Integration of Wind Power Generation and Nord Pool Electricity Market Data

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Introduction

This paper presents an innovative method for predicting the profits of a wind park by integrating wind power production data with electricity prices from Nord Pool, Europe's leading power market. By integrating these two essential data sources, we want to present wind farm owners with a more precise and comprehensive perspective of their revenue potential. In contrast to conventional techniques that often overlook the economic aspect of energy production, our methodology employs an integrated prediction model that considers both the total amount of energy produced and its market value. The model employs historical wind power production data and real-time electricity prices to provide a complete forecasting framework that captures the dynamic interaction between energy supply and market demand. We employ advanced time-series analysis and machine learning methodologies to forecast future earnings with considerable precision.

Aims and Goals

The purpose of this investigation is to enhance the economic feasibility and decision-making capabilities of wind farm operators by integrating wind power generation data with Nord Pool electricity market data to predict revenue with high precision.

Main objectives:

- Develop an integrated forecasting framework that combines wind power production data with real-time electricity prices from Nord Pool.
- Employ advanced time-series analysis and machine learning techniques, including TPOT, to optimize model performance. Evaluate the precision of the model using key metrics such as R^2, MAE, MSE, and RMSE.
- Provide wind farm operators with precise financial forecasts to help in investment planning, pricing strategies, and market participation.

Methods

The data used in this study consist of two sources: weather forecasts obtained from the Open-Meteo API and hourly power generation measurements from a wind farm in Lithuania with six turbines, each rated at 2.75 MW. Weather data include wind speed, wind direction, temperature, humidity, and atmospheric pressure, synchronized with turbine data based on time and location.

The data set was divided into a training set that covered the period from January to October 2023 and a test set that covered November 2023. This partitioning ensured that the model was evaluated on unseen data to avoid overfitting and assess its predictive accuracy in real-world scenarios.

Using synchronized weather and turbine data, the forecasting model was trained and its performance was evaluated using R^2.

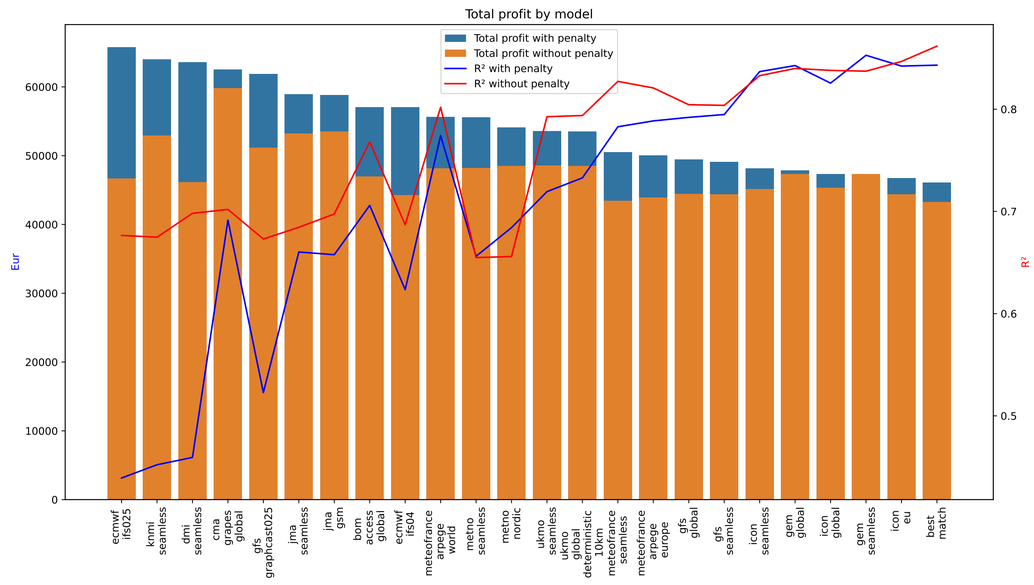

Figure 1: Illustration of total profit by model

Results

The forecasting model demonstrated notable differences in performance and profitability under two conditions: with and without the Nord Pool price penalty. The results are illustrated in Figure 1.

When incorporating the Nord Pool price penalty, the model trained using the *best_match* weather data achieved a total profit of 53k EUR. The model validation metrics included a R^2 score of 0.75, a root mean squared error (RMSE) of 1.96, and a mean absolute error (MAE) of 1.56.

The model validation score was higherR^2 without the price penalty, showing better predictive accuracy in terms of model fit, but its total profit was lower (45 k EUR). The results of the best match are shown in Figure 2.

These findings highlight the importance of including market penalties in the forecasting framework and draw attention to the trade-off between model accuracy and economic success.

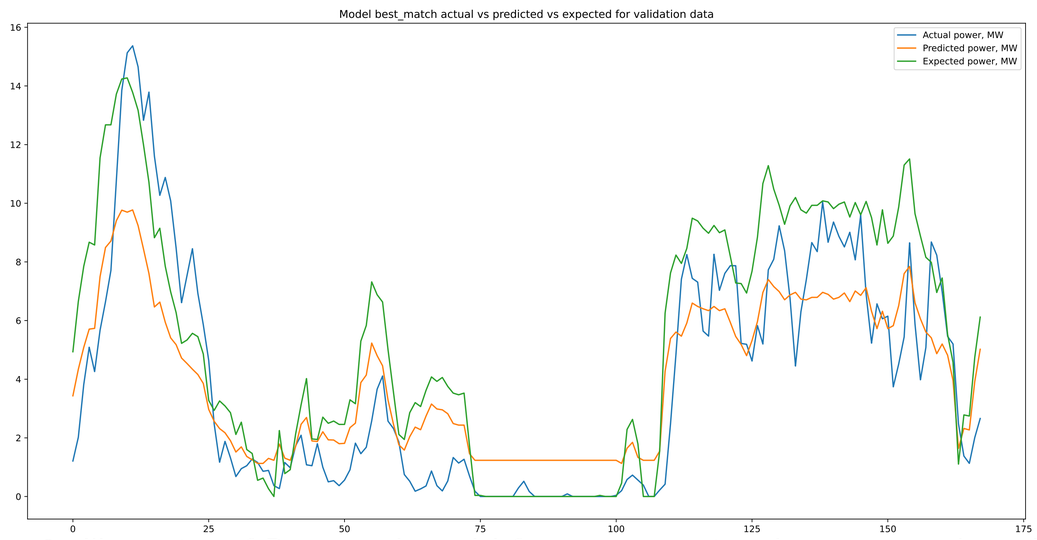

Figure 2: Illustration of Best match model forecast comparison between actual, predicted and expected

Conclusions

- Incorporating the Nord Pool price penalty can increase total profit by up to 19%, but may reduce predictive accuracy.
- Models trained without the price penalty achieve better R^2 scores, indicating higher predictive precision.
- The results underscore the importance of balancing economic objectives with model precision in forecasting frameworks.