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OF ELECTRICAL POWER AND ENERGY TECHNOLOGY

TUHH
Hamburg University of Technology

Dynamic Modelling and Optimal Operation of Intelligent Integrated Energy Systems

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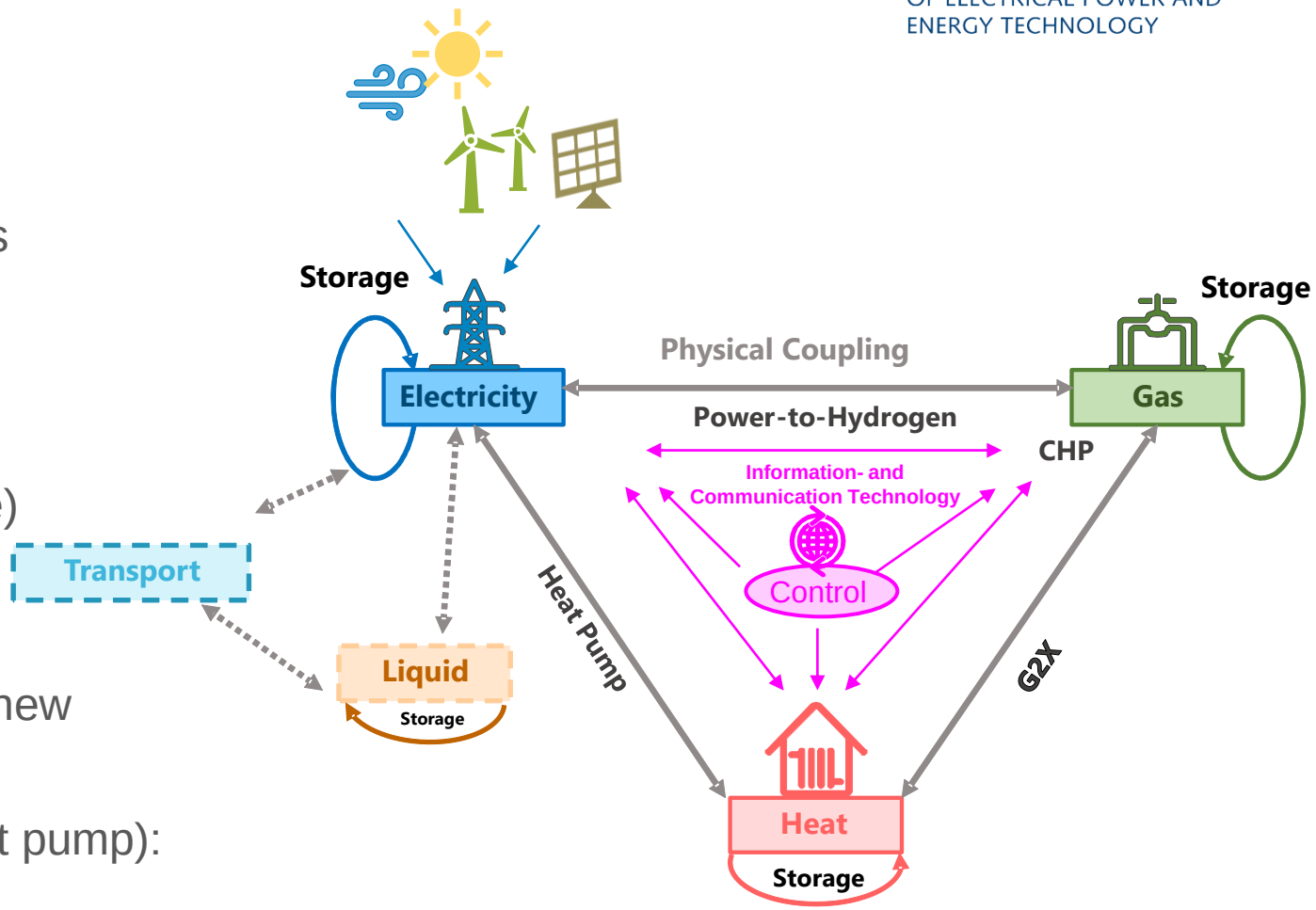
DigiSect Expert Workshop 2023, AIT, Vienna, 20/04/2023

Grids and sector coupling

- **Motivation**
  - Decarbonization: use of renewable energies in various consumption sectors (industry, commerce, transport, households)
  - Energy sector coupling
  - Flexibility from different sectors (storage)
- **Challenges**
  - Stability, resilience and reliability of the new system
  - Increase of peak load/demand (EV, heat pump): Congestion management
  - Coupling needed also at data / ICT level
  - Market design and regulatory aspects



Research areas for sector coupling @ ieet

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open-source

TransiEnt Library

DISRUPSYS ResiliEntEE

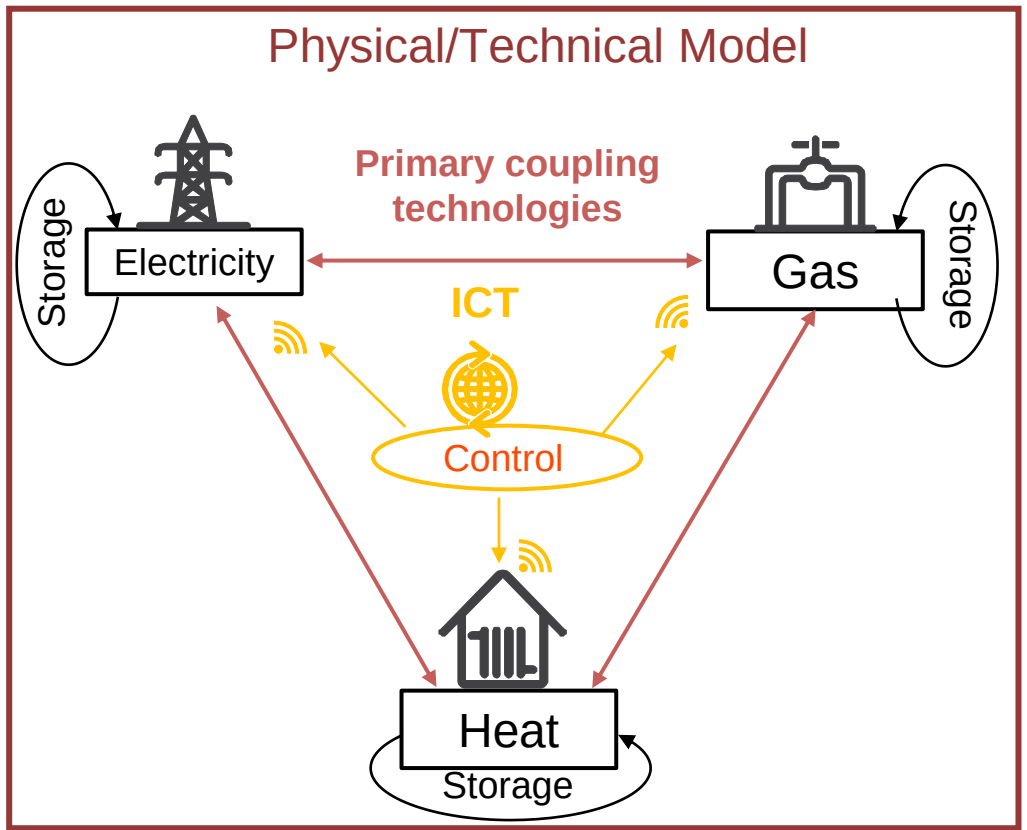
- Dynamic modeling of electricity, gas, heat networks and P2X
- Resilience and stability assessment

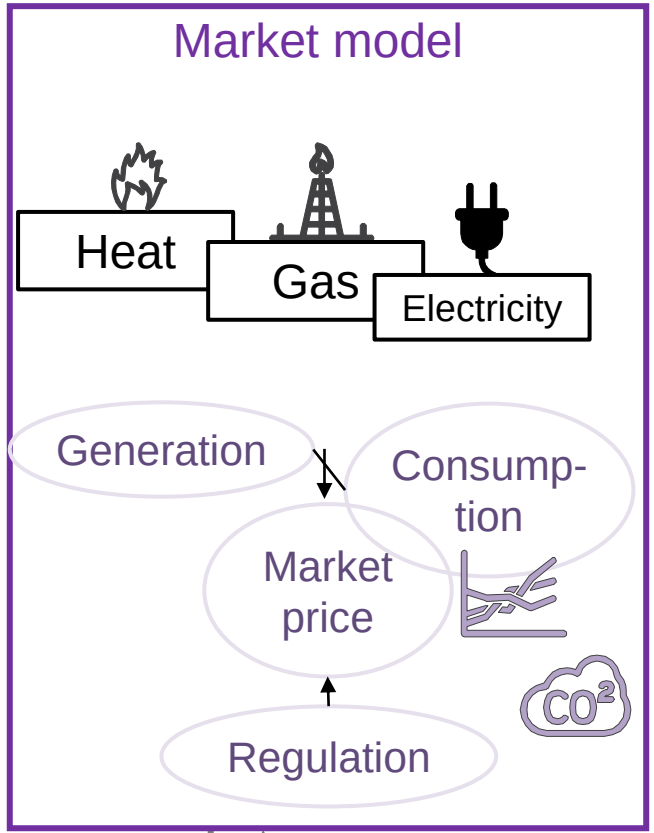
CyEntEE DISRUPSYS

- ICT and operating strategy (cells)
- Model database, co-simulation

CyEntEE EffiziEntEE

- Flexibility modeling, market design
- Optimization of real-time operation





Control commands: Setpoints

Market presettings

Operational optimization (e.g. unit commitment)

Measurement data

Market relevant information

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ResiliEntEE: Resilient Sector-Coupled Energy Systems

2017-2021

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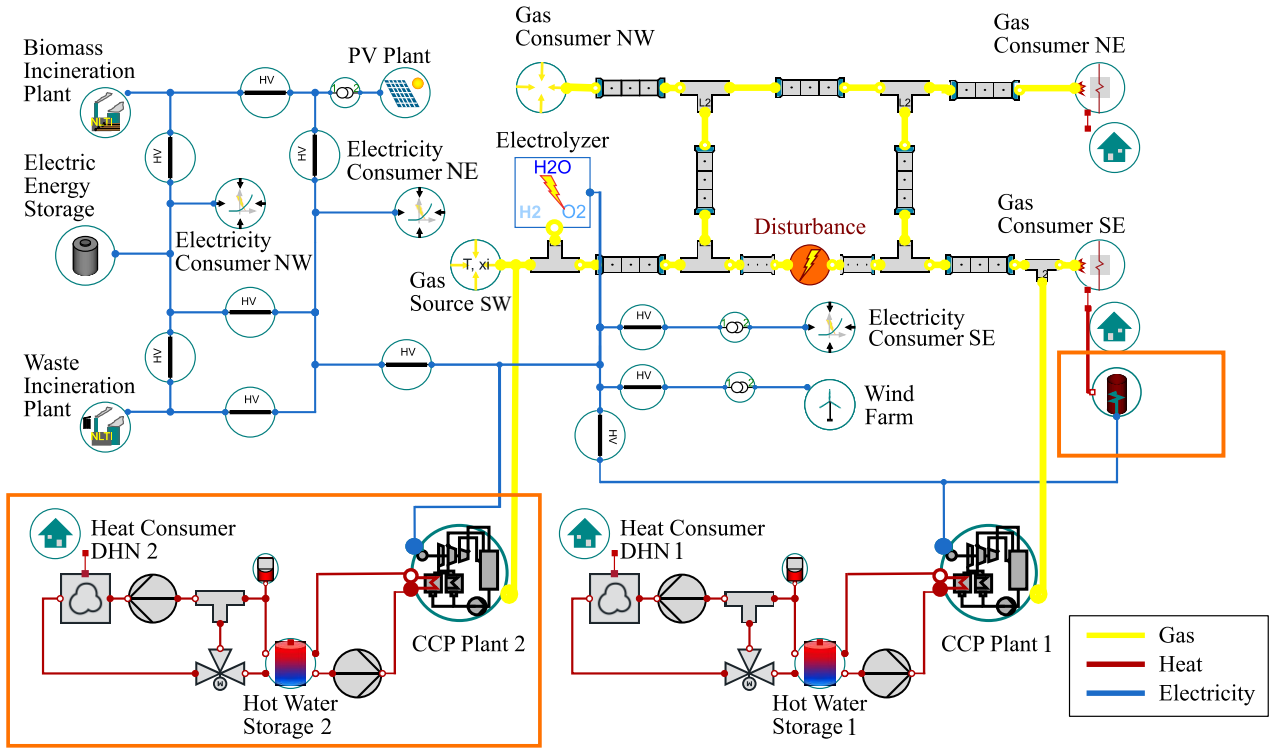
Objectives

- **Dynamic modeling** of electricity, gas and heat networks
- Methods for **resilience assessment** and **voltage stability**
- Modeling of complex events and **interaction analysis**
- Extension of the open source TransiEnt Library

  (https://www.tuhh.de/transient-ee/)



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ResiliEntEE

GASNETZ HAMBURG Stromnetz Hamburg TUHH XRG Simulation GmbH TUHH

CyEntEE: Cyber-Physical Integrated Energy Systems

2019-2024

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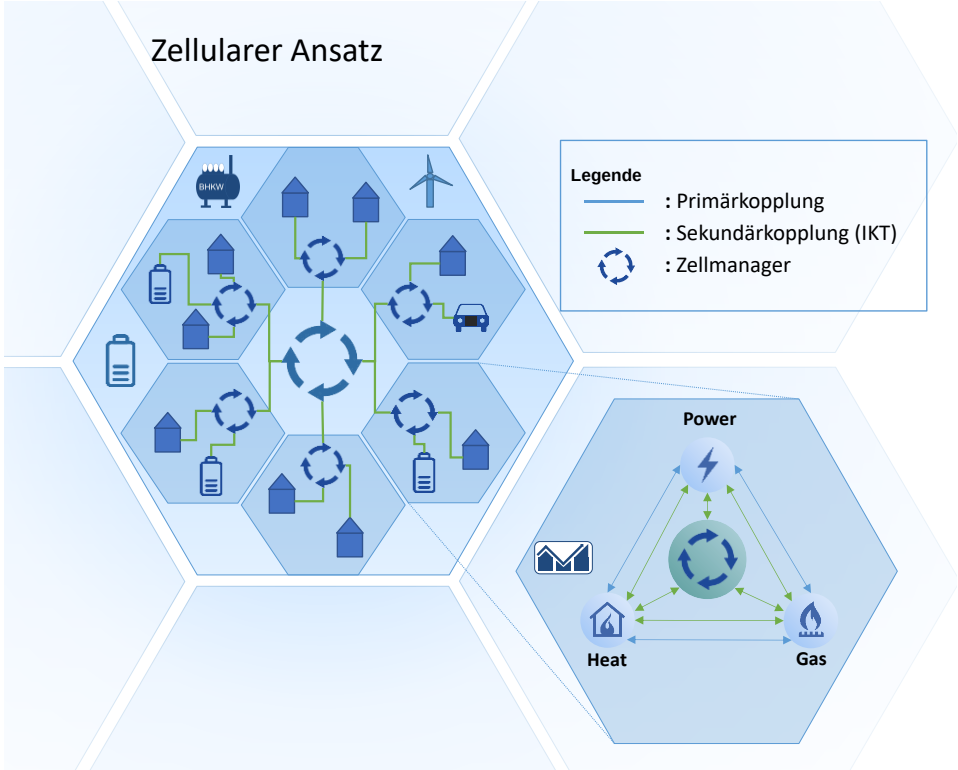
Objectives

- Dynamic modeling and evaluation of **future technologies** (EV, P2X, EHP)
- System architecture: "**Cellular** Energy System" with focus on sector-coupled **distribution grids**
- Investigation of suitable **ICT solutions** and architectures
- Optimal **operating strategies** for smart integrated energy systems and optimized **use of flexibility**



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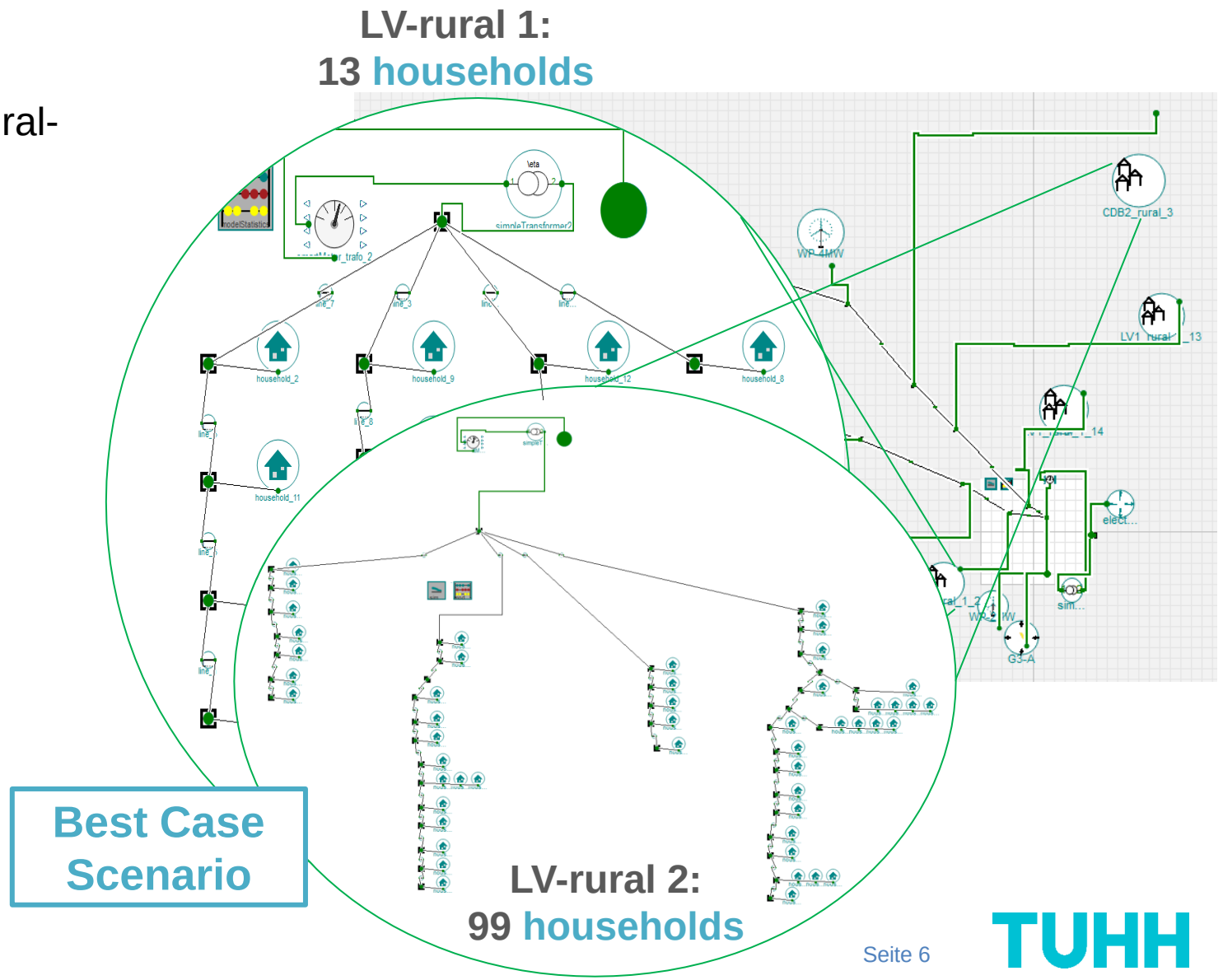
Schleswig-Holstein Netz · Stromnetz Hamburg · GASNETZ HAMBURG · XRG Simulation GmbH · Hamburger Energiewerke

Usecase: Bottleneck analysis in MV-LV-networks

- MV ring operated open (**Simbench** MV-rural-2-no-switches) with subdivided rural **low-voltage networks**
- **Electrification scenario** with high penetration of electric cars (90%) and electric heat pumps (80%)
- 48-hour simulation: "**best case scenario**" in **summer**
  - Outside temperature: ~20°C (avg.)
  - Battery level often high
  - Heat pumps almost not active



Simulation Results – Examples

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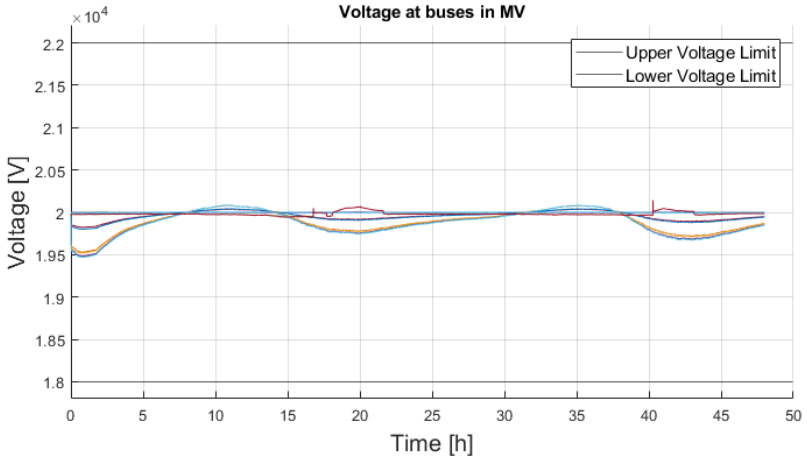
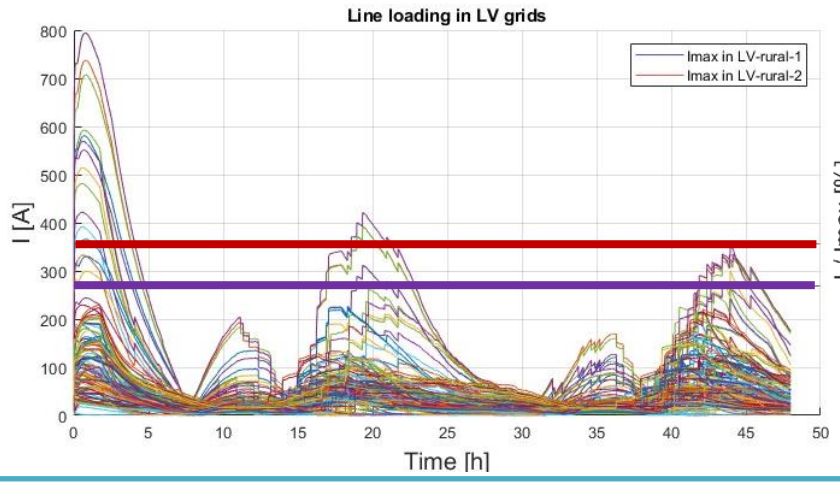
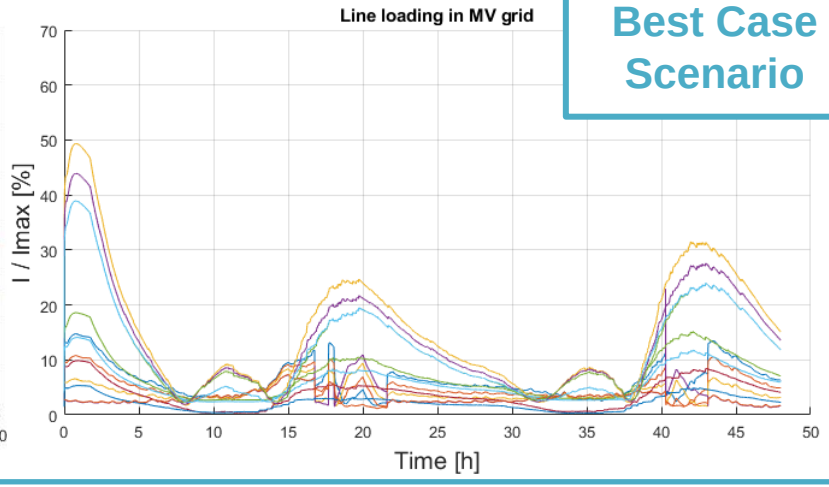
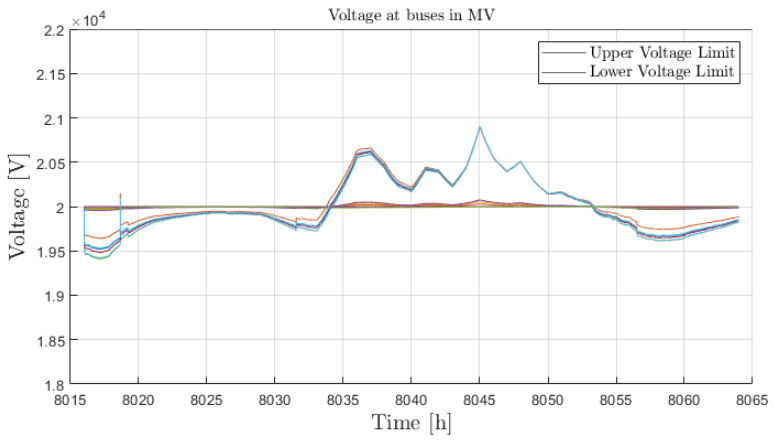
Best Case Scenario

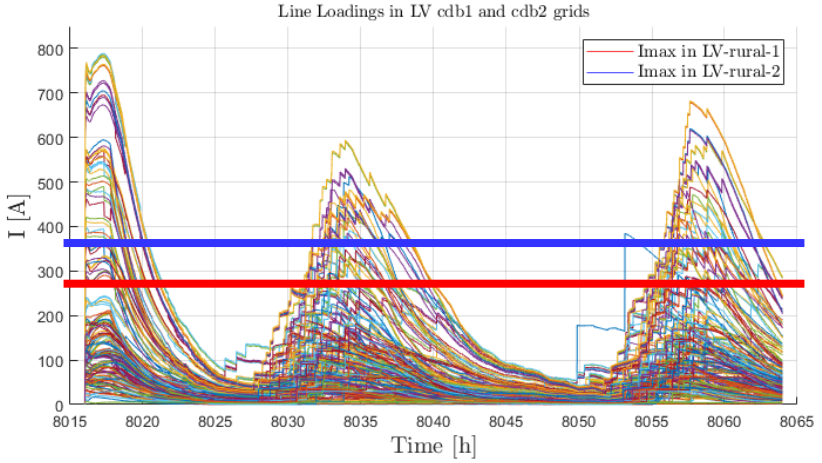


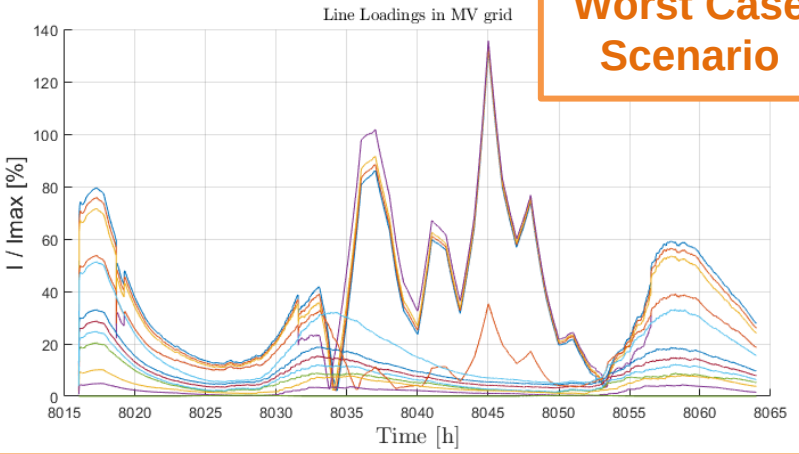




Worst Case Scenario







DisrupSys: Integration of H_2-infrastructure (storage CHP)

2021-2024

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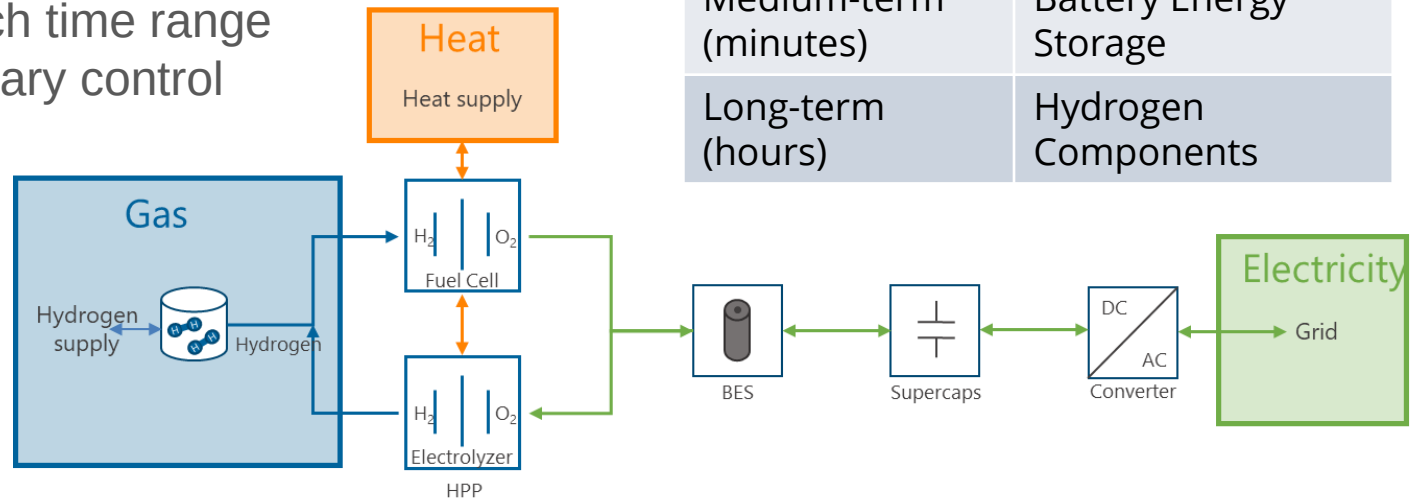
Objectives

- Stability analysis of **voltage angle control according to H. Weber*** in inverter-dominated networks
- Modeling and control of a **hydrogen generation and storage unit**
- Provision of **anxillary services** for each time range (from instantaneous reserve to secondary control reserve)

*** Weber, H.**: *Von der Frequenzregelung mit Schwungmassen (netzstützende Maßnahmen) zur Winkelregelung mit Umrichtern (netzbildende Maßnahmen)*, 12. ETG/GMA-Fachtagung „Netzregelung und Systemführung“, 26.–27.09.2017, Berlin

Time scope	Technology
Short-term ((m)seconds)	Supercaps
Medium-term (minutes)	Battery Energy Storage
Long-term (hours)	Hydrogen Components



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DISRUPSYS

EffiziEntEE: Market design and efficient utilization of flexibility

2022-2025

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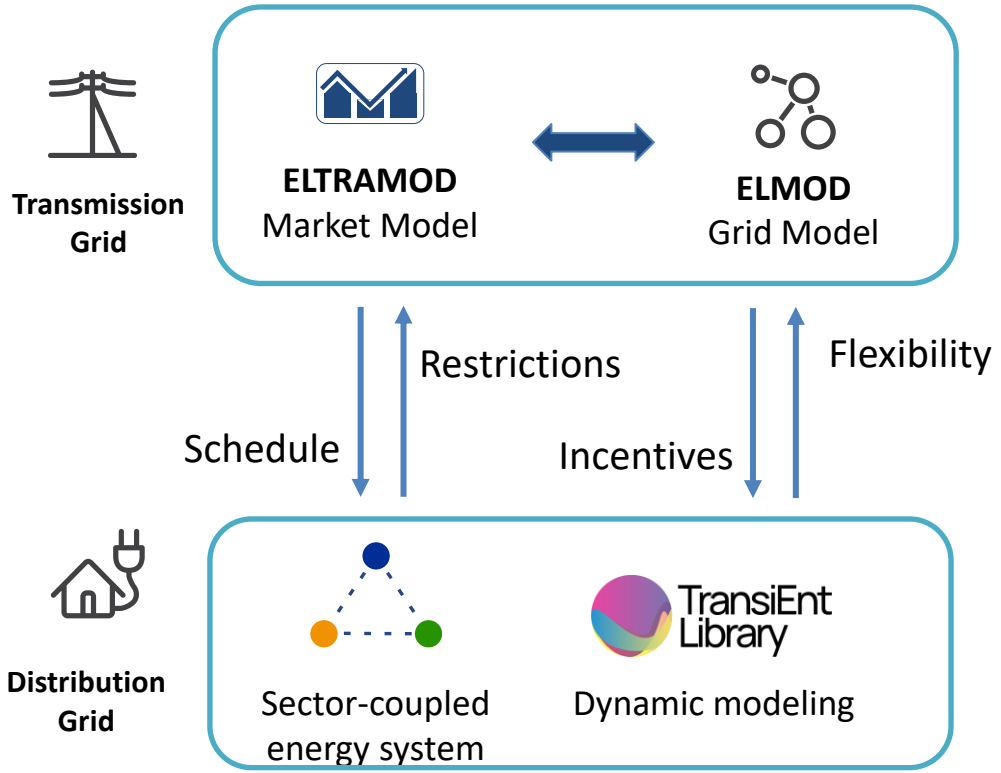
Objectives

- Evaluate interaction of **market mechanisms** and **physical system operational strategies** considering sustainability and resilience aspects
- Analysis of different **market based incentive schemes** for provision of **flexibility** by market relevant actors
- Development of **models and methodologies for optimization of the real-time operation**



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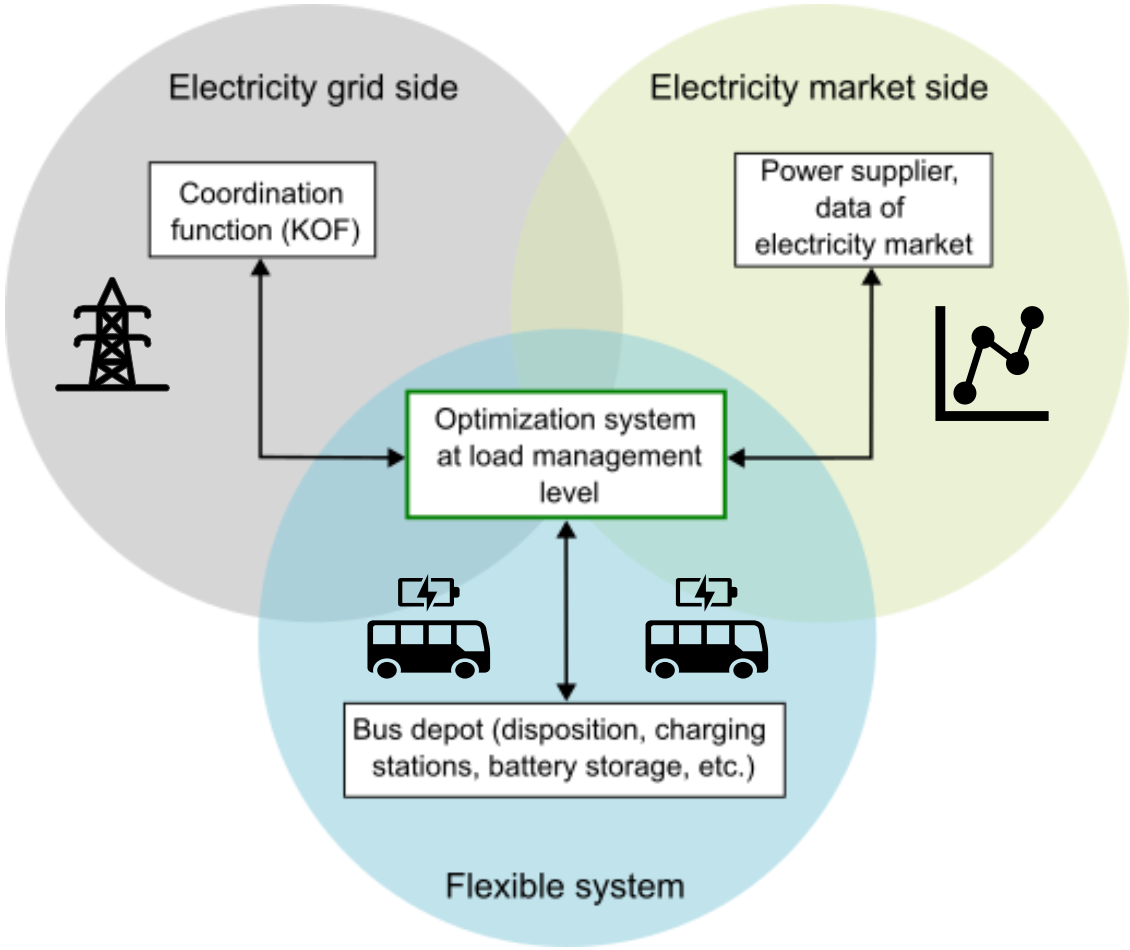
KoLa – Flexibility Coordination btw. Energy and Transport Sectors

Electrified Public Transport Use-case

2022-2026

- **Objectives**
  - Development of a **„coordination function“** to ensure grid stability while offering flexibilities
  - Optimal charging and **flexibility management** of electrified bus depot
  - Validation of overall system in **distributed laboratory setup** and in **field test**



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Laboratory setup „PHilLs Lab“

- Digital network simulator OPAL OP5707XG
- 3x four-quadrant amplifier 7.5 kVA Spitzenberger & Spies APS7500

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THANK YOU!

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