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Intelligente Netzsteuerung von morgen

CO-SIMULATING ELECTRIC GRID AND AGENT-BASED EV TRAFFIC/CHARGING USING HAMBURG AS AN EXAMPLE

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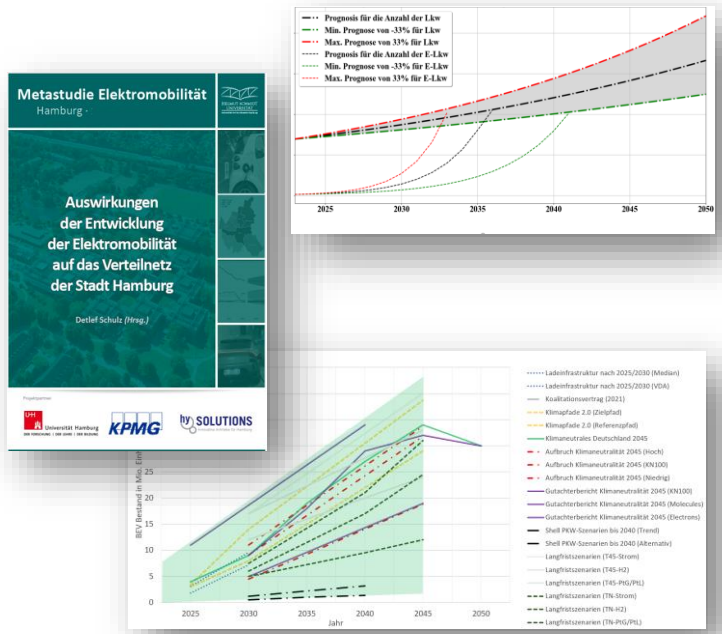
Finanziert von der
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Agenda

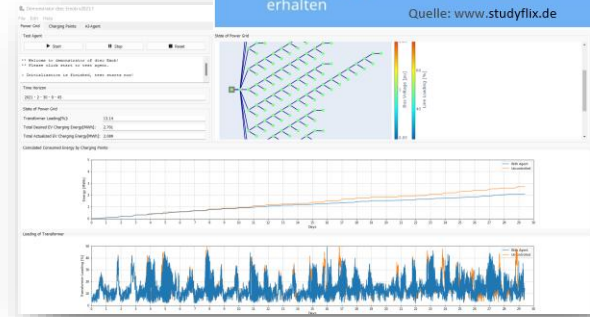
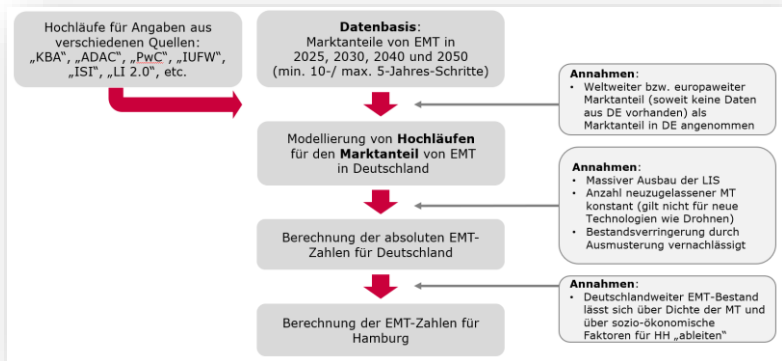
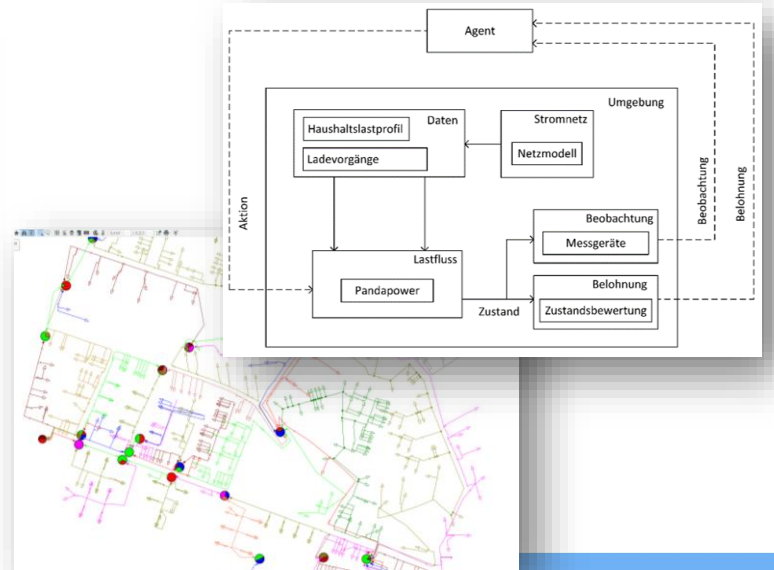
- Project
- Introduction
- Methodology
- Case Study – Hamburg
- Results
- Conclusion



1. Analysis of systems



2. Development of inelegant management systems

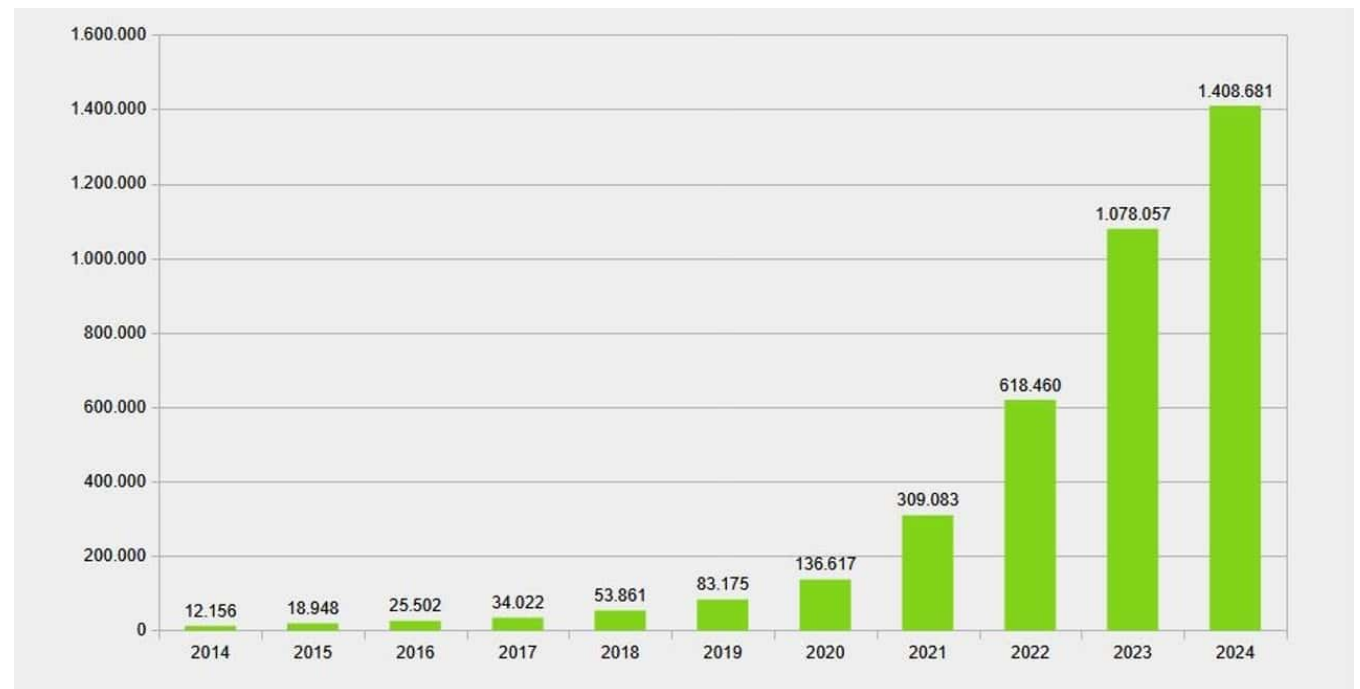


3. Real-life implementation and experiments



- Rising demand of electrical vehicle sales in Germany
- Electrical grid which is not designed for this amount of extra demand
- Distribution system operator (DSO) use worst case planning
 - Potential of oversupply
 - Extra costs for grid fees
- Simulation framework BEAM-pandapower-HELICS
- Case Study Hamburg

BEV-fleet in Germany



<https://cdn.motor1.com/images/mgl/Kb7b4R/s1/bev-bestand-in-deutschland.webp>

- The framework bridges the gap between agent-based mobility modelling and grid analysis
- It captures the influence between charging behaviour and grid stability.

BEAM

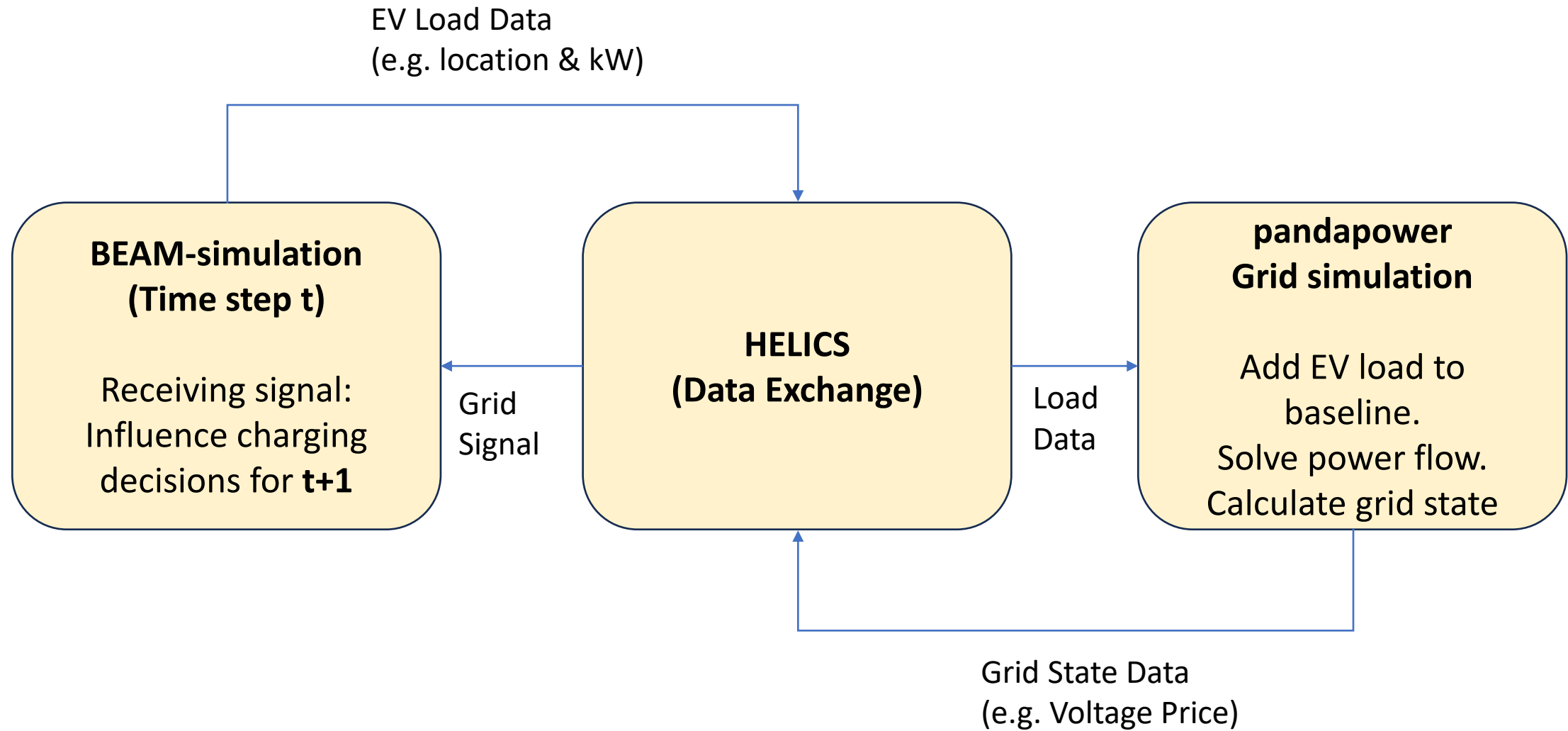
- Behaviour, Energy, Autonomy, and Mobility
 - Based on MATSim
- OpenStreetMap (OSM), OD-Matrix, Modal Split of Hamburg
- Simulation is activity based.
- Agents choose alternatives (routes, modes, charging times) that maximize their personal utility function

Pandapower

- modelling physical components like lines and transformers within distribution grid
- Quasi-Static Time Series analysis
- time-dependent coincidence of generation and demand
- The electrical dynamics (voltage settling) are instantaneous relative to the simulation time step

HELICS

- Hierarchical Engine for Large-scale Infrastructure Co-Simulation
- High-level orchestrator between BEAM and pandapower (separate simulators):
 - managing time-step synchronization
 - inter-process communication



1. Input Data and Population:

- MATSim Open Hamburg Scenario (“Digital Twin” of the region's mobility demand)
- Population:
 - Synthetic population with specific home location and a daily activity chain (e.g., Home → Work → Shop → Home).

2. Network:

- OpenStreetMap, a routing graph
- GTFS HVV Public Transport system for Hamburg

3. Cars:

- KBA data: around 801000 cars and 60000 EVs (BEVs and PHEVs)

4. Validation:

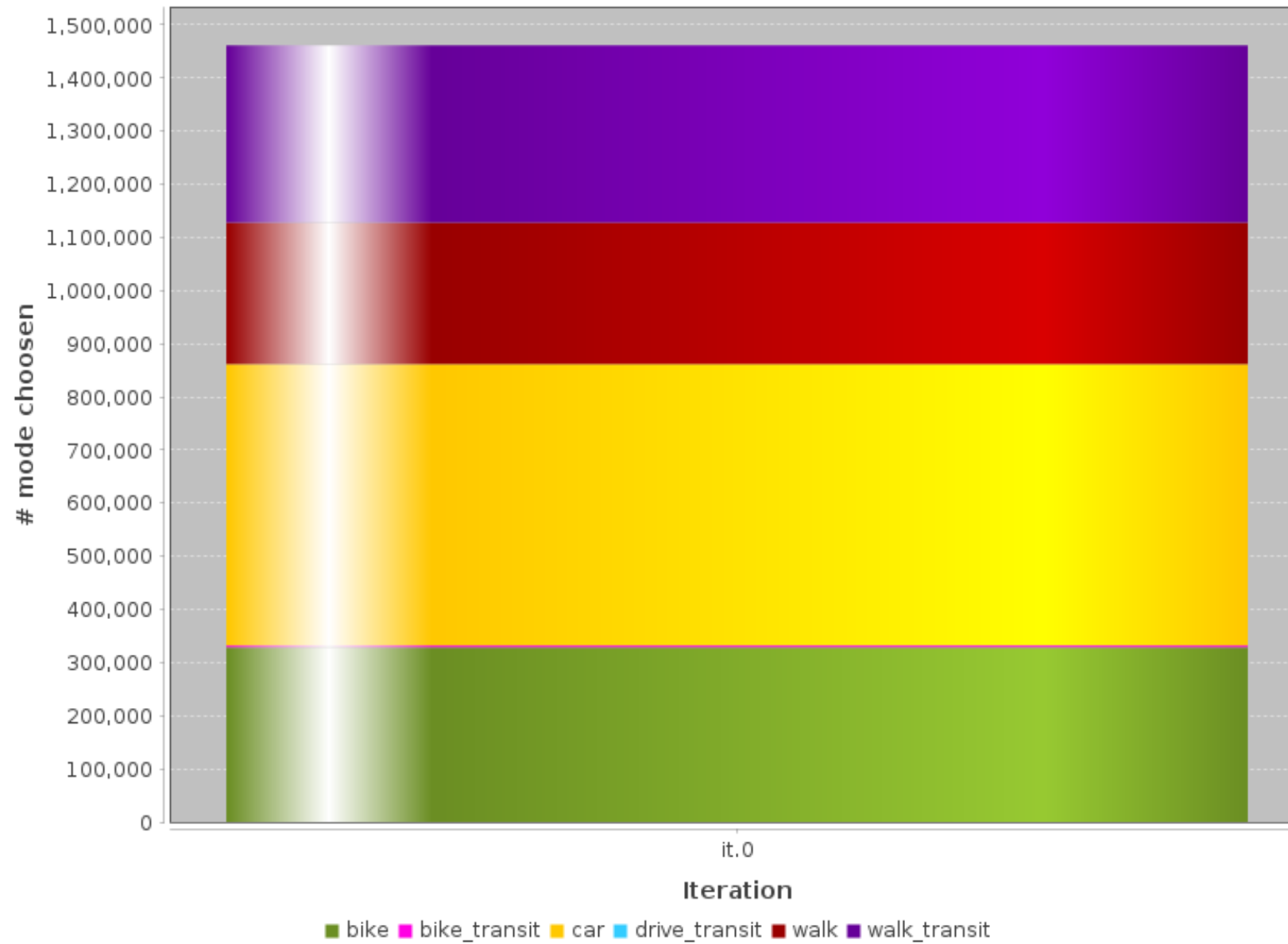
- Demand calibrated against "Mobilität in Hamburg 2022" survey

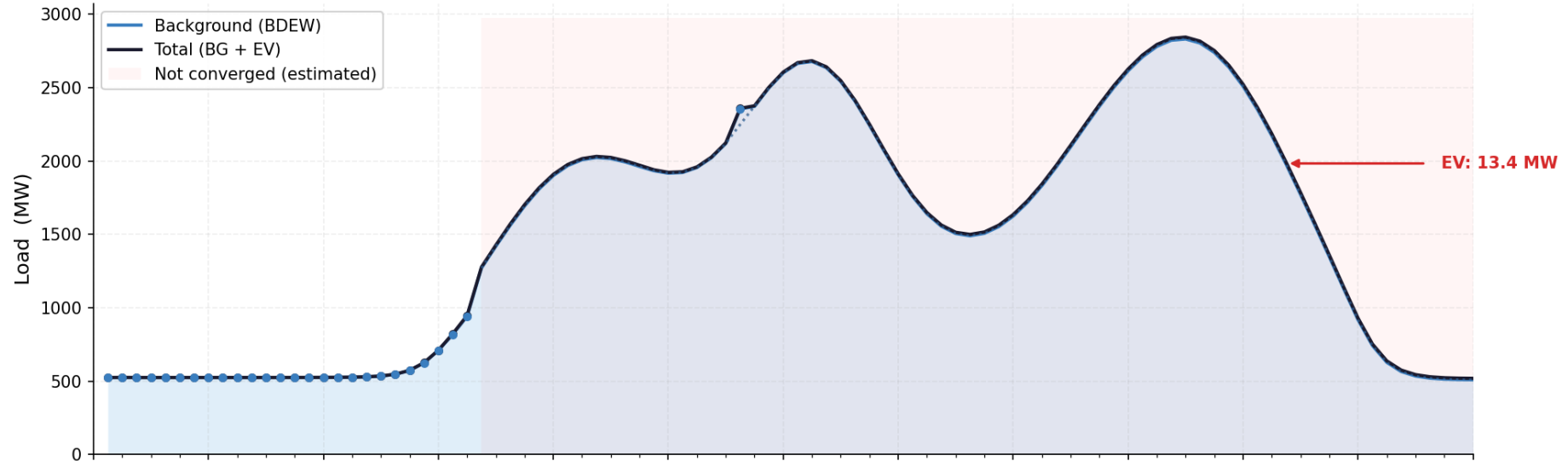
| Component | Count | Description |
|--------------|---------|---|
| Districts | 37 | MV grid, mapped to BEAM charging zone |
| Buses | 332,200 | Electrical nodes (connection points) at HV, MV, and LV levels |
| Loads | 225,103 | Households, commercial, industrial consumers |
| Transformers | 9,052 | Stepping voltage down (110kV → 20kV → 0.4kV) |
| Lines | 512,783 | Cables/overhead lines connecting buses |

| Description | Status quo calibration |
|----------------------|---|
| Key Variables | Current EV adoption (~5.4 %), current model split |
| Modal Split | Cars: 32% PT: 24% Bike: 22% Walk: 22% |

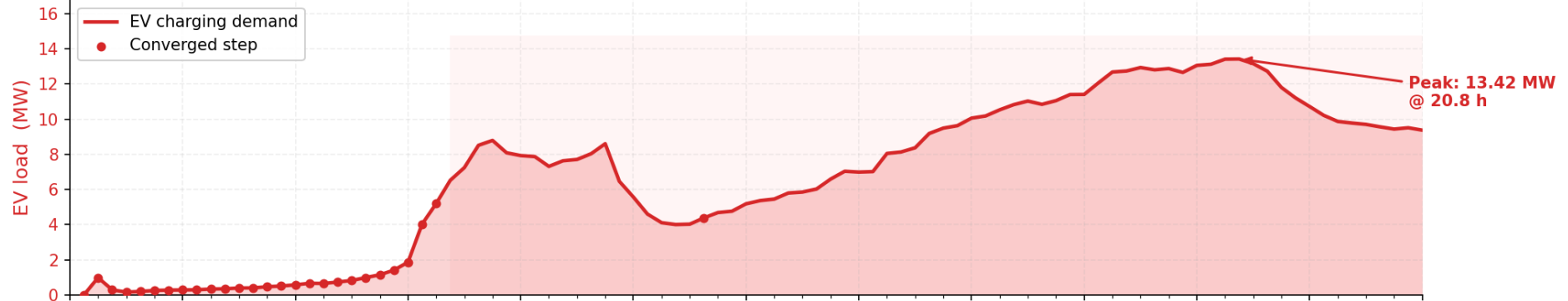
| | |
|------------------------------|---------------|
| EV battery cap | 60 kWh |
| Power consumption | 15 kWh/100 km |
| Charging | 11/50 kW |
| Public charging price | 0.3/0.6 €/kWh |

Mode Choice Histogram

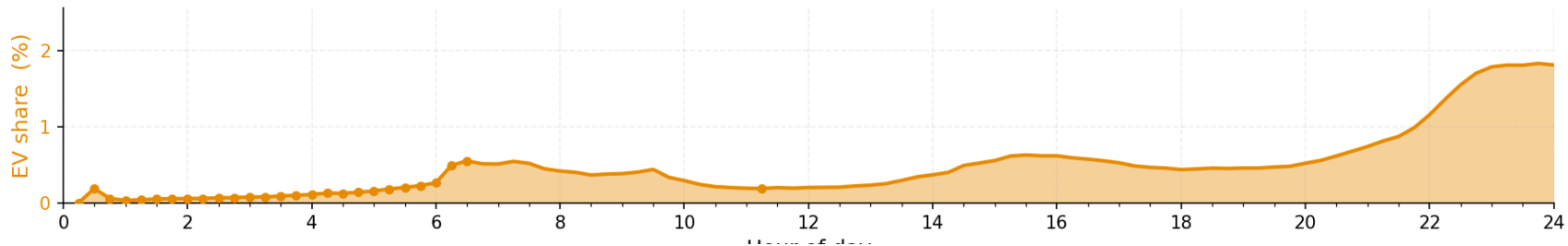




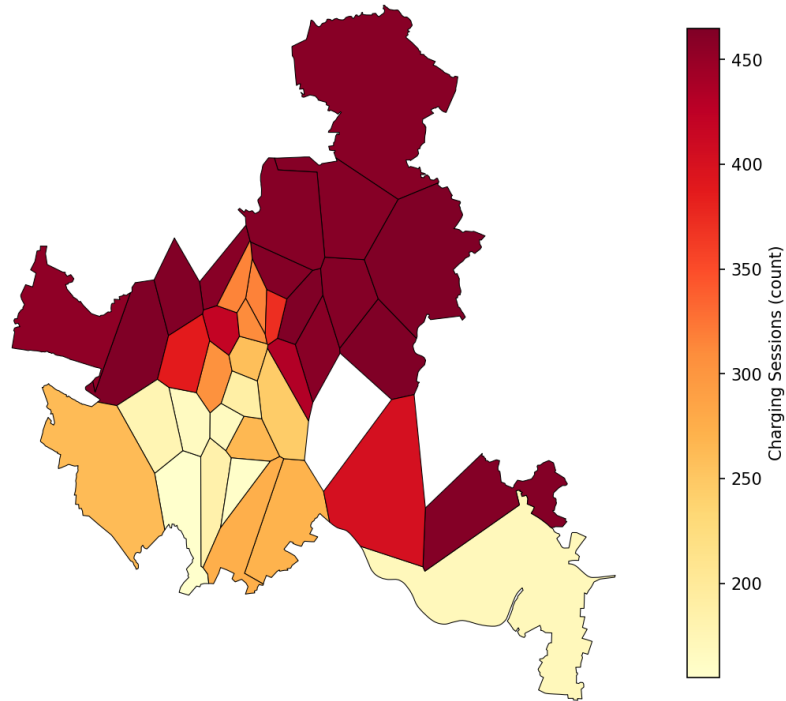
EV charging load (zoomed)



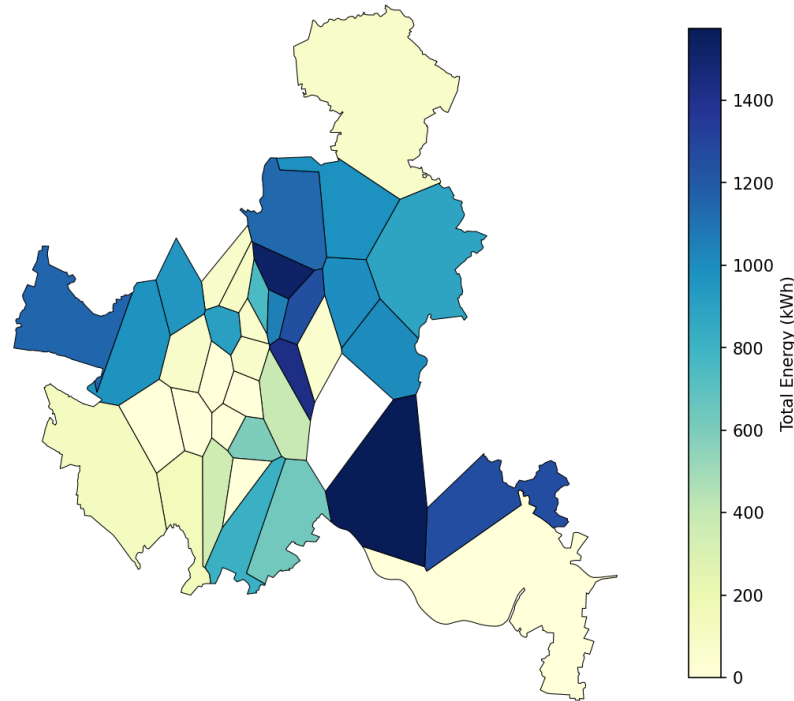
EV share of total load



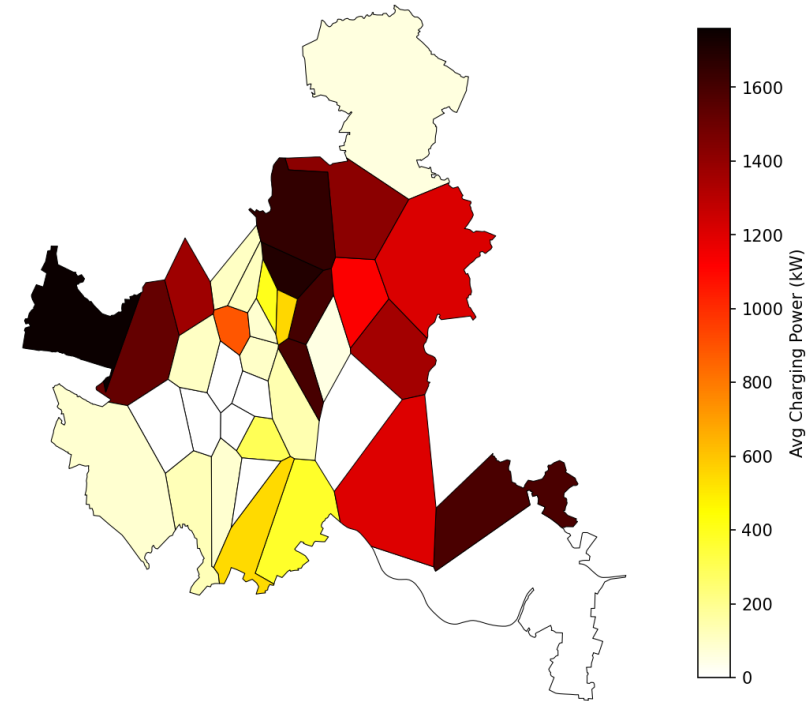
Charging sessions



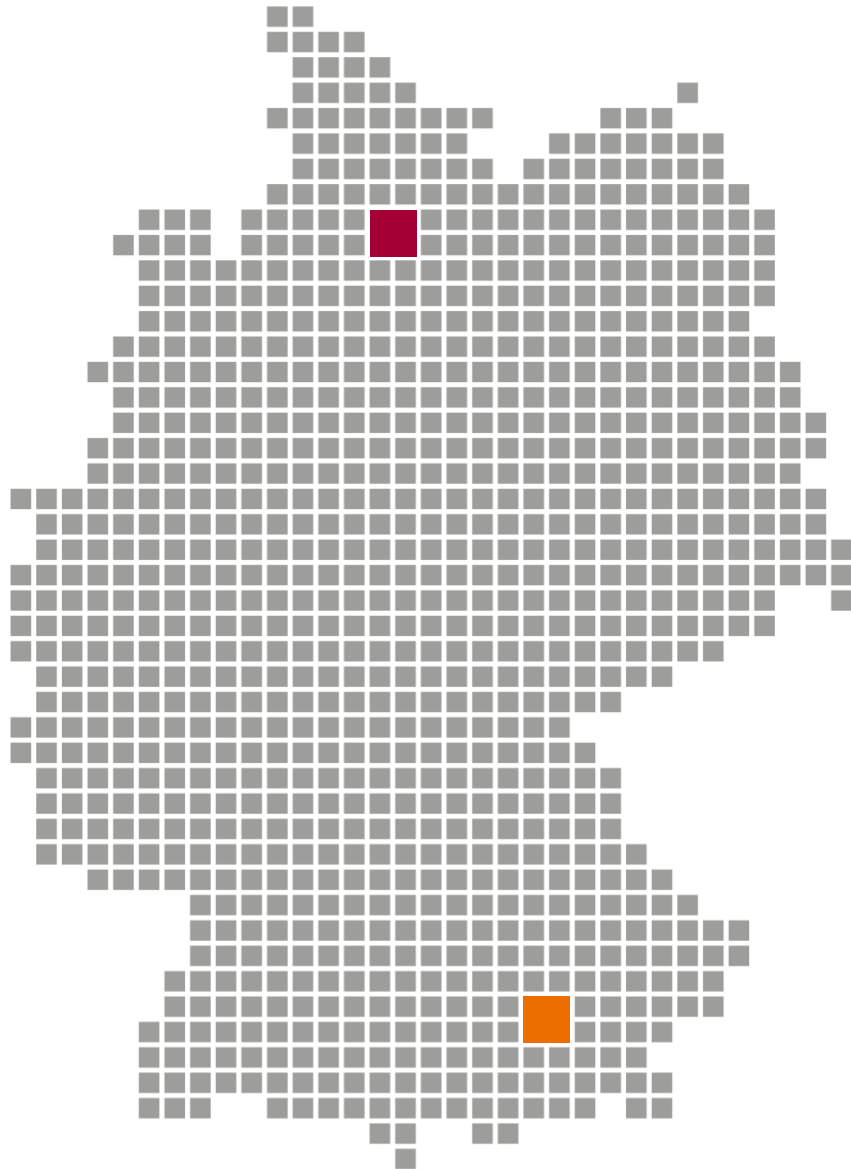
Total energy



Average load



1. Suggested co-simulation framework BEAM → HELICS ← pandapower works
2. Where and when “extra” load of EVs
 - Help to estimate the future grid expansion
3. Needs further work:
 - Stable synthetic grid
 - More gradual LV grid
 - Management measurements: e. g. variable grid fees
 - AI optimizations



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**Thank you for your
attention!**