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Nacelle-Mounted Lidar reduce the uncertainty of Power Performance Test by Met Mast: a fully investigation

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Abstract

Nowadays, Nacelle-mounted lidar (NML) technology is increasingly leveraged for Power Performance Test (PPT) and is widely accepted by wind turbine manufactures, certification society and operators. The new release of IEC 61400-50-3 provides industrial guidelines of NML as an IEC-complaint technology.

Fig.1 NML installation photo

Met masts are traditionally the standard solution for Power Performance Test (PPT). However, results from field measurement and simulation increasingly reveals that the anemometer is easily affected by the mast, while the PPT measurement by PPT is less scattered.

This study presents the result of a polit project for PPT, and the objective is to prove the suitability of the NML system for contractual PPT, according to the IEC procedures. This study investigate the measurement accuracy of wind speed and uncertainty for PPT by two devices.

Setup: Measurement

Measurements are taken at wind farm in flat terrain using WindCube Nacelle (formerly named Wind Iris), installed on the nacelle of 2.7 MW wind turbine. One IEC met mast are located at 290m in front of wind turbine to vertically measure free wind speed at hub height of 89m. The wind sector from 140° to 210° fulfils the IEC requirement for the typical PPT test for a better measurement efficiency due the wind direction. A smaller wind sector from 187° to 207° is studied because the met mast is exactly in front of wind turbine.

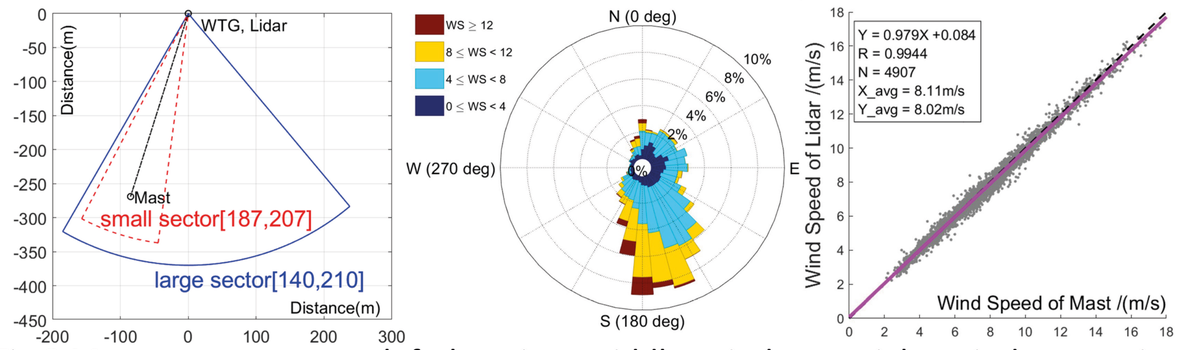

Fig.2 Measurement setup: left, location; middle, wind rose; right, wind comparison

Result: Measurement

Scattering points of PPT by NML in wind sector[140,210] are more concentrated than that by Met Mast, showing in Fig3(a) and Fig3(b), because NML is always measuring the wind speed exactly in front of the wind turbine. Fig3(d) shows the standard deviation by NML (red line) in the bin of wind speed is significantly lower than that by Met Mast(blue line).

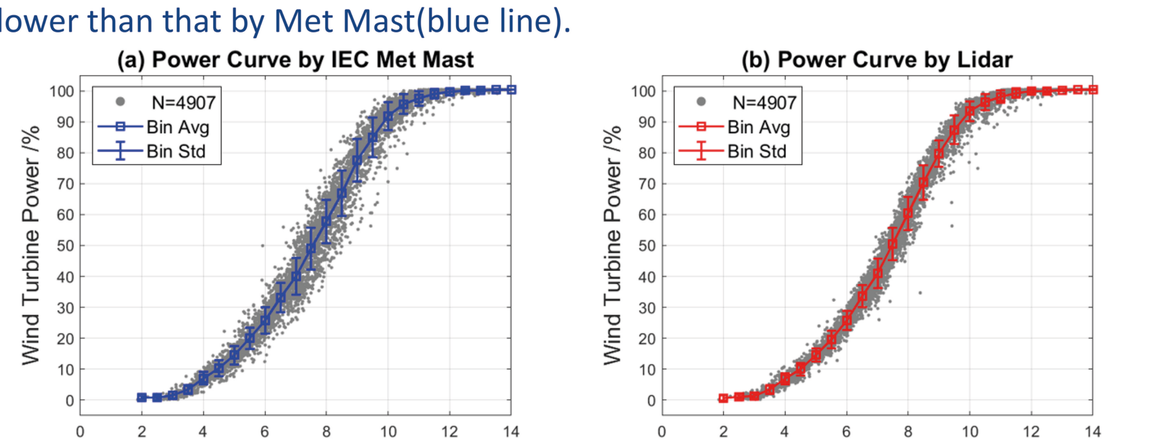

Fig.3 Comparison of PPT by Met Mast and NML

Result: Simulation

OpenFOAM is used to simulate the wind field difference at two locations at multiple wind directions, and the configuration is shown by Fig4. The simulation result shows in Fig5 that, the small undulation of the terrain surface can still cause some difference of wind field of two locations, even in the flat terrain.

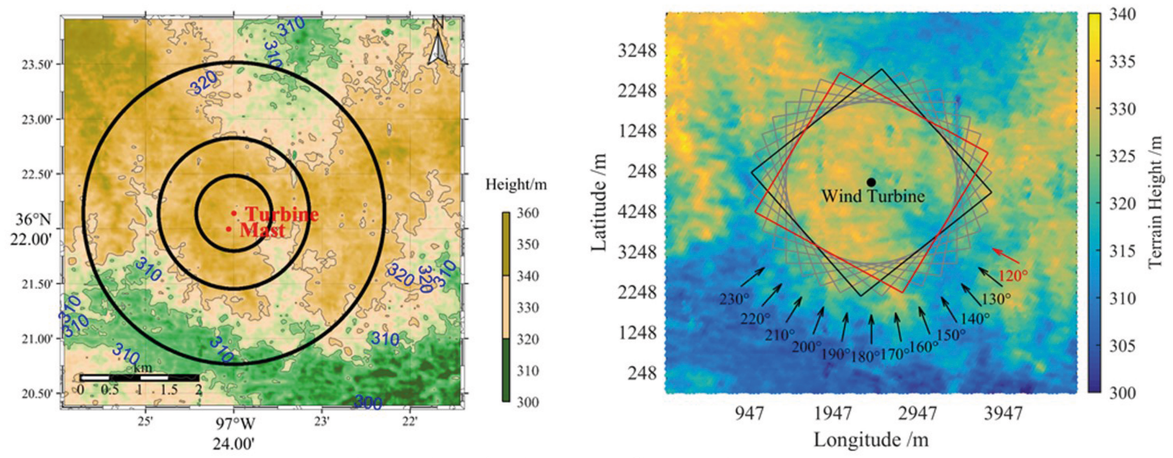

Fig.4 simulation configuration

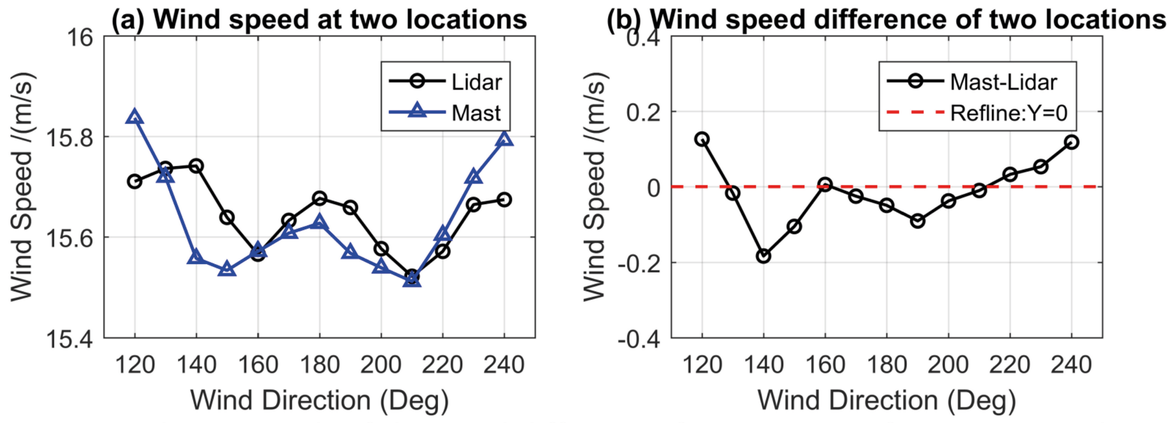

Fig.5 simulation result of the wind difference for positions of Met Mast and NML

Discussion

Fig 6 shows the evaluation the difference of PPT by two devices on Annual Energy Production (AEP), by assuming wind Weibull distribution. The AEP range by Met Mast and NML are respectively [3592h, 4265h] and [3739h, 4252h] for the large wind sector[140, 210]. The overall uncertainty of NML is within the uncertainty range of Met Mast.

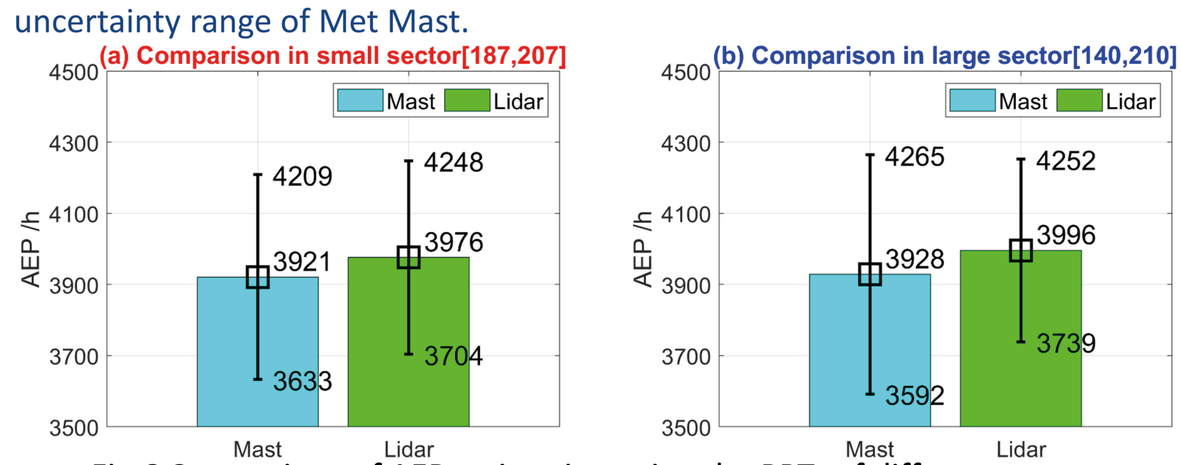

Fig.6 Comparison of AEP estimation using the PPTs of different sectors

Conclusions

This study shows that Nacelle-Mounted Lidar (NML) has a high accuracy and less uncertainty for the measurement of Power Performance Test (PPT).

(1) The wind speed of NML is accurate: the correlation coefficient with Met Mast is 0.994 with a slope of 0.979 and an offset of 0.084.

(2) NML has a lower uncertainty of PPT test: scattering points of PPT are more concentrated, and standard deviation is lower. Investigation by CFD simulation support this phenomenon.

(3) The AEP assessment results shows that the uncertainty of AEP calculation by NML is within the uncertainty range by Met Mast.

References

1. IEC. (2022). International Electrotechnical Commission: Wind energy generation systems-Part 50-3: Use of nacelle-mounted lidars for wind measurements. www.iec.ch
2. A. Borraccino, et al. (2015) Generic calibration procedures and results for nacelle-based profiling lidars.

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