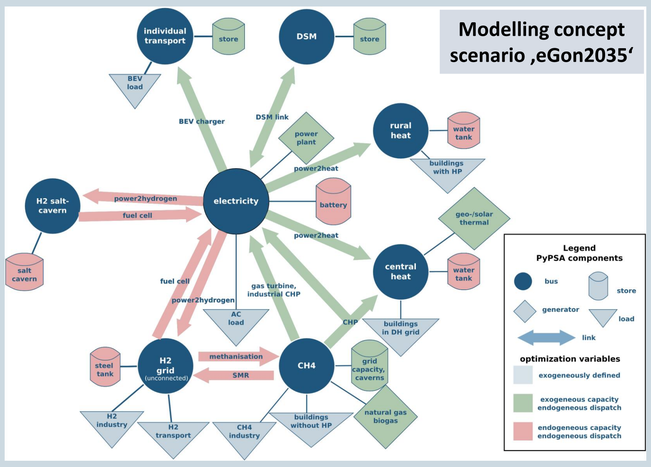
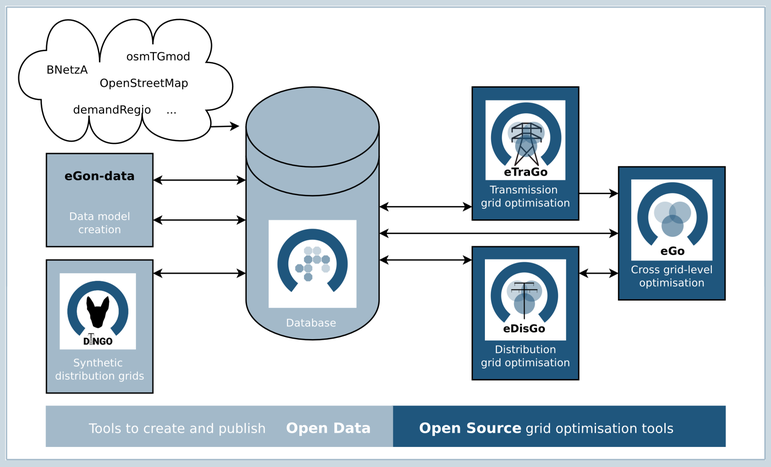
eGo^n

Open and cross-sectoral planning of transmission and distribution grids

Driven by the expansion of renewable generation capacity and the progressing electrification of other energy sectors, the electrical grid increasingly faces new challenges: **fluctuating supply of renewable energy** and simultaneously a **changing demand pattern** caused by **sector coupling**. However, the integration of non-electric sectors such as **gas**, **heat** and **e-mobility** enables **more flexibility options**. This project aims to investigate the effects of sector coupling on the electrical grid and the benefits of new flexibility options.





Basic project information

- **Project duration:** Dec 2019 – Jul 2023
- **Open-source** and **open-data-project**
- **Project partner:**
  - Flensburg University of Applied Sciences
  - Europa-Universität Flensburg
  - Reiner Lemoine Institute
  - German Aerospace Center (DLR) - Institute of Networked Energy Systems
  - Otto von Guericke University Magdeburg
  - Fraunhofer Institute for Energy Economics and Energy System Technology
- **Funded by Federal Ministry for Economics and Climate Action**
- **Website:** ego-n.org

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Workflow Management

egon-data retrieves and processes data from several different external input sources which are all freely available and published under an open data license. The process handles data with different data types, such as spatial data with a high geographical resolution or load/generation time series with an hourly resolution.
The workflow is composed of four different sections: database setup, data import, data processing and data export to the **OpenEnergy Platform**[1]. Each section consists of different tasks, which are managed by *Apache Airflow*[2] and correspond with the local database.

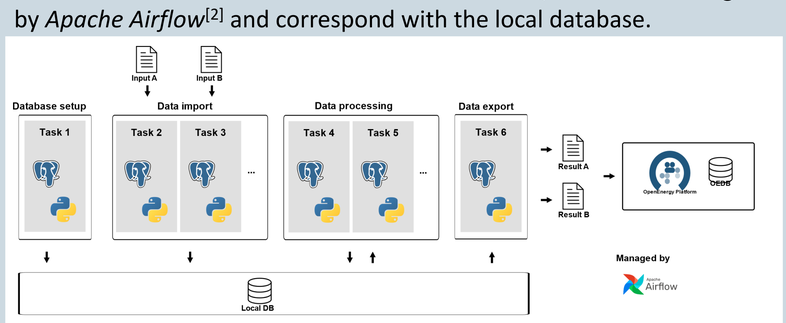


Figure 1: Execution of workflow to create open-data model of the German energy system

Scenarios

eGon2035

This scenario is based on the network expansion plan (NEP[3]), scenario C2035 which is characterized by a high penetration of sector-coupling flexibility options. Information on foreign countries origin in the TYNDP 2020[4], scenario distributed energy.

eGon100RE

This scenario depicts a scenario with 100% renewable generation. *PyPSA-Eur-Sec*[3] has been used as scenario generator.

Supply

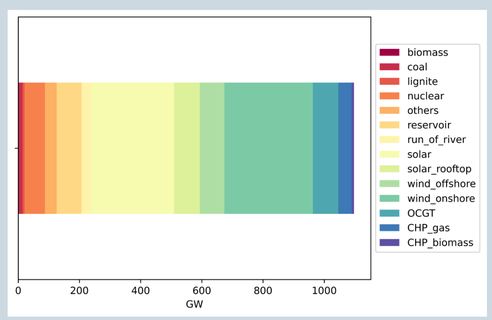


Figure 2: Installed capacity of electrical supply in Germany in ***eGon2035***

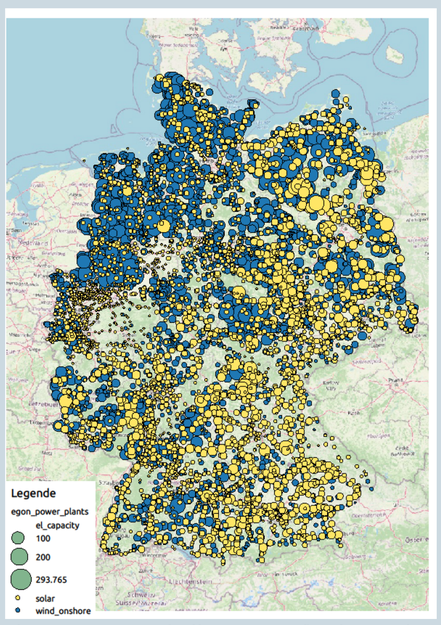


Figure 3: Spatial allocation of solar and wind onshore generation in Germany in ***eGon2035***

The national capacities for electrical supply depicted in **figure 2** are taken from the network expansion plan (NEP[3]), scenario C2035 and spatially allocated. Therefore, potential areas for the placement of renewable power plants (e.g. wind turbines onshore) are considered.
Natural gas and Biogas potentials are attached to the corresponding methane buses.
Heat is supplied by electricty (heat pumps and resistive heater), by gas (boilers and CHP) and by direct renewable heat generation (solar- and geothermal plants).

Demand

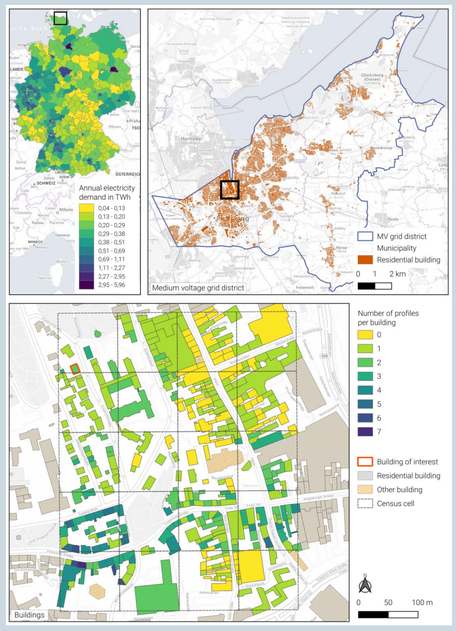


Figure 4: Demand in different aggregation levels

The electricity demand covers residental, service and industry sector. Heat demand comprises space heating and drinking hot water of private households and the service sector. The creation of residental electricity and heat demand time series is described in detail in *Büttner et al.*[6]. Industrial demands are divided into hydrogen and methane demands. Additionally, transport demands considering motorized individual travel and heavy-duty transport are depicted.

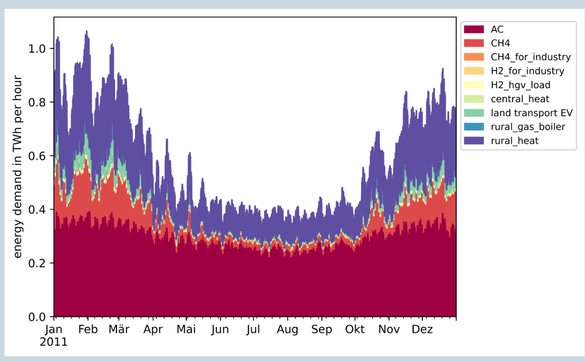


Figure 5: Spatially aggregated load time series for Germany in ***eGon2035***

Grid Topologies

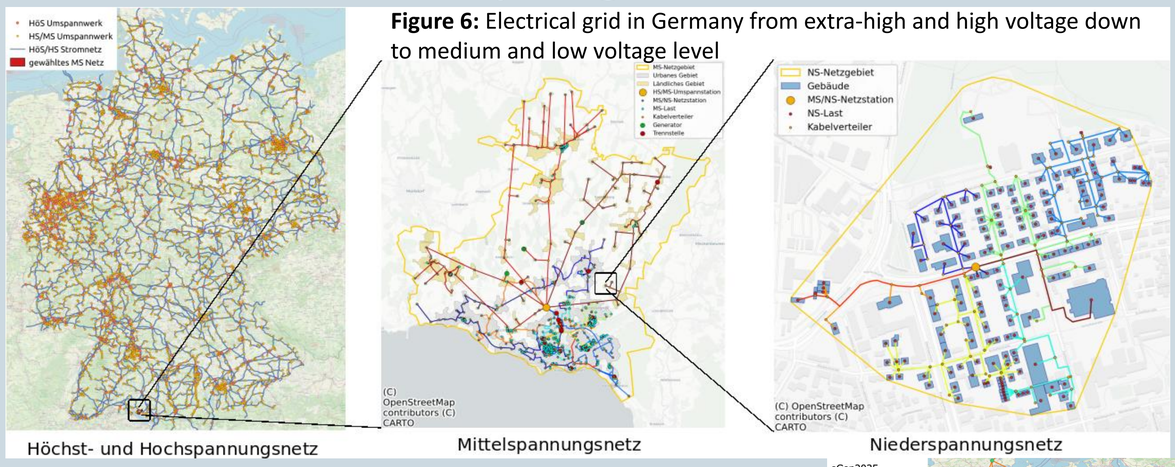


Figure 6: Electrical grid in Germany from extra-high and high voltage down to medium and low voltage level

The model depicts the German electricity grid from extra-high and high voltage down to medium and low voltage level. The topology of the higher voltage levels is extracted from *OpenStreetMap*[7] using *osmTGmod*[8] whereas the topologies of grids in the lower levels are generated using ***ding0***, a tool to generate synthetic power distribution grids based on open data containing information on geographical conditions and historical background.

In the ***eGon2035*** scenario, a CH4-grid [9] is considered which can not be extended (**figure 6**), whereas in the ***eGon100RE*** scenario a CH4-grid with a retrofit to a additional H2-grid is considered where the H2-grid includes potential to being extended.

Figure 7: Gas grid in Germany

Flexibilities

Demand Side Management

- potential comprises shifting of loads within the sectors of industry and CTS
- loads eligible to be shifted mainly derive from heating and cooling processes and selected energy-intensive industrial processes
- flexible shares are identified considering technical and sociotechnical potentials using the parametrization elaborated in *Heitkötter et al.*[10]

Dynamic Line Rating

- capacities of overhead transmission lines fluctuate between 100% and 150% of their nominal values
- depending on current weather data: solar radiation, wind speed and temperature

Storages

- battery storages, heat stores and hydrogen stores as extendable flexibility option

E-Mobility

- hourly travel and charging profiles for motorized individual travel are generated with *SimBEV* [11] using a stochastic approach based upon data from *"Mobilität in Deutschland"* [12].
- generation of a pool of electric vehicles (EV) profiles and random selection of profiles corresponding to the number of EVs within the medium voltage grids
- base state-of-charge and flexibility time series per medium voltage grid derived from profiles considering several constraints

Sector-Coupling Technologies

- sector-coupling technologies getting optimized in dispatch and capacity: fuel cells, electrolyzers, methanisation, Steam Methane Reformation

References:

[1] OpenEnergy Platform: https://openenergy-platform.org/
[2] *Apache Airflow*: https://airflow.apache.org/
[3] Übertragungsnetzbetreiber: *Netzentwicklungsplan Strom 2035, Version 2021, 1. Entwurf*. 2021.
[4] *PyPSA-Eur-Sec*: https://pypsa-eur-sec.readthedocs.io/en/latest/
[5] entso-e and ensto-g*: TYNDP 2020 Scenario Report*. 2020.
[6] Büttner et al.: *Open modeling of electricity and heat demand curves for all residential buildings in Germany*. 2022.
[7] Geofabrik GmbH and OpenStreetMap-Mitwirkende: *OpenStreetMap Data Extracts, Stand 01.01.2021*. 2021
[8] *osmTGmod*: https://github.com/wupperinst/osmTGmod
[9] Pluta et al.: *SciGRID_gas - Data Model of the European Gas Transport Network*. 2022.
[10] Heitkötter et al.: *Assessment of the regionalised demand response potential in Germany using an open source tool and dataset*. 2021.
[11] *SimBEV:* https://github.com/rl-institut/simbev
[12] Bundesministerium für Digitales und Verkehr: *Mobilität in Deutschland 2017*. 2017.

Github-Seite des Tools **eGon-data**:
GitHub - openego/eGon-data

Authors: eGon development team