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Evaluating the impact of Numerical Weather Prediction variables on wind power forecasting: A case study of the Alpha Ventus offshore wind farm

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Abstract-

**Offshore wind power generation has emerged as a reliable and stable source of renewable energy. However, accurate short-term forecasting of power generation remains a challenge due to the stochastic nature of weather conditions. This study evaluates the contribution of Numerical Weather Prediction (NWP) outputs and lagged explanatory variables for short-term offshore wind power forecasting. The analysis was conducted using data from the Alpha Ventus wind farm, located in the North Sea. NWP outputs from the ICON-D2 (ICOsahedral Nonhydrostatic D2) model were integrated with historical power generation data collected from Alpha Ventus turbine sensors. The performance was evaluated using a state-of-the-art recurrent neural network (Long Short-Term Memory, LSTM) alongside four established machine learning baselines (Multi-Layer Perceptron, XGBoost, Random Forest, and LightGBM).The results highlight three main findings. First, the inclusion of NWP predictors consistently improves performance across all evaluated technologies. Second, LSTM-based models improve forecasting accuracy compared to the alternative algorithms. Third, while adding 1 h lagged variables is beneficial, extending the lag structure beyond this does not yield additional gains in predictive performance. These findings emphasize the potential of advanced neural network architectures combined with NWP data to improve offshore wind power generation forecasting accuracy. **
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Index Terms- Numerical weather prediction; Offshore wind farms; Wind power forecasting; Long short-term memory; Deep learning

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