System Imbalance Forecasting

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Project description

Power systems are evolving in response to the growing integration of variable renewable resources. Therefore, maintaining the continuous balance between generation and demand becomes more important. In power system operation, deviations between planned production and actual consumption occur due to factors such as incorrect forecasts or unplanned variations. These deviations cause *system imbalance*, leading to frequency fluctuations, which the Transmission System Operator (TSO) must correct in real-time to ensure system stability.

The objective of this project is to develop a machine learning model that can forecast the volume of system imbalance shortly before it happens, e.g., within a forecasting window ranging from one hour to several hours ahead of real-time operation, allowing the TSO to take protective measures by activating the corresponding volume to compensate for the imbalance.

The scope of the project therefore consists of the following steps:

1. Data collection and preprocessing (see section below on *Useful datasets*).
2. Feature selection for identifying relevant features for prediction.
3. Select an appropriate machine learning method for forecasting system imbalance.
4. Tune relevant hyperparameters.
5. Train and test the model to evaluate its predictive accuracy.

To support this, the references listed below provide examples of forecasting models used in a similar context and can help guide the choice of approach.

Objective:

The expected deliverable is a short-term forecast of system imbalance volumes.

References:

[1] P. F. Austnes, S. Riemer-Sørensen, D. A. Bordvik, and C. A. Andresen, “Balancing the Norwegian regulated power market anno 2016 to 2022,” *Energy Strategy Reviews*, vol. 52, p. 101331, Mar. 2024, doi: 10.1016/j.esr.2024.101331.

[2] K. De Vos, N. Stevens, O. Devolder, A. Papavasiliou, B. Hebb, and J. Matthys-Donnadieu, “Dynamic dimensioning approach for operating reserves: Proof of concept in Belgium,” *Energy Policy*, vol. 124, pp. 272–285, Jan. 2019, doi: 10.1016/j.enpol.2018.09.031.

[3] T. S. Salem, K. Kathuria, H. Ramampiaro, and H. Langseth, “Forecasting Intra-Hour Imbalances in Electric Power Systems,” Feb. 01, 2019, *arXiv*: arXiv:1902.00563. doi: 10.48550/arXiv.1902.00563.

[4] J.-F. Toubeau, J. Bottieau, Y. Wang, and F. Vallee, “Interpretable Probabilistic Forecasting of Imbalances in Renewable-Dominated Electricity Systems,” *IEEE Trans. Sustain. Energy*, vol. 13, no. 2, pp. 1267–1277, Apr. 2022, doi: 10.1109/TSTE.2021.3092137.

Useful datasets:

- Open-source data from the European Transparency Platform: https://transparency.entsoe.eu/dashboard/show
- Open-source data from Fingrid: https://www.fingrid.fi/en/
- Open-source data from Svenska Kraftnät: https://mimer.svk.se/