CASE STUDY – Turbine optimization through Lidar yaw error corrections

Valorem is a producer of renewable energy, mainly wind and solar. Established in 1994, Valorem group is active in every step of energy projects, from creation to operation. With nearly 400MW of wind power installed, it is one of the largest independent power producers in France.

Campaign highligths

Objective	Measure yaw error, estimate AEP loss and optimize production		
Measurements	Yaw error		
Wind turbine	Acciona 82	1,5 MW (rated)	Rotor 80m
Commissioning	01/10/2009		
Installation duration	6 hours (during low wind period)		
Campaign duration	2 weeks		
Results	7° yaw error translating into 1.9% AEP loss		

Feedback

"With more than 100 MW of wind power in operation at Valorem, every percent of yield systematically won or lost on our turbine makes a big difference. That's why we had the will of measuring the wind before it passes through the rotor, to precisely measure the free wind characteristics (speed, horizontal and vertical direction, turbulence) and evaluate the expected power. As a main result, the experience made on one turbine has shown that a 1.9% yield increase could be obtained by setting up more precisely the yaw angle. We now believe that it should be a standard value for most turbines. Optimization in load management is also expected, thanks to the Wind Iris free wind measurement."

Simon Brillet, Technical Director
Valorem

Objectives

As any windfarm owner and operator, Valorem aims to optimize the performance of its wind assets. To maximize energy production and reduce asymmetric rotor loads, turbines face the incoming wind direction by periodically adjusting their yaw heading. These yaw control actions are based on the wind direction measured by a sensor (wind vane or sonic anemometer) located on the nacelle. An offset in this measurement, known as yaw error, causes a loss of energy production.

In this context, **Valorem's objective is to validate an operational tool allowing them to correct the loss due to static yaw errors, turbine after turbine.** In a second step, Valorem aims to improve its wind sector management.

Solution

Yaw errors can be the consequence of complex aerodynamics effects, such as blade passage or rotor induction, which require these sensors to have a specific calibration function. This calibration can drift over time or not be well-suited for a specific site. Improper wind vane mounting or defective maintenance operation can also be at the origin of an offset.

Valorem decided to test the Wind Iris as it fits their multiple needs. Re-calibrating and realigning the wind vane (ie determining and correcting the offset) with a nacelle based Lidar measuring in the free stream is a very cost efficient solution to recover lost AEP. Additionally, it allows for analysis of turbulence intensity in order to improve wind sector management.

This case study describes how yaw error is efficiently measured by the Wind Iris, and how to optimize turbine performance with this information, leading to additional AEP and return on investment.

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Measurement principle

The 10 simultaneous measurement ranges of the Wind Iris are used to improve the determination of yaw errors. This reduces the required measurement period and increases the accuracy and robustness of the measurements, which is particularly important in turbulent wind sectors.

This method detects yaw errors independently by using the Lidar as a standalone tool, through straight-forward averaging of wind direction measurements obtained upwind, in the free wind stream. The user can in turn directly use the Wind Iris data without significant post-processing.

View of the Wind Iris on the turbine

Results

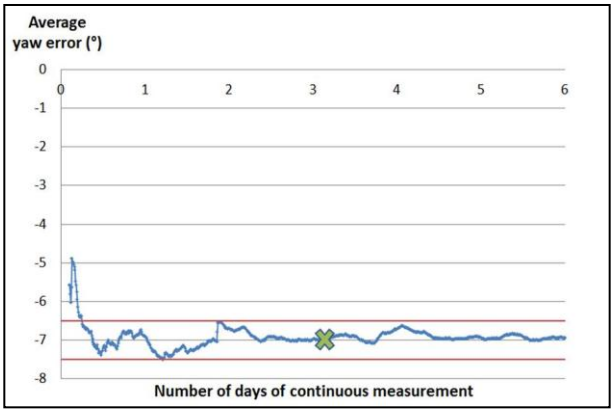
Yaw error

After a few days of continuous measurements, an accurate average yaw error is computed and is here close to -7°, as illustrated below. We focus on yaw error below rated power as it causes loss of production.

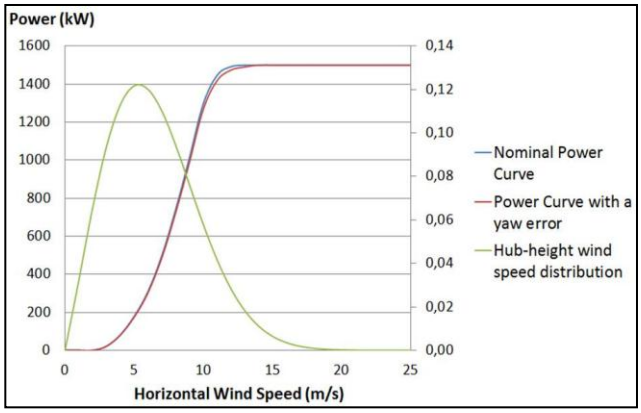
Only 70 hours of continuous turbine operation and Lidar measurements were needed to reach 7° +/- 0.5° with a confidence interval of 95% on the yaw error. Under typical wind conditions this translates into a 2 weeks campaign for each turbine (including mounting and unmounting, half a day each).

AEP loss

The AEP loss was estimated from these results by using the wind turbine power curve and the on-site wind speed Weibull distribution. This loss was established to be 90.3 MWh annually, which is roughly 1.9% of the wind turbine annual output.



Convergence of average yaw error over time: less than 3 days of valid data were needed to reach the required level of confidence.



Power curve (nominal and with yaw error) and onsite wind distribution.

Valorem has met its objective to find an operational tool for yaw error correction and plans to develop its use further. A 2-week campaign (a conservative hypothesis) has shown a 1.9% production gain for this turbine. It is easy to see the optimization potential that can be yielded by expanding the use of the Wind Iris to increase this benefit turbine after turbine.

Contact us for detailed information!

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TURBINE-MOUNTED WIND INTELLIGENCE