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Benchmarking Forecast Modelling Algorithms of Grid Dynamic Data using a Benchmark European Transmission Grid Model

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Introduction and Motivation

Introduction:

To ensure the security and stability of the power flows across Transmission System Operators (TSOs) in Europe, the European union established the regulatory framework that led to the creation of the Regional Coordination Centres (RCCs) in 2022 [1]. RCCs provides services such as grid security analysis, capacity calculations and optimization studies for TSOs [2] that relay on simulated power flow computations of merged transmission grid models – know as the common grid models (CGMs), to optimize for grid scenarios that could occur during real-time operation.

Motivation:

These simulations are computed using forecast grid models that represent real-time grid situation for the forecast timeframes. Ensuring the accuracy of the forecast grid models, compared to real-time snap shot (RTSN) grid stuation is vital for the security and stability of TSOs real-time grid operation [3]. Our work aims to improve the service quality, and reproducibility of RCC's services by developing a benchmark electrical grid network model framework using anonymized actual TSO topology data, with the forecast grid model accuracy benchmarked against the RTSN, using accuracy metrics that maximizes grid security and social welfare gains; with assumed correlation to the dynamic grid data forecast model algorithms.

Key Words:

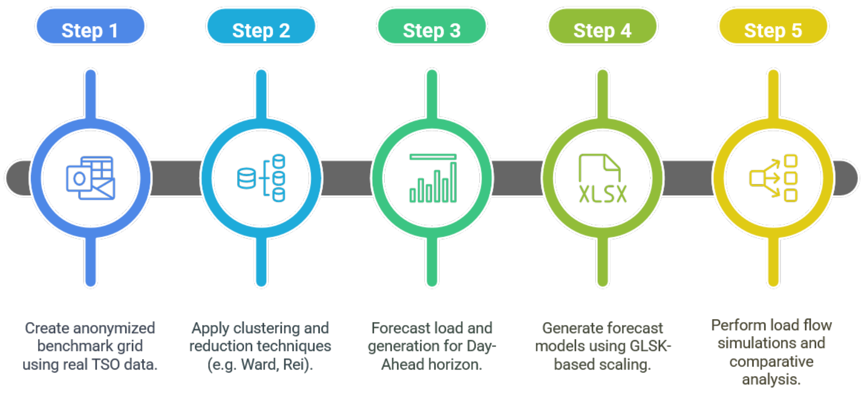
Forecast, Grid Security Analysis, Power Flow Calculation, Benchmark Grid Models.

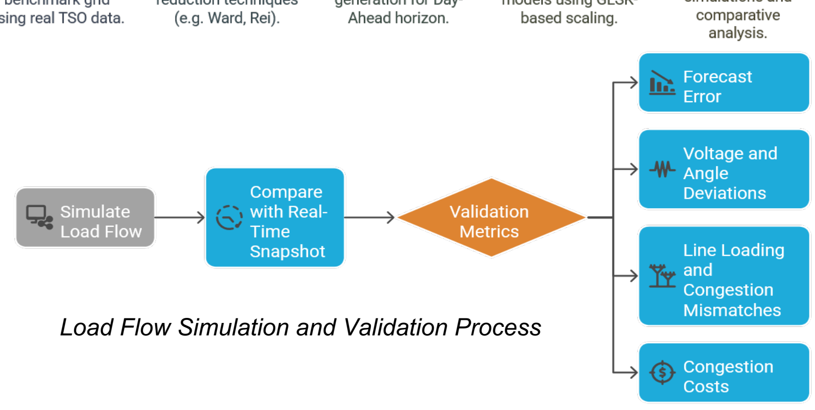
Objectives and Methodology

Objective:

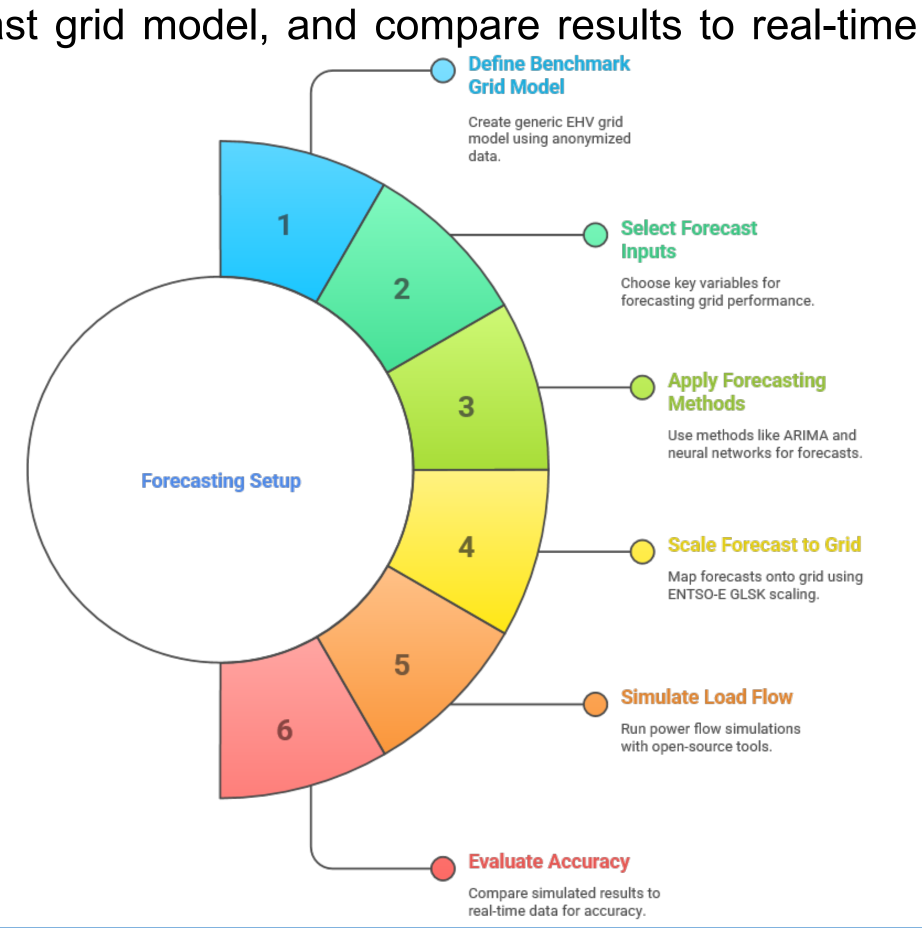
Develop a generic benchmark transmission grid model, based on actual TSO electrical grid topology data. Create a "Day-Ahead" forecast grid models of the benchmark grid using various algorithms, simulate power flows on the forecast grid model, and compare results to real-time grid data using defined accuracy metrics.

Methodology:





Load Flow Simulation and Validation Process



Results: Forecast Grid Model Accuracy Assessments

Existing Grid Model Net Position Forecast (NPF) Methodologies and Accuracy Benchmarking using the Realised Market NP. Accuracy Methodology:

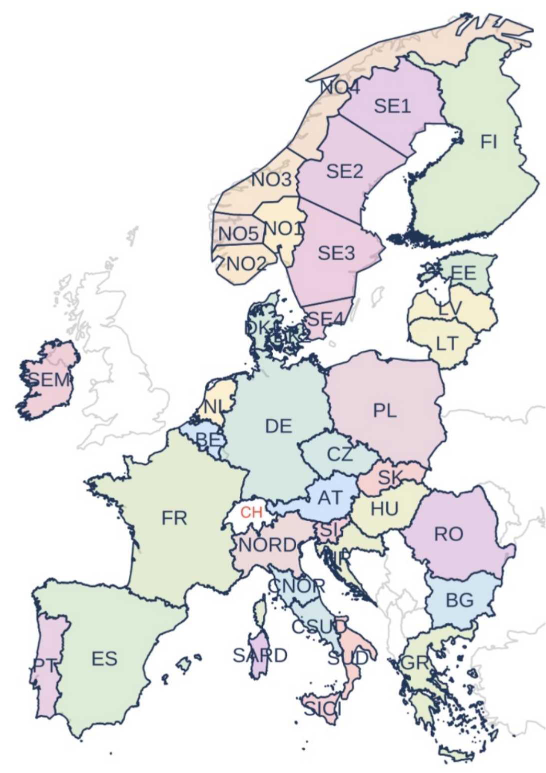
- Aggregating result data over domain space to calculate the **Euclidean Distance**: by comparing two sets of net positions $X_{forecast}$ and the $X_{reference}$ (Realised NP)
- Aggregating over time (4 years data): The aggregation of the calculated distance using the **mean absolute error** and the **root mean square error in MW**
- **Forecast timeframes:** D-1, D-2, and D-7 NPFs compared to Realised NP – including the Day-Ahead control block bidding zone areas from the ENTSO-E verification platform.

Error aggregation	Reference D-7 (Week-Ahead)	Reference D-2 (Day-Ahead)	RCC's D-1 Forecast
Total RMSE	8033,32	7000,87	2382,29
Total MAE	8691,69	7678,67	2553,23

Implemented PoC: Net Position Forecast of Week-Ahead and Day-Ahead Common Grid Models [3]. PoC Methodology:

Eq -1: $\sum NPF_{country} = Gen - Load - Losses = \sum_{country-borders} Exch_{country-border}$

- Identify model study area and relevant bidding zones
- Train ML models to forecast the load and generation of the study area and relevant bidding zones using defined historical influence factors (IFs)
- Predict the load and generation of study area and relevant bidding zones using trained models with forecast IFs parameters
- Scale the forecast load and generation proportionally to the active component of the reference CGM and adjust the reactive components with respect to the active power and generation.
- Compute the NPF by running a load flow on the adjusted forecast model.



EU bidding cones (incl. Norway & Switzerland) [3]

Conclusion and Outlook

Forecast model algorithms optimized for different Transmission System Operation's RCC services: starting with Day-Ahead & Week-Ahead use cases

NPF PoC results from [3] successfully performed DC LFC in PowerFactory for 86 Adjusted CGMs. Adjusted CGMs had significant imbalance LIKELY due to the scaling methodology applied.

Future work:

Extending to intraday & long term forecast timeframes. Expanding to more forecast model algorithms and using open-source load flow engines.

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1 EU Regulation establishing guideline for electricity Transmission System Operation: Commission Regulation (EU) 2017/1485 - link

2 Clean energy package (CEP) regulation (EU) 2019/943 - https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943

3 D. C. Abonyi, *"Net Position Forecast of Week-Ahead and Day-Ahead Common Grid Models"* M.S. thesis, Dept. of Electrical and Computer Eng., TUM, Munich, BY, 2023.