

Project Title: Data-driven Network Reduction for Electrical Distribution Networks for TSO-DSO Coordination

Project Type: Master's Thesis or Semester Project

Project Description: The increasing penetration of distributed energy resources (DERs), electric vehicles, and flexible loads is creating new challenges for the coordination between Transmission System Operators (TSOs) and Distribution System Operators (DSOs). Detailed distribution network models are often too large and computationally expensive for system-level studies and real-time coordination. This project aims to develop data-driven techniques for reducing the complexity of electrical distribution network models while preserving the key operational characteristics required for TSO-DSO interactions.

The student will investigate and implement network reduction methodologies based on historical measurements, power flow data, and machine learning/statistical techniques [1]. The resulting reduced-order models will be evaluated for their accuracy, computational efficiency, and suitability in applications such as congestion management, flexibility assessment, and voltage stability analysis.

Key tasks during the project:

- Conduct a literature review on power system network reduction and TSO-DSO coordination.
- Develop data-driven network reduction methodologies using statistical learning and optimization techniques.
- Implement and validate reduced network models using power system simulation tools.
- Compare different reduction approaches based on accuracy and computational performance.
- Assess the impact of reduced models on operational studies and TSO-DSO coordination use cases.

Useful skills software:

- Power systems fundamentals and power flow analysis.
- Programming in Python (NumPy, Pandas, Scikit-learn, PyTorch/TensorFlow is a plus).
- Optimization and machine learning techniques.
- Experience with power system analysis tools such as Pandapower, MATPOWER, PyPSA, DlgSILENT PowerFactory, or OpenDSS.
- Data analysis and visualization.
- Familiarity with Git and scientific computing workflows.

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Reference:

[1] Taheri, Babak, Rahul K. Gupta, and Daniel K. Molzahn. "Optimizing parameters of the Lindistflow power flow approximation for distribution systems." *IEEE Transactions on Smart Grid* (2025).