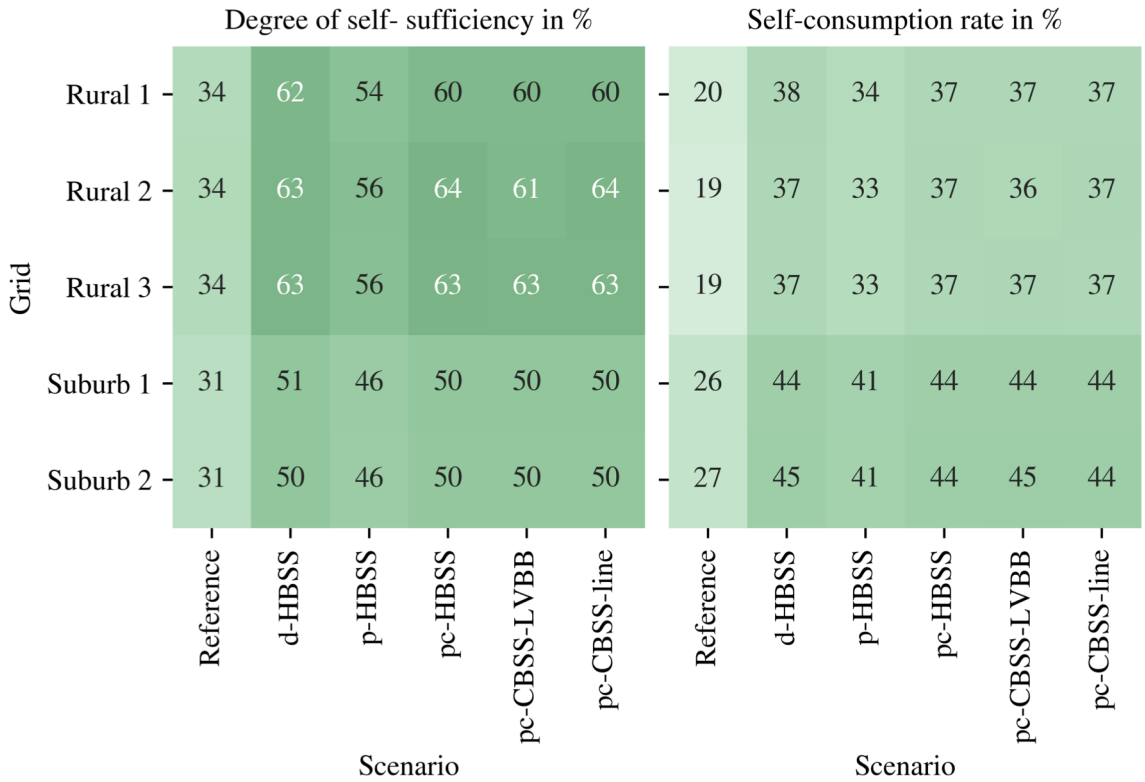



| | |
|---|---|
| PV | Photovoltaic |
| HBSS | Home battery storage system |
| CBSS | Community battery storage system |
| d | direct |
| p | preventive |
| p-c | preventive-curative |
| LVBB | low voltage busbar |

Fig. 7: Comparison of losses due to curtailment in different low voltage grids and storage scenarios

# Results




| | |
|---|---|
| HBSS | Home battery storage system |
| CBSS | Community battery storage system |
| d | direct |
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Fig. 8: Comparison of degree of self-sufficiency and self-comsumption rate in different low voltage grids and storage scenarios

# Conclusion

- **Positioning strategies:** Only small impact on curtailment and self-consumption

- **Operating strategies:** Increase of both local generation balancing and network efficiency through strategies that actively respond to grid states

- **Rural and suburban areas:**
  - Grids affected differently by PV power fed into the grid and increased power supply due to sector-coupling
  - Benefit from implementing BSS in both areas

# Bibliography

[Meinecke et al. 2020] Steffen Meinecke; Dzanan Sarajlic; Simon Ruben; Drauz; Annika Klettke; Lars-Peter Lauven; Christian Rehtanz; Albert Moser; Martin Braun. Simbench - A Benchmark Dataset of Electric Power Systems to Compare Innovative Solutions based on Power Flow Analysis. Energies, 13(12), 2020.

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