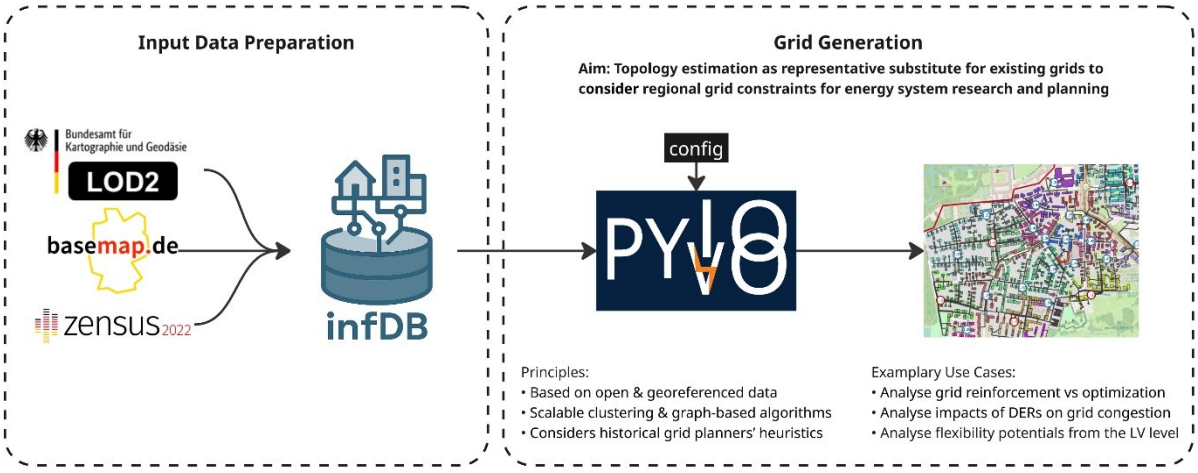
Chair of Renewable and Sustainable Energy Systems
Department of Electrical and Computer Engineering
Technical University of Munich

Master's Thesis

Validation and Enhancement of Synthetic Low-Voltage Grid Models

Background

The rapid electrification of heating and mobility is expected to push existing low-voltage (LV) distribution grids beyond their originally planned operating conditions. Accurate models of LV networks are needed for planning and optimizing grid transformations; however, detailed data on LV grids is often incomplete or unavailable. To bridge this gap, an open-data-based tool called pylovo was developed at our chair to generate synthetic LV distribution grid models from public data sources. Pylovo utilizes geographic open datasets (e.g. buildings, roads, transformer locations) and applies clustering algorithms and graph-based heuristics to mimic DSO planning principles. This approach can efficiently produce realistic feeder topologies and network parameters at large scales using a PostgreSQL/PostGIS backend and Python integration. Despite these advances, ensuring that synthetic networks faithfully represent real grid behavior remains a challenge. Validation and calibration of the generated grids are necessary to improve their realism. Building on previous validation frameworks, the next step is to systematically validate pylovo's synthetic grid models using real distribution system operator (DSO) network data and to enhance the tool's analysis functions for greater automation and accuracy.



Objective:

The goal of this Master's thesis is to extend and refine the pylovo tool's analysis and validation capabilities for low-voltage grids. This involves implementing automated validation metrics and comparison functions in pylovo to assess how closely synthetic grids resemble actual DSO networks. Using real grid data from two selected regions as benchmarks, the student will validate and calibrate the synthetic grid models, improving their accuracy. Ultimately, the thesis aims to enable more robust evaluation of synthetic LV grids and to enhance their realism by adjusting generation algorithms based on empirical findings. This includes performing power flow simulations to identify performance limits and optionally suggesting a method to classify grid states (using a "Netz-Ampel" traffic-light scheme).

Work Packages:

- WP1: Literature & Tool Familiarization – Review relevant literature and prior work on synthetic grid validation and get familiar with the pylovo codebase.
- WP2: Validation Function Enhancement – Develop and implement enhanced validation functions within pylovo including statistical and operational metrics.
- WP3: Validate & Calibrate with Real DSO Data – Compare pylovo-generated synthetic grids with DSO data based on chosen metrics in two case study regions and calibrate the pylovo algorithms.
- WP4: Hosting Capacity & Congestion Analysis – Perform pandapower-based power flow simulations to assess hosting capacity and congestion in cables and transformers.
- WP5 (optional depending on progress): “Netz-Ampel” Classification Method – Develop a traffic-light-based classification system to interpret operational grid states and identify capacity constraints.

Requirements:

- Strong programming and data analysis skills (Python)
- Basic SQL (PostgreSQL, PostGIS) knowledge
- Familiarity with power system analysis (pandapower experience is a plus)
- Interest in open data, power distribution grids, and modeling/simulation
- Independent and analytical working style

Learning Outcomes:

- Be part and contribute to a relevant project funded by the BMWE
- Improve your skills with python/PostgreSQL
- Get a deep understanding of real grid structures and validation methods
- Optional: Be part of and learn how to write a scientific paper in a prestigious journal

Contact

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