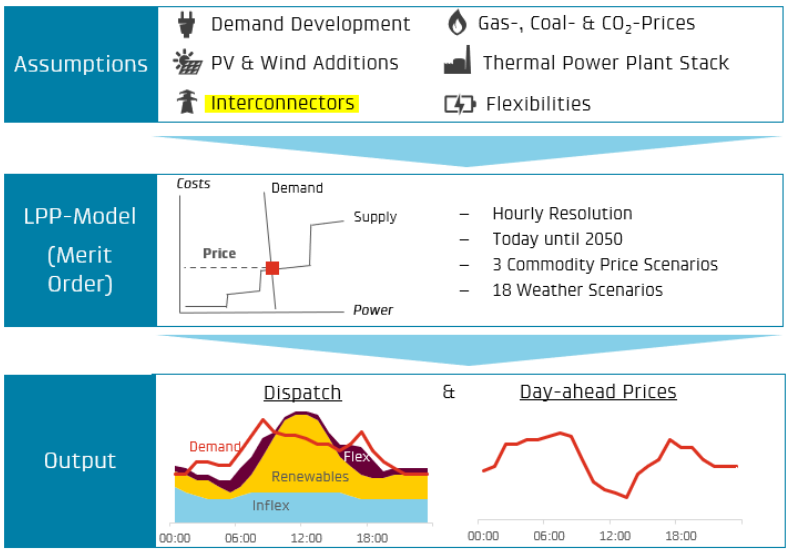
Semester Thesis Proposal - Spring Semester 2025

1 Background

The Strategic Market Analysis Team at BKW Energie AG is responsible for long-term electricity price forecasts within the Group. To this end, the team operates a fundamental model for the countries of Europe. The resulting price curves are used, among other things, for the valuation of BKW power plants in the corporate balance sheet and for the assessment of new business cases in the energy transition. The model solves an optimisation problem based on the merit order curve and thus delivers hourly electricity day-ahead prices up to 2050. To make this possible, assumptions and upstream models are required to generate the inputs needed for the main model run. In addition to the expansion plans for renewables and the expected development of electricity demand, transmission capacities play a very important role in pricing. These cross-border lines are often simply referred to as interconnectors. The interconnector capacities determine the maximum amount of electricity that can flow from one bidding zone to another in one hour and therefore have a major impact on absolute prices and price spreads among countries.



At present, grid bottlenecks very often mean that the physically available cross-border capacities in the electricity grid cannot be fully utilised. Particularly in the case of extreme feed-ins from renewables, cross-border capacities often must be significantly reduced. However, maintenance and outages of grid elements also play a major role. These restrictions on transmission capacities are implemented by the transmission system operators (TSOs), who are responsible for N-1 grid stability in the respective country. To determine these grid restrictions, the TSOs carry out complex calculations with detailed physical grid models. The Strategic Market Analysis team does not currently have such physical grid models and is not endeavouring to do so. However, improving the modelling of hourly transmission capacity profiles is of great importance. This is where this project comes in: instead of building a physical grid model, a machine learning model is to be developed that can predict the hourly transmission capacities of the relevant borders in the European power grid.

2 Project Goal

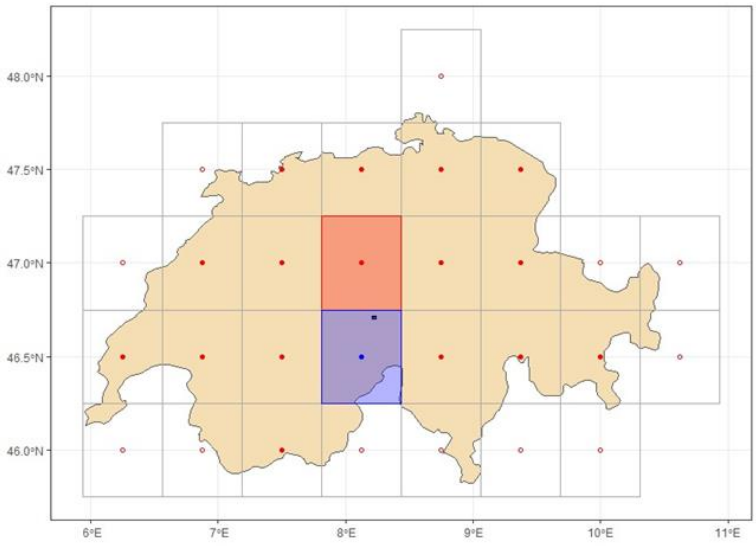
The project has the following objectives:

- Developing an understanding of the relationship between potential input variables and the target variable "maximum cross-border transmission capacity" on different borders
- Training data cleansing and potential addition of further relevant time series
- Development of a machine learning model for the prediction of hourly transmission capacities at relevant borders in the European electricity system
- Detailed explanations of model performance quality on the selected historical test data set
- Application of the model to the future
    - How will the transmission capacity profiles change in the context of climate change, the energy transition and grid expansion in Europe?
    - According to the model, what steps would make sense to avoid future restrictions on cross-border transmission capacity as far as possible?

3 Methodology

- Data analysis
    - BKW offers access to a wide range of fundamental data
        - weather data (from Nasa Merra2 data set, ~50x50km grid size)
            - precipitation
            - temperature
            - wind speed
            - solar irradiance

Nasa Merra2 Grid Cells for Switzerland

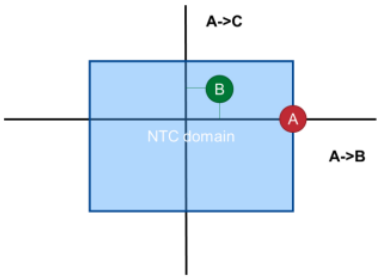


- grid element outages and maintenances
- power plant outages and maintenances
- conventional electricity demand in individual zones
- renewable feed-in volumes
- installed power production capacities per technology and country
- …

- Border type differentiation
  - There are two different types of borders in the current European electricity system. Certain countries and zones are located in the so-called flow-based market coupling area, while other countries are not and therefore use so-called net transfer capacities (NTCs). Flow based market coupling (FBMC) gives a potentially better utilization of the power grid because it to a greater extent accounts for the physical properties of the grid. More and more countries and regions are joining the FBMC zone. For example, the Nordic countries (Denmark, Finland, Norway, Sweden) are planning to switch to an FBMC approach at the end of this year. It is therefore important that the machine learning model developed can handle both types of borders.

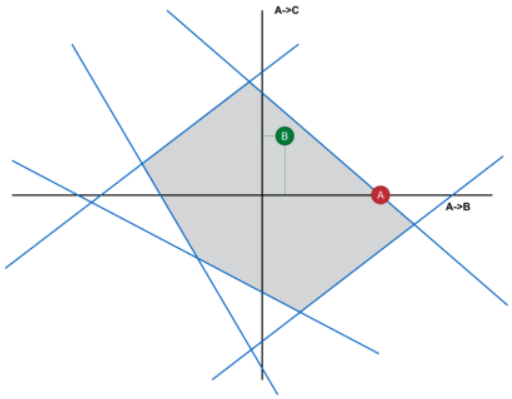
NTC Domain

- **NTC limits**: import and export limit for every border
- **Market result A**: Capacity in A→B direction is used fully, no Exchange in direction A→C
  - Regardless of Exchange in A→C direction, more Exchange in A→B direction is not allowed
- **Market result B**: Transaction in direction A→B and A→C



FB Domain

- **FB limits**: lines = CNEC
  - RAM – distance from origin, PTDF – incline
- **Market result A**: Capacity in A→B direction is used fully, no Exchange in direction A→C
  - More transaction in A→B direction is allowed if there is negative transaction in A→C direction



- Code development
  - The code should be written in Python and stored in a Git repository.

4 Collaboration

- There will be a kick-off event where the initial situation will be discussed in detail with the student.
- In addition, BKW strongly supports the student in the data preparation and cleaning phase.
- The Strategic Market Analysis team is happy to offer a weekly exchange during the project. There is also the option to work at our office in Bern on individual days to be able to discuss questions and problems in the project even more efficiently.
- To give the candidate access to our internal BKW data, a confidentiality agreement must be signed beforehand. Distribution of the code outside the circle of people required for the project is not permitted without the consent of BKW.

5 Literature & Weblinks

- Flowbased Market Coupling
  - Introduction to Core FBMC workshop - 22 Nov 2021.pdf (eepublicdownloads.blob.core.windows.net)
  - PuTo Core CCR (jao.eu)
- Net Transfer Capacities
  - Data view (entsoe.eu)
- Effects on cross-border transmission capacities (list is not exhaustive at all – just examples provided here)
  - Impacts of renewables generation and demand patterns on net transfer capacity: implications for effectiveness of market splitting in Germany (wiley.com)
  - Impact of German wind generation forecasts on net transfer capacities | IEEE Conference Publication | IEEE Xplore
  - Zugnoetal12_windimpactpowerflows.pdf (pierrepinson.com)

6 Contact

Fabian Gottschlich
Head of Strategic Market Analysis
fabian.gottschlich@bkw.ch
BKW Energy