

While offshore wind energy presents substantial economic and environmental benefits, its widespread adoption continues to be constrained by the significant expenditures associated with Operations and Maintenance (O&M) activities. In this study, we focus on the application of machine learning models to improve predictive maintenance strategies for offshore wind turbines using Supervisory Control and Data Acquisition (SCADA) data and environmental information. We developed and systematically evaluated three machine learning frameworks: Extreme Gradient Boosting (XGBoost), Categorical Boosting (CatBoost), and Light Gradient Boosting Machine (LightGBM). Models were trained on real-world offshore SCADA data to predict critical turbine operational parameters. Model performance was assessed based on mean squared error (MSE) and predictive accuracy. Our evaluation demonstrates that LightGBM achieved the highest predictive accuracy and the lowest mean squared error, outperforming both XGBoost and CatBoost, while also exhibiting superior generalization and robustness to noise present in the SCADA dataset. Model validation is being conducted using data from the U.S. North Atlantic region, an area with multiple offshore wind farms currently under development.