Sustainable Energy Authority of Ireland

National Energy Research, Development & Demonstration Funding Programme

REPORT

This project has been supported with financial contribution from Sustainable Energy Authority of Ireland under the SEAI Research, Development & Demonstration Funding Programme 2019, Grant number 19/RDD/559

SECTION 1: PROJECT DETAILS

Table 1.1 – Summary of Project Details

Project Title	RDD559 TurbinePredict
Lead Applicant (Organisation)	MHL Energypro Ltd
Lead Applicant (Name)	Sheila Layden
Report Prepared By	Sheila Layden
Total Project Duration (months)	42 months

	Name	**Organisation**
Partner Applicant(s)	Ronan O'Meara	Energypro Asset Management
Collaborator(s)		Optinergy
External Consultant(s)		

Project Summary/Abstract (max 500 words)
The project aims to develop and deploy new innovative predictive processes to improve the performance of existing turbines by: 1: Early detection of underperforming turbines. 2. Early identification of parts that are about to fail (major components) 3. Changing from reactive maintenance to proactive maintenance.

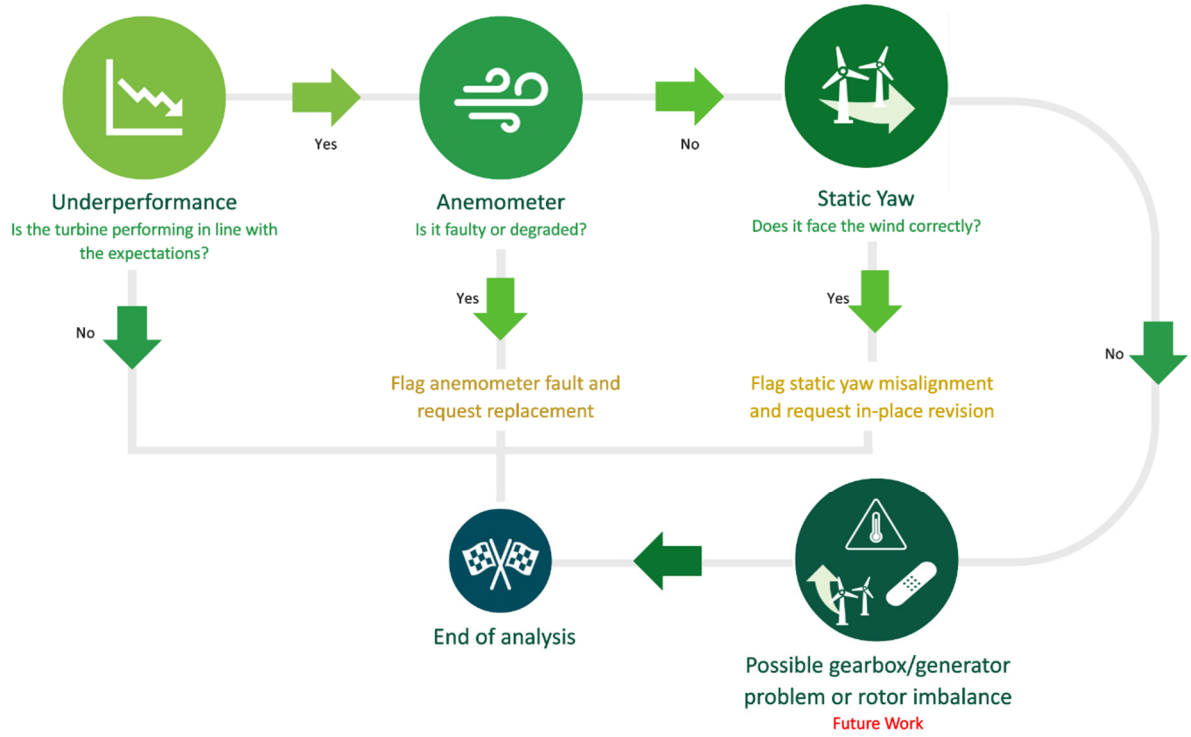
Keywords (min 3 and max 10)	Improving the performance and reducing downtime of wind turbines.

SECTION 2: EXCELLENCE & INNOVATION

2.1 Overall Project Update

Please provide an overview of your annual project progress, the context, objectives, key results and outcomes. If applicable, please include any relevant photographs/graphs, etc.

In 2024, we focused on the application of Machine Learning algorithms for the detection of wind turbine underperformance, the diagnosis of anemometer faults and detection of static yaw misalignments. We developed and tested a cascade methodology for the correct diagnosis of underperformance.



In the figure above, each rounded icon represents a Machine Learning algorithm conditionally applied, depending on the output of the previous stage. Our methodology successfully detects underperforming turbines and faulty anemometers only from SCADA data.
In a blind test of 81 operational WTs the Underperformance Detection algorithm detected that 30 were underperforming, ~ 30% more than an experienced analyst was able to detect, and with average underperformance of 3% annual energy production or ~€17k losses per annum at average 2024 REFIT rates for an onshore windfarm.
In the same blind test, the Anemometer Fault Detection algorithm obtained a 92% agreement with analyst on identifying anemometer faults. We refer the reader to Appendix A, for technical details about the algorithms.
Our module to detect Yaw misalignment spots several suspect cases that will be assessed in the near future, with the help of LiDAR sensors, planned to be deployed during 2025.
Finally, our work has opened the door to novel ideas that can be applied to other problems like Gearbox/generator inefficiency detection and rotor imbalances detection form SCADA data.

2.2 Innovation / Novelty – Beyond State-of-the-Art

Please provide an update on your project achievements during this reporting year, detailing how your project has furthered the current state-of-the-art, current knowledge or current practice. Clearly highlight the degree of novelty and innovation demonstrated.

Address each innovation (achieved or anticipated) in a bullet point below. Add as many bullet points as required:

- Innovation 1: Effective detection of turbulent wind directions [Achieved]

  Turbulence is a known cause of underperformance that skews the estimation of underperformance. Works on the literature normally disregard turbulence detection, due to the difficulty of setting acceptance thresholds. Our Statistical Machine Learning algorithm dynamically detects such thresholds, by analysing the distribution of turbulent winds in every specific WT location.

- Innovation 2: Improved WT underperformance estimation [Achieved]

  Manual underperformance detection is time-consuming and prone to oversee borderline cases. The literature normally compares the performance of a WT against the expected power curve, published by the manufacturer, or requires a reference period in the past when the WT is known to perform correctly. Our algorithm combines the published power curve comparison with a statistical analysis that compares a single WT against other nearby WTs, estimating an accurate underperformance probability score.

- Innovation 3: Machine-Learning-based enhancement of the Measure-Correlate-Predict Algorithm for large-scale faulty anemometer detection [Achieved]

  Ruling out anemometer faults as first step after spotting underperformance is paramount in the correct diagnosis of underlying causes. The literature offers a set of methods that have only been tested in constrained toy scenarios and papers report results only of few specific study cases, which compromises the scalability and generalization capacity of their methods. Our work is among the first ones in providing a comprehensive and effective method for faulty anemometer detection using only SCADA data, tested in more than 80 WTs.

- Innovation 4: Enhanced Maximum-point-capture algorithm for Static Yaw Misalignment detection

  Design and Preliminary Testing [Achieved]

  Static Yaw Misalignment detection normally requires LiDAR sensors. Attempts in the literature to detect such issues only with SCADA data only report very constrained toy scenarios and one or two study cases. We designed a comprehensive algorithm that combines the Maximum Point Capture technique and the outputs of our underperformance and anemometer algorithms, to improve the accuracy of state-of-the-art methods. We have tested this novel algorithm in data from three wind farms and obtained very promising results.

  Blind tests and Deployment [Anticipated]

  The promising results obtained in the preliminary tests encourages us to keep on working in the development of this algorithm, even considering that it surpasses the timeline of the closing project. As next steps, we plan to perform massive-scale blind tests, with the help of wind energy specialists to assess the accuracy of the method. Subsequently, we plan to integrate this algorithm in our ticketing system that is currently processing live data to detect both underperformance and anemometer issues.

- Innovation 5: Ticketing System [Achieved]

We have deployed the front-end ticketing system that seamlessly integrates with the machine learning and decision-making components. This system automatically generates tickets once when under-performance is detected, and it sends the asset manager(s) a notification/alert. The manager can access the platform where they can see information and detailed data visualisation. about the under-performance. The system has a very easy and helpful interface for logging and managing tasks – with the intention of ensuring that tickets are closed out efficiently.