Wind farm optimization using nacelle based LiDARs

Case study: Wind farm performance optimisation in India

Campaign details

Objective:	Optimise wind turbines using nacelle mounted LiDARs
Wind turbine:	Suzlon S97 (2.1MW, Rotor 97m), Siemens Gamesa G97 (2MW Rotor 97m)
Number of turbines with LiDAR campaign:	23
Turbine commissioning year:	2015
Campaign outcome:	The average Yaw misalignment detected for all turbines measured during the campaign was -5.6°, in total identifying potential gains of more than €100,000 annually

Campaign objectives

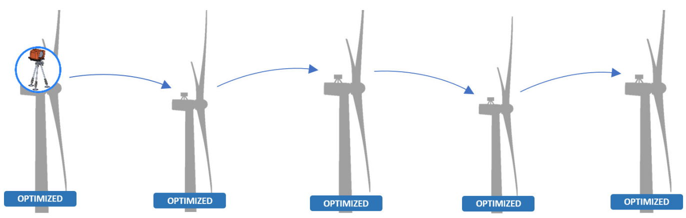
1) Ranking the performance of the WTG's from best to worst using the available data from wind farm
2) Yaw misalignment (YM) detection and verification after correction
3) Turbulence intensity
4) Quick power curve verification
5) Nacelle transfer function verification

Performance ranking using SCADA data

A comprehensive analysis of data for two wind farms was conducted to assess the power performance of 48x Suzlon S97, 45x Siemens Gamesa G97 and 1x Siemens Gamesa G114 turbines and identify the best and worst performing WTGs on which to perform the LiDAR campaigns.

LiDAR measurement principle and set-up

A nacelle-mounted LiDAR is temporarily mounted on top of the nacelle, together with a data collection and communication unit in the nacelle. The LiDAR measures the horizontal wind speed and direction at hub height in front of the turbine at 10 measurement ranges, between 50m to 400m. Nacelle-based LiDARs, are a fast and cost effective way to evaluate and optimise the wind turbine performance.



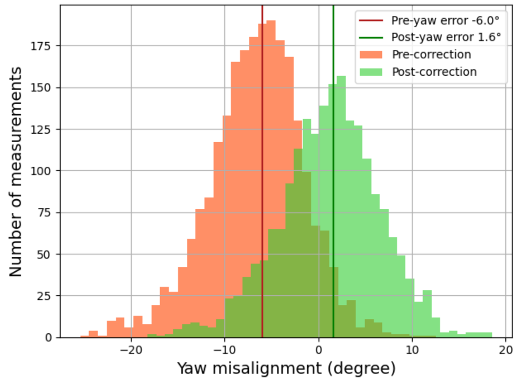
Yaw misalignment

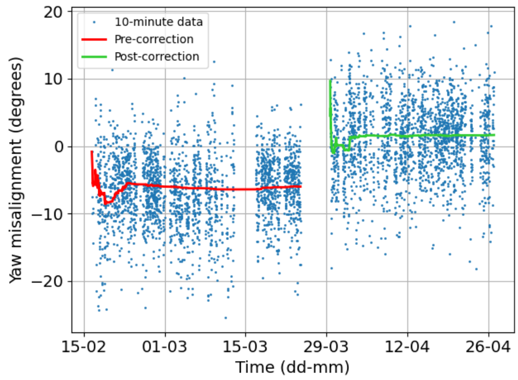
The average relative wind direction and wind speed (at hub height) are computed every 10 minutes for measurement ranges in front of the turbine. These measurements are validated or discarded based on standard or more advanced criteria, such as cut-in & rated wind speed, low data quality, etc.

Results:

Average yaw misalignment detected for all turbines measured during the campaign was 5.6°, with one turbine exhibiting a 13° misalignment. Average AEP gain across measured turbines was 1.3% per turbine, and up to 5.5% for worst affected turbine. Average calculated savings of €3,300 per year per turbine, with up to €15,300 per year for worst affected turbine.

Before correction	Wind farm 1	Wind farm 2
Number of WTGs	23	9
Average YM	-5.22°	-6.52°
Max YM	-13.16°	-10.25°
Min YM	-0.26°	-3.56°





Quick power curve & nacelle transfer function verification

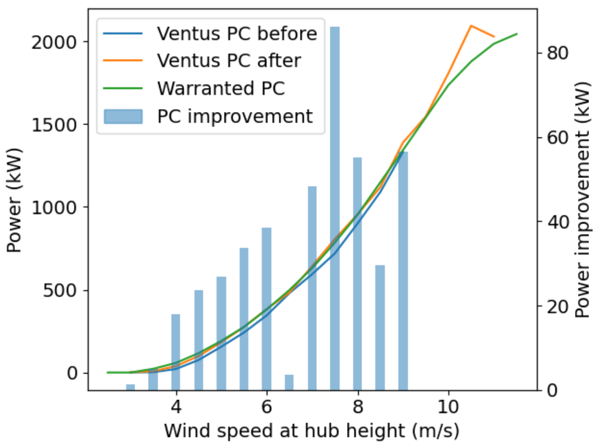
The quick power curve (PC) measurement using both the SCADA wind speeds and LiDAR wind speeds were analysed to identify areas of underperformance, as well as how effective the wind turbine anemometer is at measuring wind speed. The quick power curve measurement was also used to verify the power performance improvement after yaw misalignment correction.

Results:

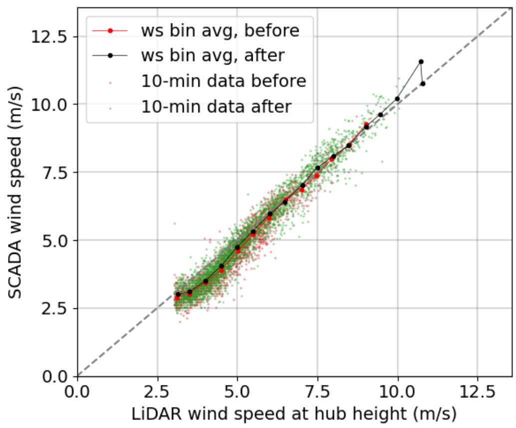
- Power curve improvements noticed after yaw correction
- SCADA PC overestimates the actual PC for the low wind speed region
- Nacelle transfer function shows undermeasurement of wind speeds by SCADA system, on average by -0.25 m/s and up to -0.6 m/s in low wind speed region

Recommendation:

- Investigate the nacelle transfer function (NTF)
- the differences observed at the SCADA and LiDAR PCs are caused by the wind speed measurement
- delayed WTG cut-in due to SCADA underestimation of the actual wind speed



Power curve performance improvement before and after YM correction



Nacelle transfer function (SCADA vs LIDAR wind speed) shows undermeasurement of SCADA wind speeds.