PO.081

Turbine performance validation; the application of nacelle LiDAR

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Introduction

To assess the performance of turbines wind measurements are conventionally taken using large meteorological masts. **Nacelle LiDARs** are being investigated to perform this assessment. Unlike a meteorological mast they measure the approaching wind and are relatively **easily deployed** compared to the alternative. Nacelle LiDARs offer the possibility to optimize wind turbine and wind farm control and to optimize O&M procedures. These subjects are assessed with the focus on **power performance, yaw misalignment** and the **control** of wind turbines.

In this work the power performance and yaw misalignment of a modern full scale, near shore turbines is assessed mimicking the offshore conditions. In addition blockage and TI is assessed and last but not least a **5-beam nacelle LiDAR of Avent** is introduced, especially developed to test turbine control applications or advanced R&D topics.

Experimental set-up

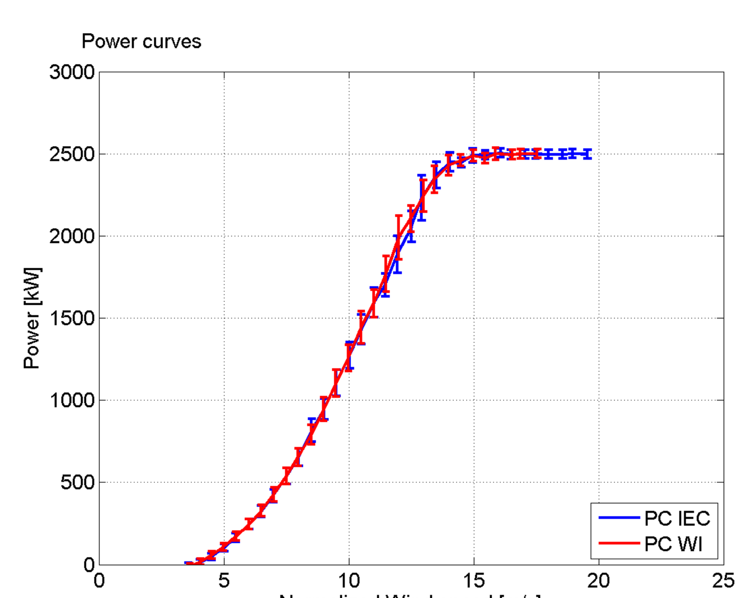
In order to assess the performance of turbines two measurement campaigns have started on the **ECN test site** EWTW, which is a near shore site consisting of flat, agricultural terrain.

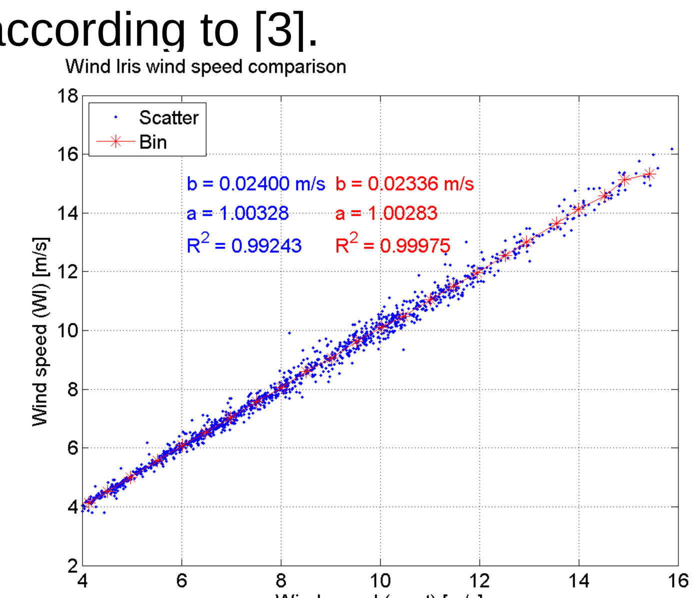
The **Wind Iris of Avent** is installed on one of the ECN research turbines. The Wind Iris is a two beam, pulsed LiDAR and the **research turbine** is a 2.5MW turbine with a rotor diameter of 80m. A fully instrumented meteorological mast is nearby including a Leosphere WindCube ground based LiDAR.

The 5-beam nacelle LiDAR of Avent is installed on the **XEMC Darwind** prototype also present on the test site. The XEMC Darwind turbine is a 5MW direct drive turbine with rotor diameter of 115m. A fully instrumented meteorological mast is installed nearby including a Zephir ground based LiDAR.

Power Curve

The power curve of the 2.5MW research turbine has been determined using the Wind Iris measuring at a distance of 200m (2.5D) according to [1] and compared to the power curve determined according to the existing standard [2]. The uncertainty in the Wind Iris measurements has been determined based on a comparison with the mast measurements according to [3].





Conclusions:

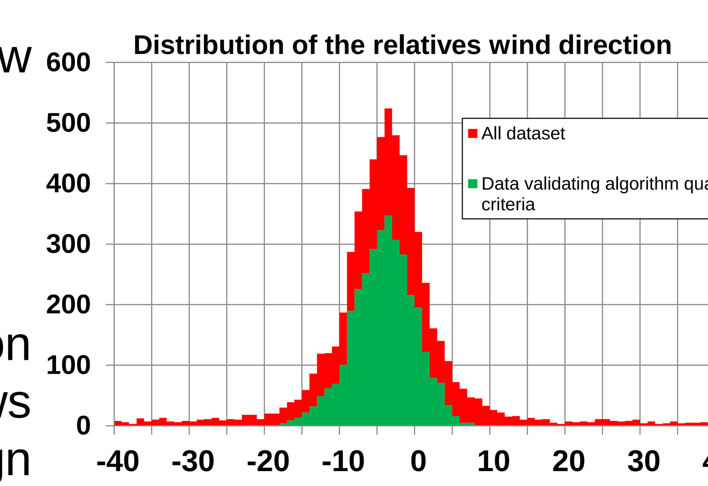
- ❖ Wind speed comparison agrees very well.
- ❖ Power curves and uncertainties compare quite well.
- ❖ Large part of Wind Iris uncertainty is due to the reference cup wind speed uncertainty itself.
- ❖ Differences at ~12m/s due to scatter.

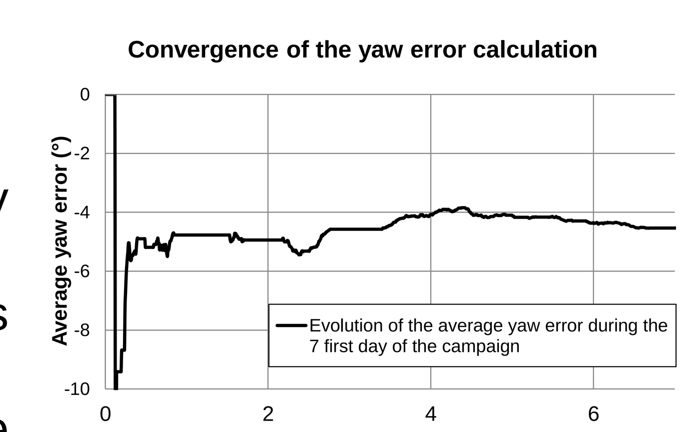
Yaw misalignment

In the context of optimized O&M procedures, yaw misalignment detection requires:

- Accuracy within 1°
- Fast
- No turbine data input

To answer these criteria, a method only based on LiDAR measurements at multiple ranges allows to define quality criteria and optimize campaign duration. The method was tested and the results compared to an analysis of the 3 month campaign dataset.



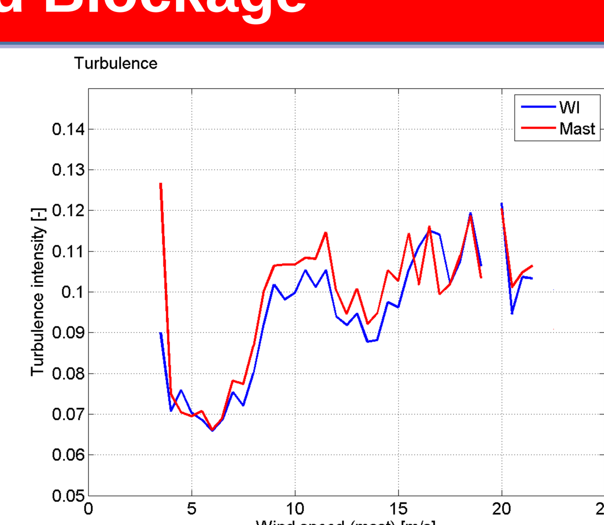


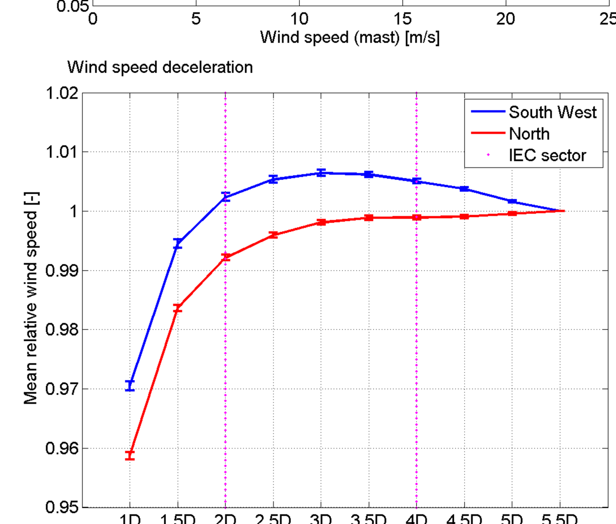
Conclusions:

- ❖ The method allows to select only high quality data without turbine data or calibration
- ❖ This reduces LiDAR campaign time to less than 7 days
- ❖ The optimized method provided the same result as the 3 month dataset analysis

Turbulence Intensity and Blockage

The turbulence intensity (TI) as obtained by the Wind Iris at 200m has been compared with the turbulence intensity obtained by the mast in the undisturbed sector. In addition, the blockage effect of the turbine has been examined up to 5.5D with the Wind Iris for the undisturbed North and South-West sector. This with reference to the IEC sector for power performance [2].



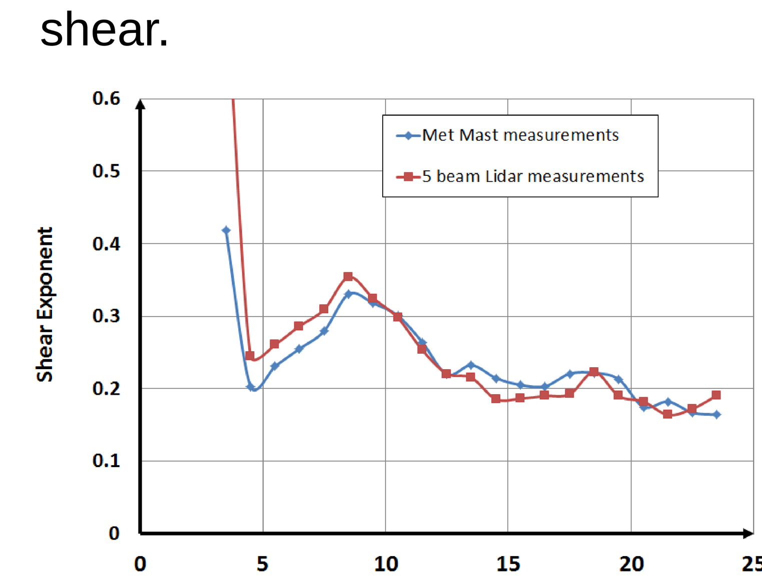


Conclusions:

- ❖ Wind Iris and cup TI compare quite well.
- ❖ Blockage effect is quantified for both undisturbed North and South-West sector.
- ❖ In the South-West sector there seems to be up-speeding, possibly due to terrain effects.

5-beam nacelle LiDAR demonstrator

The 5-beam nacelle LiDAR demonstrator with measurement ranges from 50m to 185m was tested on the XEMC Darwind turbine and compared to a meteorological mast with focus on: availability, blockage, wind speed correlation and vertical wind shear.



Conclusions:

- ❖ The LiDAR availability is ~97%.
- ❖ Wind speed comparison to meteorological mast is very positive.
- ❖ Blockage effect is quantified using the central beam.
- ❖ Promising correlation obtained for vertical wind shear.

Acknowledgements

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TKI WIND OP ZEE

XEMC sea-change in wind energy DARWIND

References

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