Capstone Project Assignment I

Title: *Explaining Price Formation in the aFRR Market – A Data-Driven Investigation*

Background

The automatic Frequency Restoration Reserve (aFRR) market plays a critical role in maintaining grid frequency stability. Transmission System Operators (TSOs) procure aFRR capacity and energy through competitive auctions, and the resulting market prices reflect a combination of technical system needs and economic bidding behavior. Unlike the Day-Ahead electricity market, aFRR price patterns may be influenced by real-time grid conditions, generation variability (e.g., solar and wind), load dynamics, and reserve activation costs.

As balancing markets become more integrated and transparent across Europe, understanding the drivers of aFRR price formation is essential for market participants, policymakers, and system operators.

Objective

The goal of this capstone project is to investigate and explain the factors that influence price formation in the aFRR market. Students will apply data analysis and machine learning techniques introduced in previous lectures to explore which variables help predict or explain the observed price behavior over time.

This project brings together all major components covered in the course: data cleaning and transformation, exploratory analysis, feature selection, regression modeling, and interpretation of results.

Project Phases and Expectations

1. **Group Exploration (in-class).** During the lecture session, you will form small teams (2–4 people) and:

- Discuss the problem context and your understanding of aFRR market price behavior
- Identify what factors you believe might influence price formation
- Consider how methods learned in Lectures 7 and 8 (e.g., regression, tree-based models, evaluation metrics) could be applied
- Sketch a plan or workflow for conducting the analysis
- Prepare a short presentation summarizing your approach and assumptions

Each team will present their approach in class. The instructor will conclude the session by presenting their own reference method.

2. **Individual Implementation (homework)**. Following the group discussion and feedback:

- You will work in teams of two to implement the analysis you proposed (or revise it based on new insights)
- Use the provided datasets and techniques covered in the course (feel free to reuse code components, but adapt them to your new context)
- Document your data preparation, model development, and results clearly

3. **Submission Requirements**. You must submit the following by **14th of July.**

- A Python Script or a Jupiter Notebook containing your code with explanations and plots
- A written report (maximum 2 pages) summarizing:
    - Your methodology
    - Key findings (e.g., which variables were most important)
    - Reflections on model performance and limitations

Data Provided

- aFRR market prices (positive and negative capacity prices)
- Day-Ahead electricity prices
- Time-series data for:
  • PV and Wind generation as well as Biomass and other renewables
  • Conventional generation
  • Storage charge/discharge

Evaluation Criteria

- Clarity and structure of your data workflow
- Sound application of modeling methods
- Depth of your interpretation of the results
- Quality of code and visualizations