PO.026

Power performance assessment and optimization using spinner anemometers and nacelle LiDAR systems

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Abstract

Wind farm operators aim at optimizing their annual energy production (AEP), and the existing SCADA systems are being relied upon for monitoring power performance. Nacelle LiDARs and spinner anemometer systems promise to measure the incoming wind field with more precision compared to the default turbine instrumentation allowing the identification of potential underperformance (e.g. yaw misalignment). In this work, methods are developed to optimize the power performance of wind farms based on the measurements of ROMO iSpin **spinner anemometer** and **nacelle LiDAR** systems.

Objectives

How could you identify possible underperformance of your turbines, such as yaw misalignment, when you rely on anemometers and wind vanes behind the rotor?

Forward facing nacelle LiDARs and spinner anemometer promise to sketch a more accurate picture of the incoming wind field. In the project 'Sensor Assisted Windfarm Optimization' the effectiveness in identifying underperformance with these systems is assessed in **free stream** and **waked wind** conditions. Subsequently, strategies to improve the power performance are proposed to the operator, and the results measured. Finally, the added benefit of using either nacelle LiDAR or iSpin spinner anemometers as a wind sensor for **wake steering applications** will be evaluated with supporting wind farm simulations.

Measurement campaign

A measurement campaign at the Danish onshore windfarm Klim Fjordeholme, operated by Vattenfall, has started summer 2021 and is comprised of:

- **ZX 300M,** a ground-based profiling LiDAR, acting as reference
- **ROMO iSpin** spinner anemometers at eight turbines
- **Leosphere WindCube Nacelle LiDAR** a circular continuous wave LiDAR
- **ZephIR Dual Mode Nacelle LiDAR**, a four beam pulsed LiDAR
- **Leosphere 200S Scanning LiDAR,** characterizing the wake conditions

Midway in the campaign the nacelle LiDARs will be exchanged to assess **interchangeability.** A frame was designed for an easy exchange while maintaining the same base frame. The measurement campaign layout can be seen in Figure 1 below.

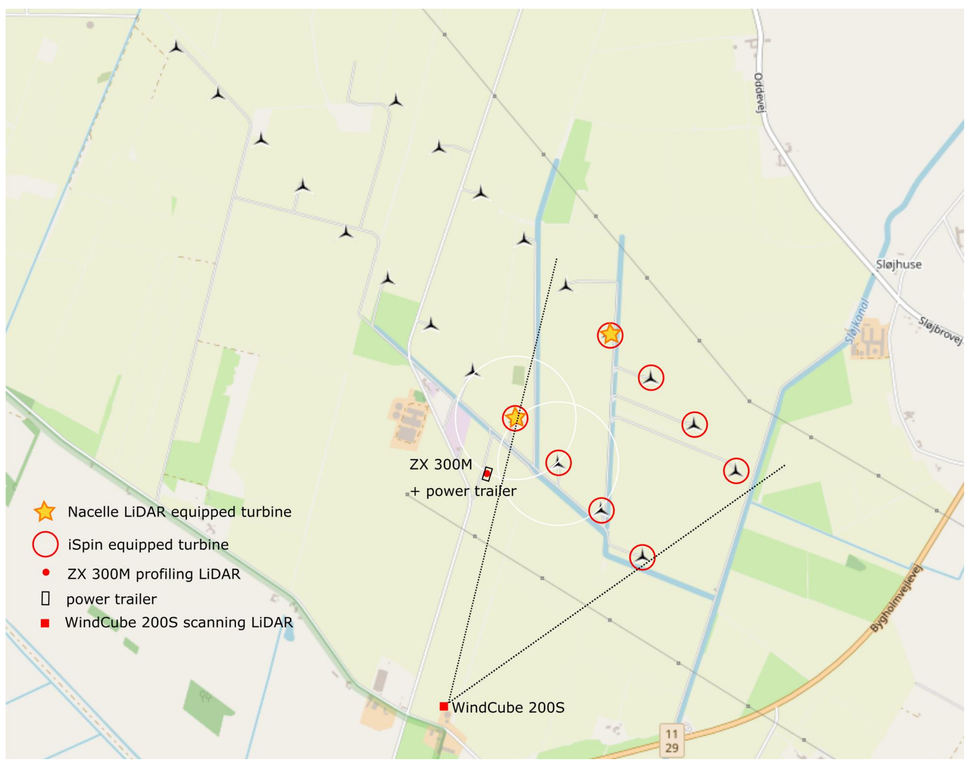

Figure 1 – Layout of measuring campaign at Klim Fjordeholme

White Box Calibration

A white box calibration provides information on the **uncertainty** of LiDAR measurements. Before the campaign at the windfarm, a white box calibration has been performed for the two nacelle LiDARs following the upcoming guidelines of **IEC 61400-50-3**[1]. The beam geometry of the ZephIR DM was tested by using infrared imaging in a dark room (Figure 3) and the LiDAR inclinometers were calibrated by measuring both the beam height at different tilt angles and an external reference inclinometer. Afterwards the two nacelle LiDARs and scanning LiDAR were positioned 270 m from a meteorological mast for a **line-of-sight windspeed calibration** (Figure 2). A **CNR map** was created using the scanning LiDAR to identify the exact location of the reference cup anemometer (Figure 4). Because of the distance only the lowest boom at 30.5m height was considered within the guidelines (i.e. maximum elevation angle of 10 degrees).

Figure 2 – Leosphere 200S scanning LiDAR (left), ZephIR DM nacelle LiDAR (middle) and Leosphere WindCube Nacelle LiDAR (right), aimed at a meteorological mast

Figure 3 – Scanning pattern of ZephIR Dual Mode in a dark room

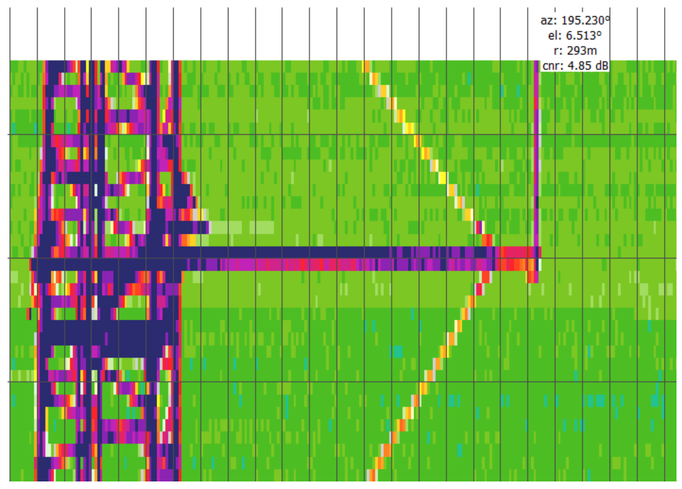

Figure 4 – CNR map of a supporting boom of the meteorological mast

Conclusions

With the set-up of the measurement campaign that is running at the Klim Fjordeholme windfarm, the power performance of the wind turbines can be assessed. The unique combination of instrumentation allows **comparison** of nacelle LiDARs and spinner anemometers in both free-stream and waked conditions. The **white box calibration** of the nacelle LiDARs delivers quantified levels of uncertainty in the measurements, according to the latest guidelines.

References

1. IEC 61400-50-3 (FDIS draft), *Wind energy generation systems – part 50-3: Use of nacelle-mounted lidars for wind measurements,* 2021

Acknowledgements

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