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ENERGY ECONOMICS ENERDAY ENERGY TECHNOLOGY

TUHH Hamburg University of Technology

Investigation of seasonal congestion situations in modern rural integrated distribution grids

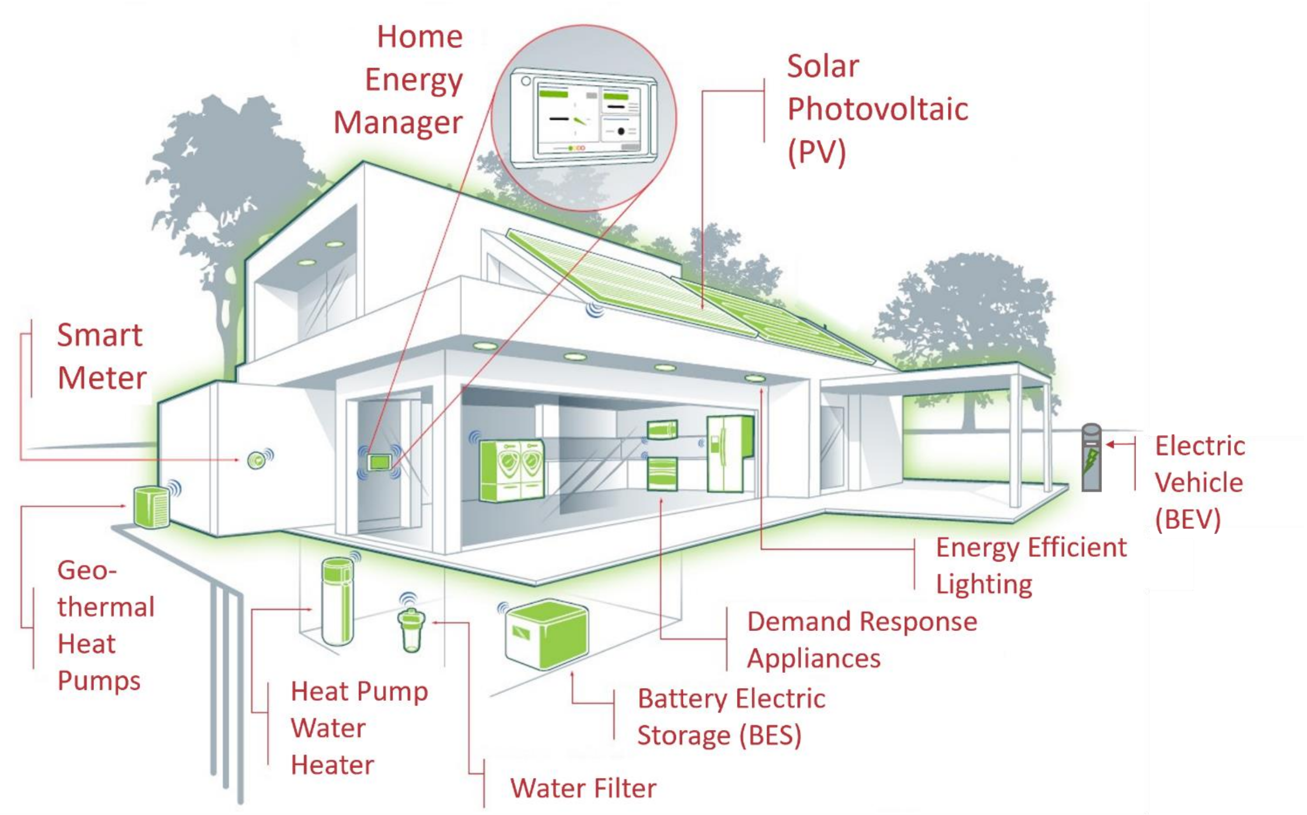
ENERDAY 2023 - 17TH INTERNATIONAL CONFERENCE ON ENERGY ECONOMICS AND TECHNOLOGY

Speaker: Tom Steffen

5th May 2023

1. Motivation

- Future energy systems rely on diversified decentralized power generation
- High shares of fluctuating renewable energy generation in distribution grids
- Integrated Energy Systems as promising solution approach, but also with potential risks
- Distribution grids need to become smart
- Focus on „How do modern and future distribution grid scenarios in look like?“ to afterwards engineer better operational strategies



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How do we model? - The CyEntEE Database

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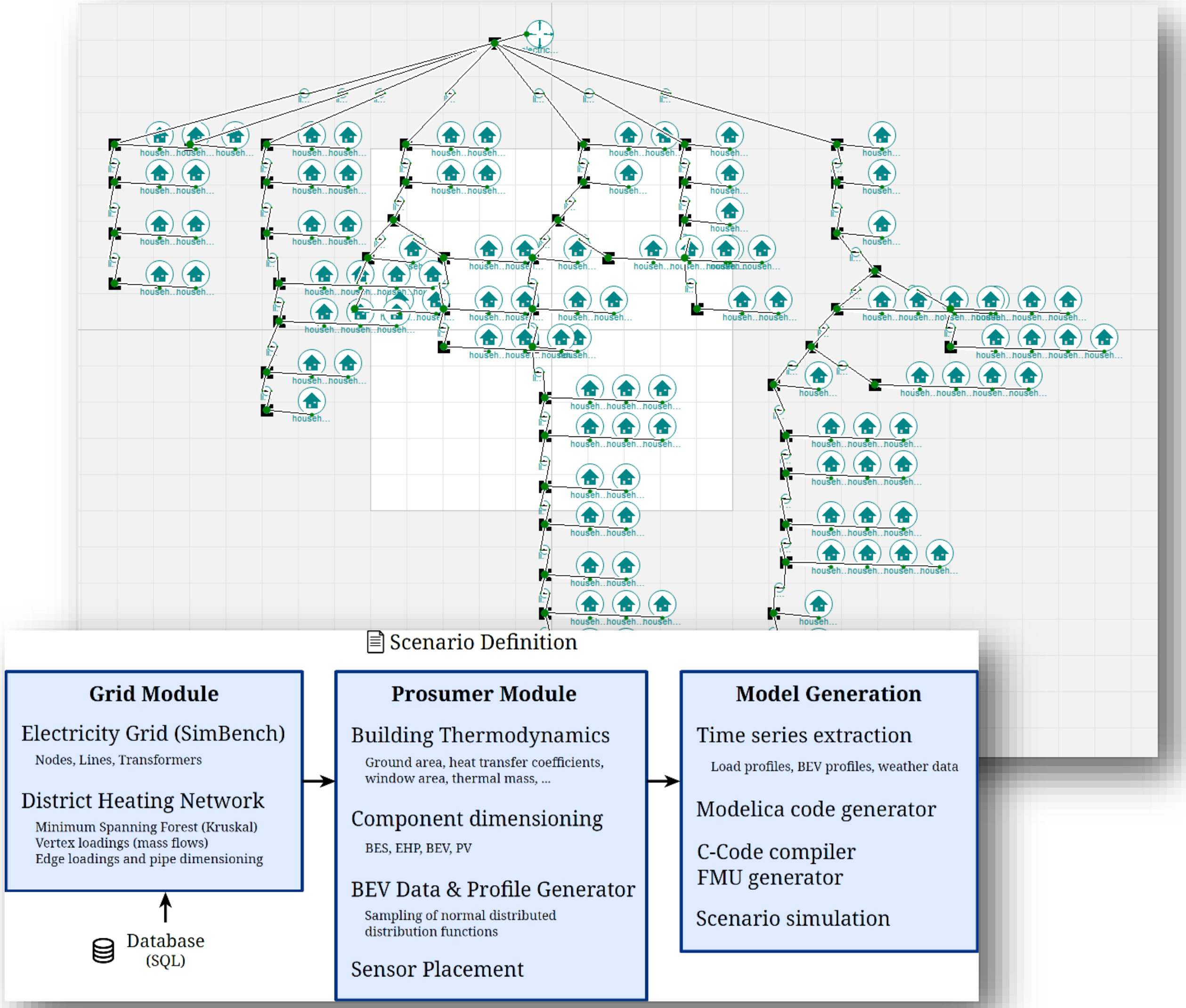
- Dynamic modelling of integrated distribution grids with Modelica and the TransiEnt Library

TransiEnt Library

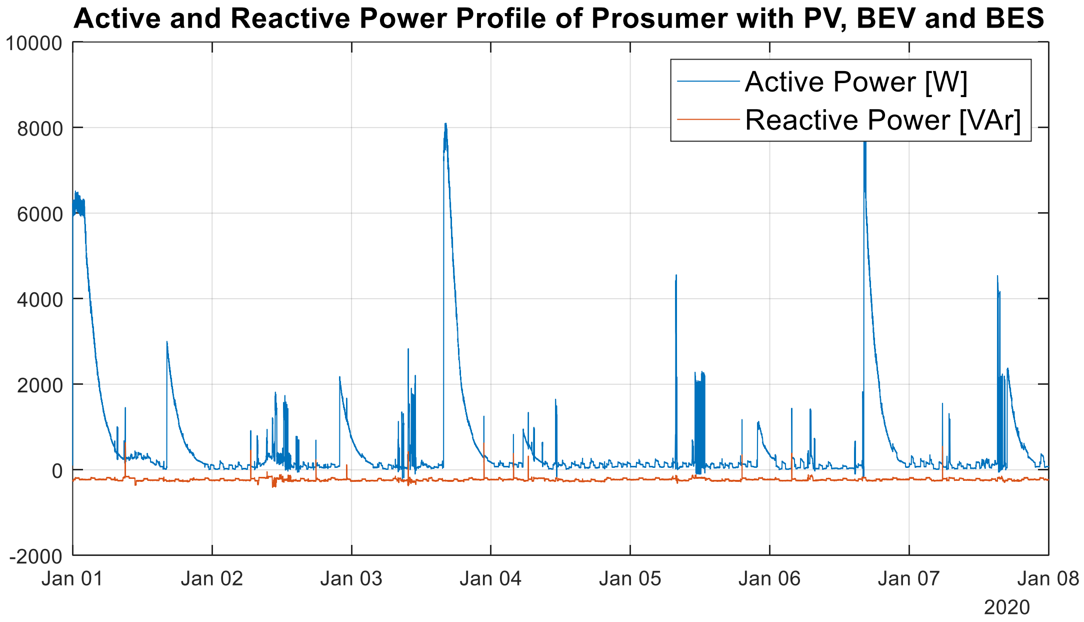
- Modelling of different modern and future energy system scenarios based on realistic topologies (Benchmark-Grids) from SimBench

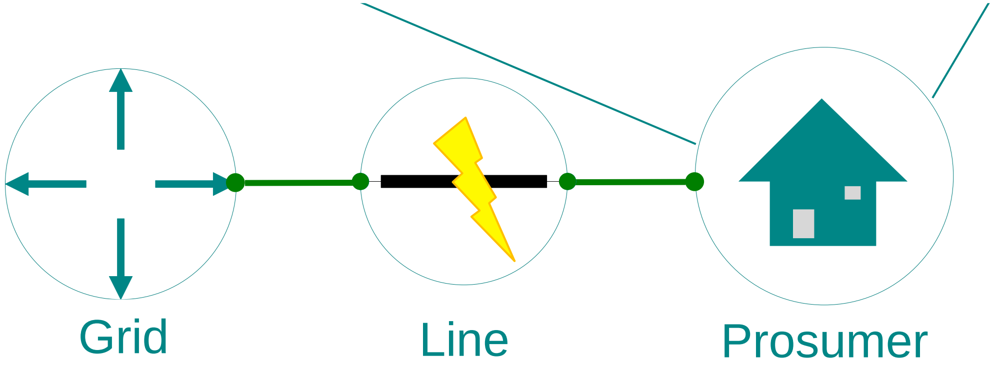
- Scenario specific information is stored within a database
  - Load Profiles
  - Study-based driving profiles for electric vehicles
  - Ambient conditions for household heating
  - Weather data from DWD („Deutsche Wetterdienst“)
  - Topology of the grid



Concept and Model of Future Prosumers

- Simulation and analysis of modern and future scenarios for households („Prosumers")
  - Photovoltaic plants (PV)
  - Battery electric vehicles (BEV) with realistic driving profiles
  - Self-consumption controlling battery electric storages (BES)
  - Smart Meter with sampling rate and normal distributed measurement uncertainty
  - Electric Heat Pump (EHP)
- Characteristic specifications of appliances, in line with real field test scenario in Lower Saxony
- How will this influence the distribution grid?





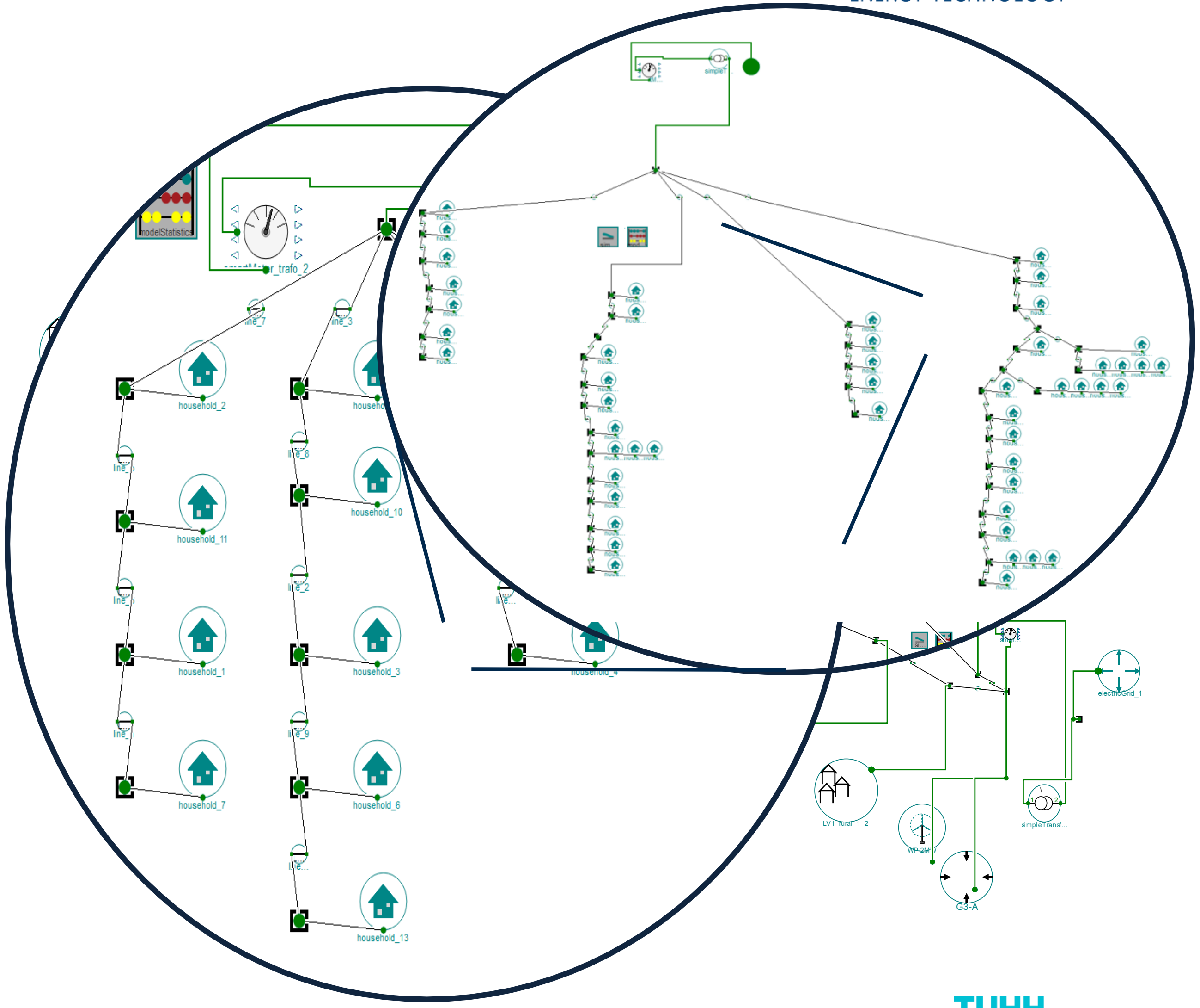
[1] T. Steffen, B. Wiegel, D. Babazadeh, A. Youssfi, C. Becker, and V. Turau, "Generation of realistic smart meter data from prosumers for future energy system senarios," 10th Conference on Sustainable Energy Supply and Energy Storage Systems, NEIS 2022, 2022

3. Scenario Description – Good Case

- Rural medium voltage ring (**SimBench MV-rural-2-no-switches**) with rural low voltage sub cells
  - LV-rural-1 with 13 **Prosumers**
  - LV-rural-2 with 99 **Prosumers**

- **Electrification scenario** with high share of electric vehicles and heat pumps
  - Share BEV 90%
  - Share EHP 100% due to no district heating

- 48 hours simulation in „**Good Case**“ (April 2020)
  - Outdoor Air temperature ~ 20°C
  - Battery storage SOC often high
  - Heat pumps nearly not active

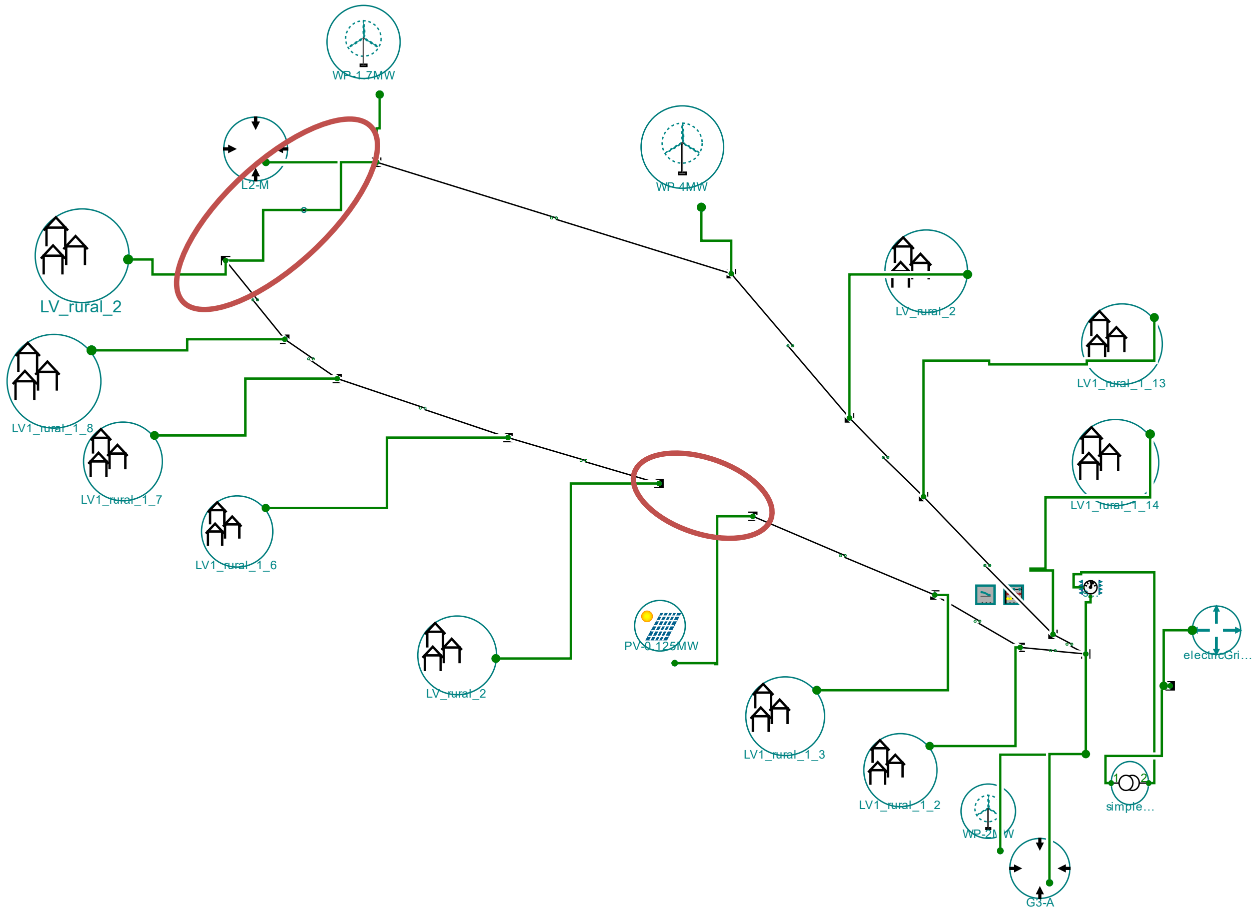


3. Scenario Description – Bad Case

- Closed rural medium voltage ring (**Simbench MV-rural-2-no-switches**) with rural low voltage sub cells
  - LV-rural-1 with 13 **Prosumers**
  - LV-rural-2 with 99 **Prosumers**

- **Electrification scenario** with high share of electric vehicles and heat pumps
  - Share BEV 90%
  - Share EHP 100% due to no district heating

- 48 hours simulation in „**Bad Case**“ (November 2020)
  - Outdoor Air temperature ~ 0°C
  - Battery storage SOC often ~ 0%
  - Heat pumps nearly always active



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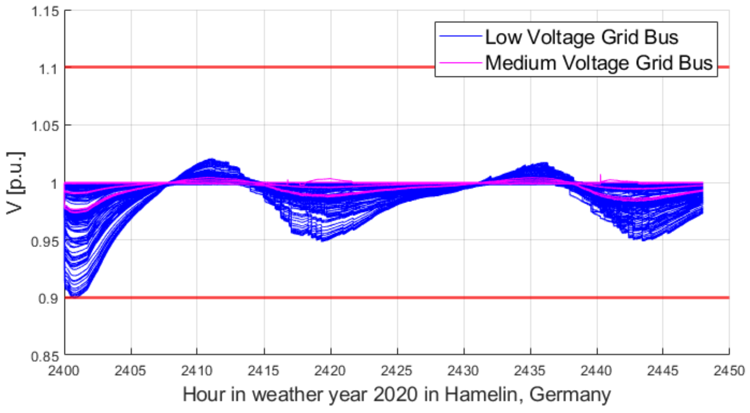
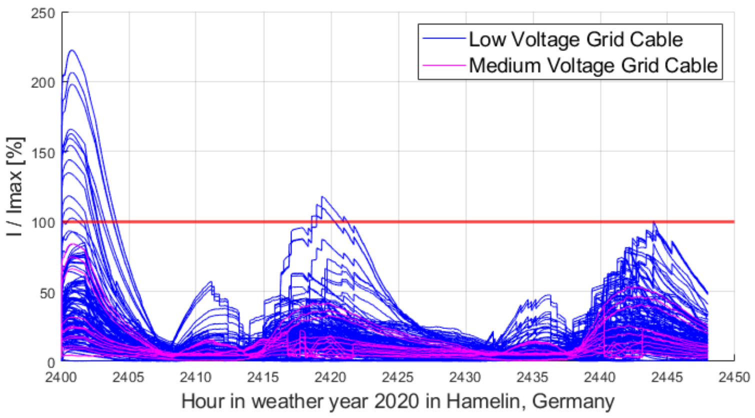
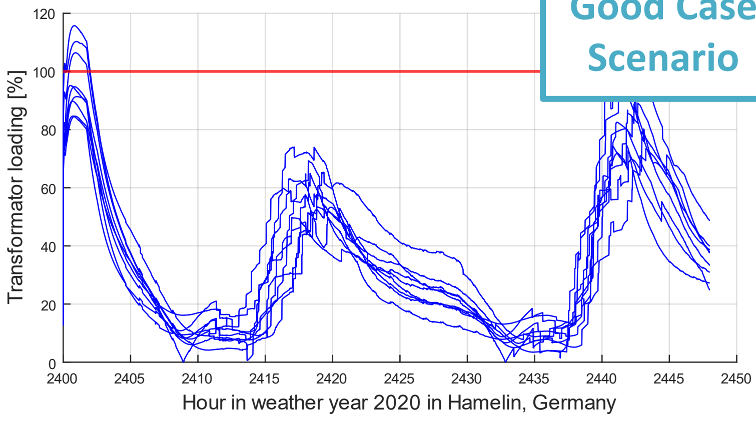
4. Results of the congestion analysis

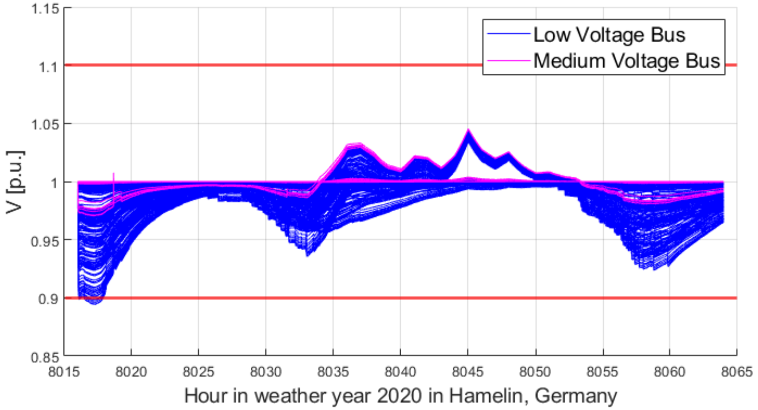
Good Case Scenario

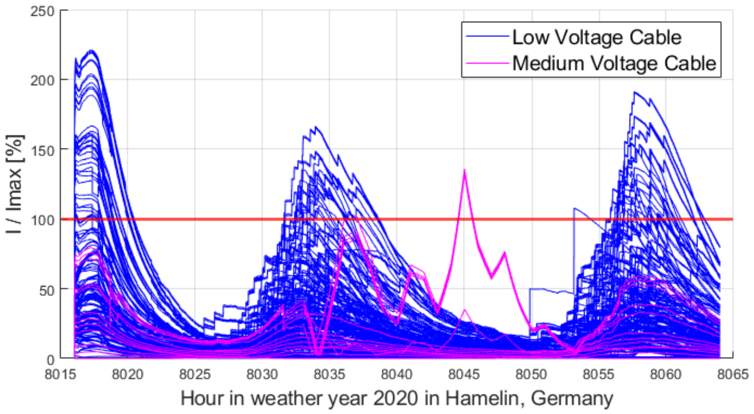


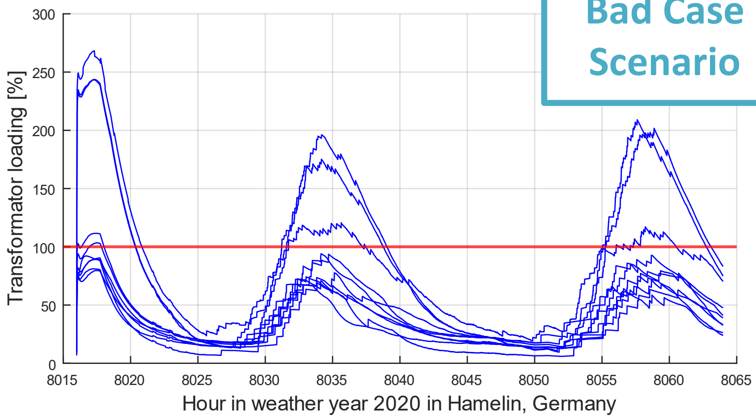




Bad Case Scenario





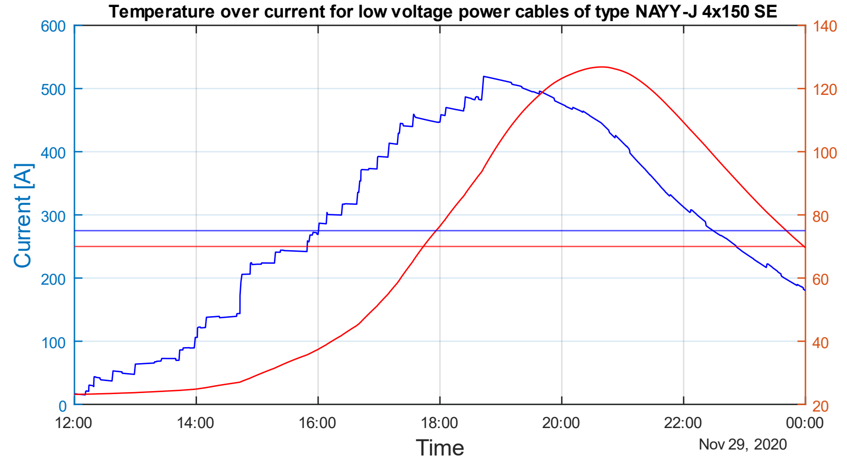


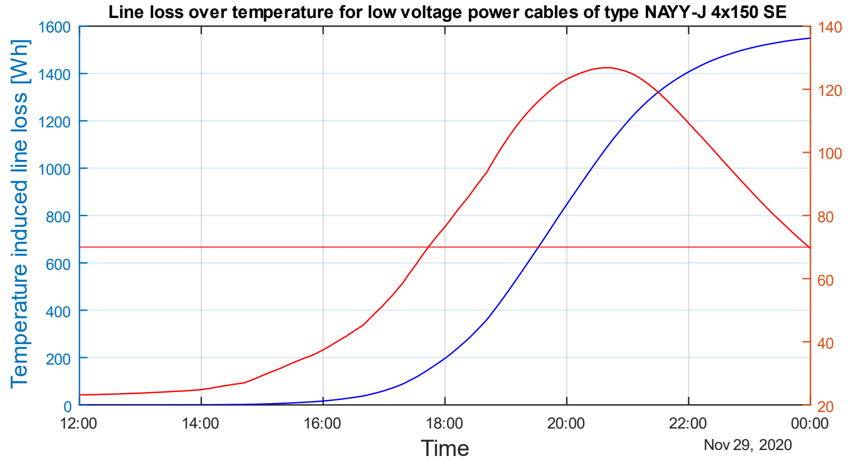
4. Results of the congestion analysis – Thermal evaluation

- Cables have a maximum allowed current I_{th} or I_{max}, also called thermal limiting current

- How to analyse and evaluate the congestion in higher detail
  - Thermal cable modelling

- First results of thermal analysis show inertia in the thermal behaviour
  - Short congestion situations are not relevant
  - Long lasting congestions lead to high temperatures in cables
  - Potential risk for outage and high grid losses





[1] Schwechater Kabelwerke, „Datenblätter Energiekabel0,6/1,0 kV", abgerufen am 6.01.2023. [Online]. Available at https://www.skw.at/upload/products/energiekabel-06-1/

Conclusion & Next Steps

- Detailed bottom-up modeling approach for Integrated Energy Systems
- Low voltage grids seem to be the most vulnerable
- Thermal analysis of low voltage cables indicates higher current capacities for short congestions
- Long overloads lead to possible cable damages and high grid losses
- Urban and sub-urban grid scenarios
- Addition and validation of electric vehicle and electric heat pump dynamics in research project „MOVES“ within EU project ERIGrid 2.0

THANK YOU! QUESTIONS?