PO.012

RETEX on 4 Years of Wind Turbine Optimization and Independent Performance Testing

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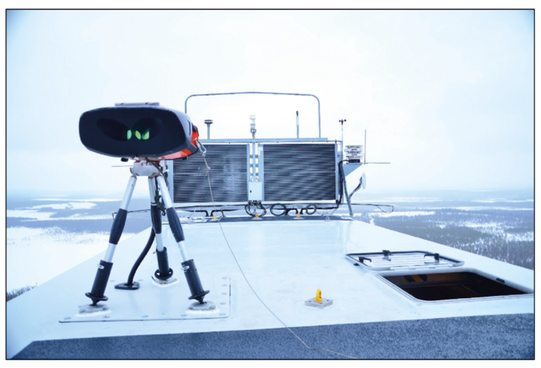
Abstract

Independent and fast turbine performance testing and multi parameters performance optimization analysis is increasingly implemented thoughtrough wind farms lifetime. Indeed, with the lowering cost of energy, wind farm profitability is strongly impacted by an operator's ability to assess turbine performance to optimize a wind turbine fleet as a whole.

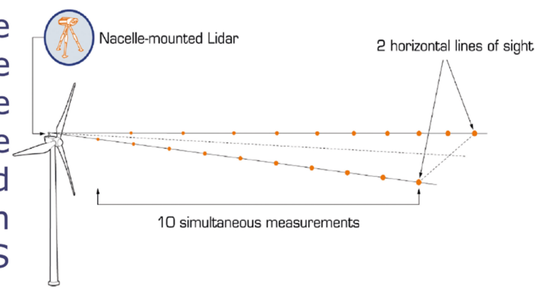
The use of innovative tools and methodologies allows today to carry complete turbine analysis that are not accessible with historical approach such as SCADA data analysis. In this context, WPO developped a complete system, that includes turbine underperformance detection, measurement system and data analysis methodologies. The WPO's Performance Measurement System was deployed for 4 years on a variety of wind farms across Europe.

We here present the operational results and key findings of the WPO's Performance Measurement System (WPMS).



Objectives

Independent wind turbine performance assessment aim at stating on the efficiency of a wind turbine via the computation of the power curve according to the IEC61400-12-1 and industry best practices. The main operational objectives of the WPMS system include:



- Characterization of the the turbine performance [1] [2] [3]
- Analysis of the the turbine set up (Yaw mis., NTF*, Pitch, RPM) [4] [5]
- Analysis of the site characteristics (Turbulence intensity) [6]

**NTF: Nacelle Transfer Function, adequation between nacelle anemo. reading and free wind speed*

Methods

Turbine underperformance detection
Based on SCADA data and innovative methodology,

Measurement campaign
Free wind speed, power, atmospheric quantities… are measured independently from the SCADA.

Turbine underperformance characterization
Gathered data are the power performance is computed and potential underperformance characterized.

Turbine underperformance correction
Depending on the findings, reccomendations are provided
Take action to tackle the underperformance.

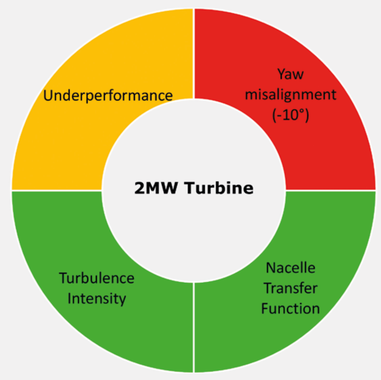
Results

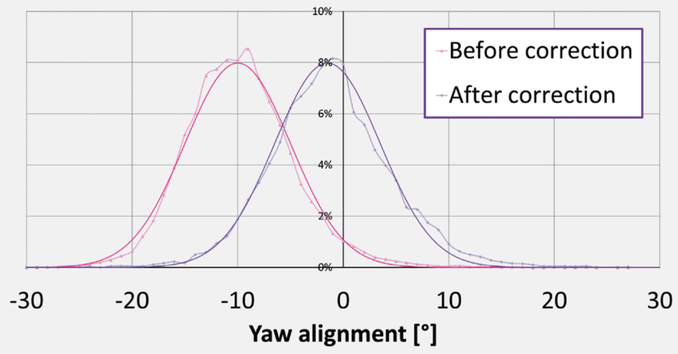
WPO pre-analyzed on behalf of its clients 126MW of asset based on SCADA data and performed independent measurement campaigns on a variety of wind farms. These pre analysis allowed to confirm or infirm the turbine operator underperformance suspicion and target specific turbines.

The targeted turbines were purposefully chosen for being erected maximum 5 years prior the measurement campaign. It allowed to exclude the wearing of the blades and the electromechanical chain as source of under-performance.

Case Study

As a first step prior fleet wide implementation, our client proposed to analyze the impact of a turbine upgrade product. After pre analysis of their portfolio, a 2month campaign took place. The turbine showed a 10° yaw misalignment that was corrected **after the manufacturer upgrade implementation.** It led to a **+1.6% AEP increase**.





Results are ordered in 4 categories by order of frequency:

	NTF* deviation	Yaw Misalignment	Underperformance
Cat. 1 (40%)	Small (<5%)	**Large (>5deg)**	Yes
Cat. 2 (20%)	**Large (>8%)**	Small (<5deg)	Yes
Cat. 3 (20%)	No	No	Yes
Cat. 4 (10%)	No	No	False detection

**NTF: Nacelle Transfer Function, adequation between nacelle anemo. reading and free wind speed*

The turbines in category 1 represent 40% of the turbine analyzed. The yaw misalignment correction generated +1.8% AEP improvement in average.

For the turbines belonging to the category 3, depending on the shape of the power curve, the turbulence intensity or wind shear can be reponsible for the underperformance. A pitch angle analysis is can be advised in certain case.

Conclusions

Thanks to innovative pre analysis, WPO was able to reduce the uncertainty around the veracity of the under performance diagnostic based on SCADA data, and limit the false detection. The reduction of false underperformance detection is critical for operators, and optimize the operator's investment.

The WPO measurement system was able to perform IEC like power curves and to characterize under performance causes with measurement campaigns 15days long (yaw misalignment characterization) to 3months long (full analysis). The time efficiency was allowed by the use of a nacelle Lidar and efficient data analysis monitoring.

WPO's track record shows that the yaw misalignment issue represents the main source of under performance.

References

[1] IEC standard for wind turbine power performance measurement 61400-12-1, Edition1, 2005
[2] DTU, R Wagner et al. 'Procedure for wind turbine power performance measurement with a two-beam nacelle Lidar'. DTU Wind Energy-E-0019, 2013.
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[4] ECN, JW Wagenaar et al. 'Turbine performance validation; the application of nacelle Lidar'. ENC Wind Energy, 2014
[5] ECN, JW Wagenaar et al. 'Use of a nacelle LiDAR to assess nacelle transfer functions'. EWEA Technology workshop, 2014.
[6] DTU, R. Wagner et al. 'Turbulence measurement with a two-beam nacelle Lidar'. DTU Wind Energy, 2013