



# Nacelle-mounted lidar for Power Performance Testing — A joint industry project by ENGIE North America, GE Renewables, DNV, and Vaisala

**Robin COTE**

WindCube Nacelle Product Manager - Vaisala

ACP Webinar – Wind Turbine Testing Using Nacelle Lidar– 23 September

**VAISALA**

# A joint industry Power Performance Testing (PPT) project

## Objectives

- Extensive field study to prepare for the use of nacelle-mounted lidars for PPT on operational basis
- First joint industry project in the context of the IEC 61400-50-3 standard upcoming release

## Methodology

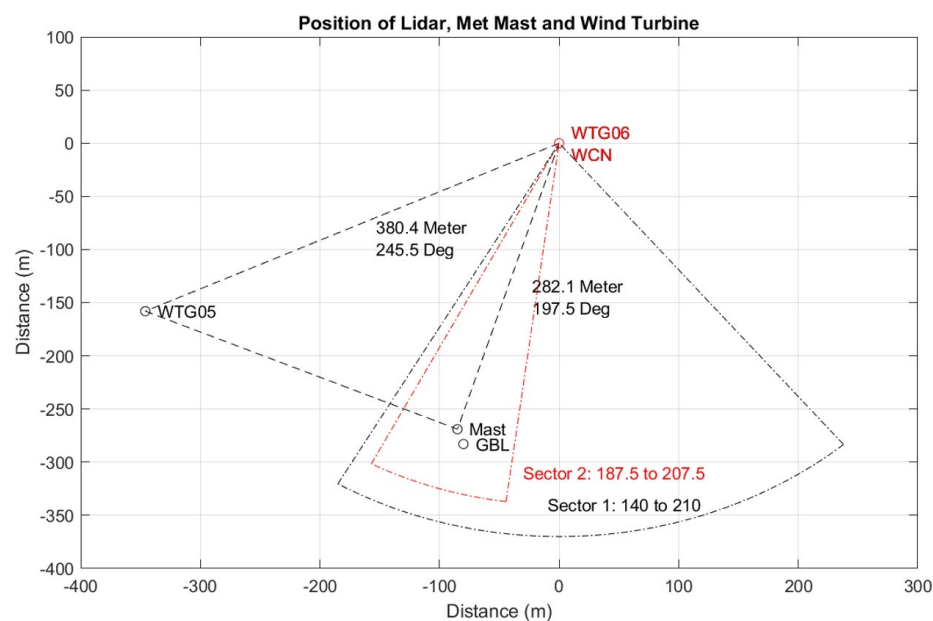
- 3-months campaign at ENGIE's wind farm in the US
- Onshore flat terrain
- Reference instruments: IEC met mast and WindCube ground-based lidar



VAISALA

# Direct comparison of nacelle lidar, ground-based lidar, and IEC met mast

## Map



### Two wind sectors:

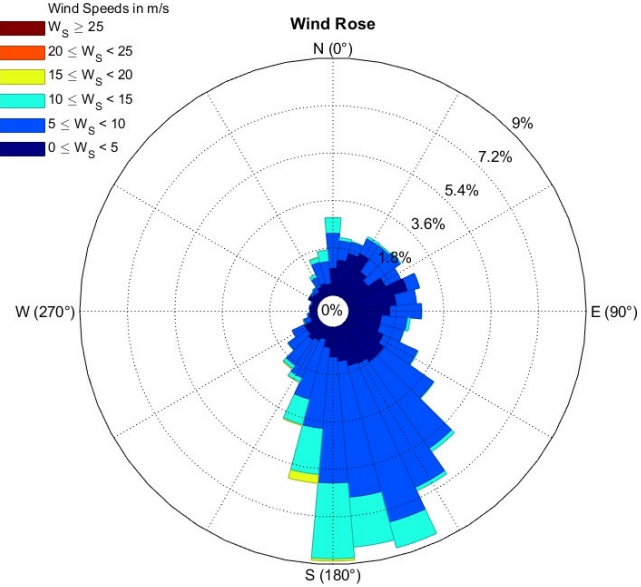
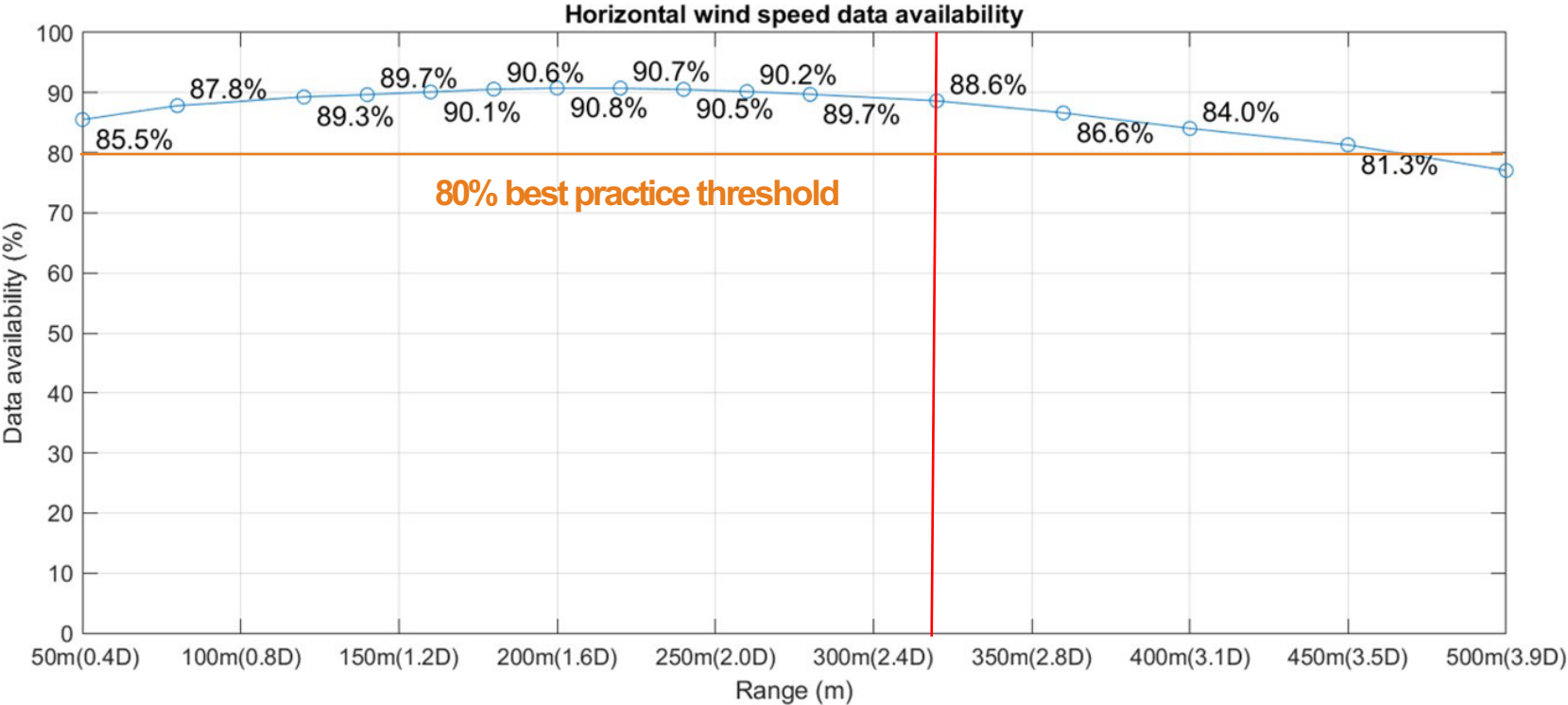
- 1) 140°-210°: IEC valid wind sector
- 2) 187°-207°: met mast centered wind sector

Instrumentation	Type	Measurement Height [m]	Distance from WTG [m]	Distance from WTG in [D] (rotor diameter)
Nacelle-mounted lidar	WindCube Nacelle	89m	50m-700m	0.4D-5.5D
Met mast	IEC compliant	32m-89m	282m	2.2D
Ground-based lidar	WindCube	40m-200m	290m	2.3D

# Data availability

## Key takeaway

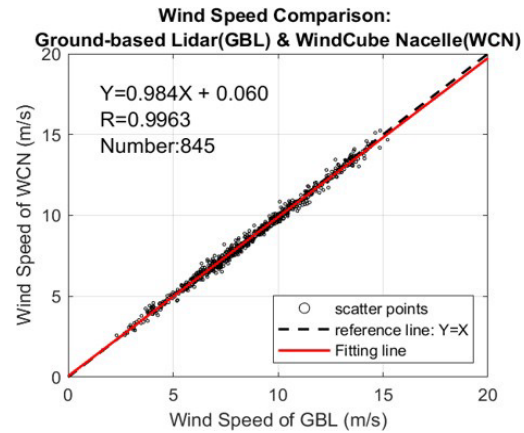
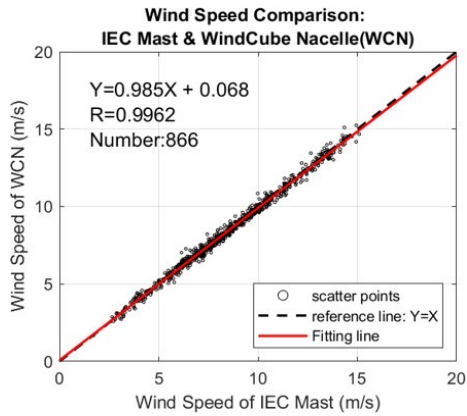
- 88.6% HWS data availability at 2.5D
- Above 80% availability threshold at most ranges between 2D and 4D



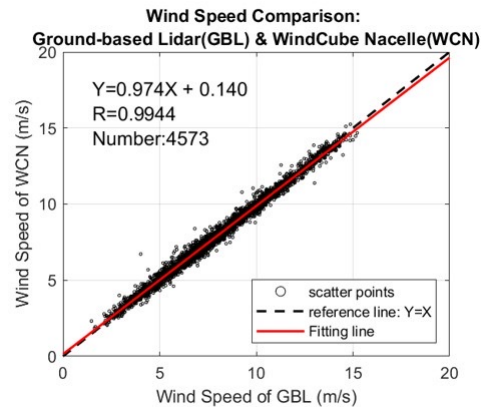
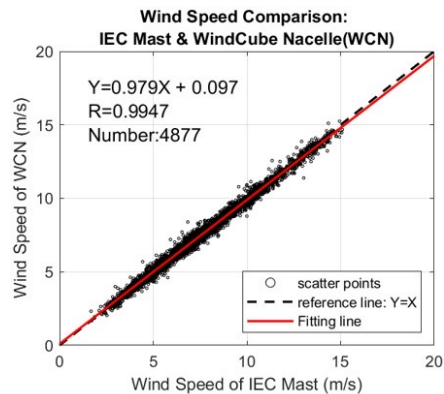
Sector	ALL	140°-210°	187°-207°
Data points	13743	6507	1232

# Wind speed correlation

## Reference instruments centered wind sector: 187°-207°

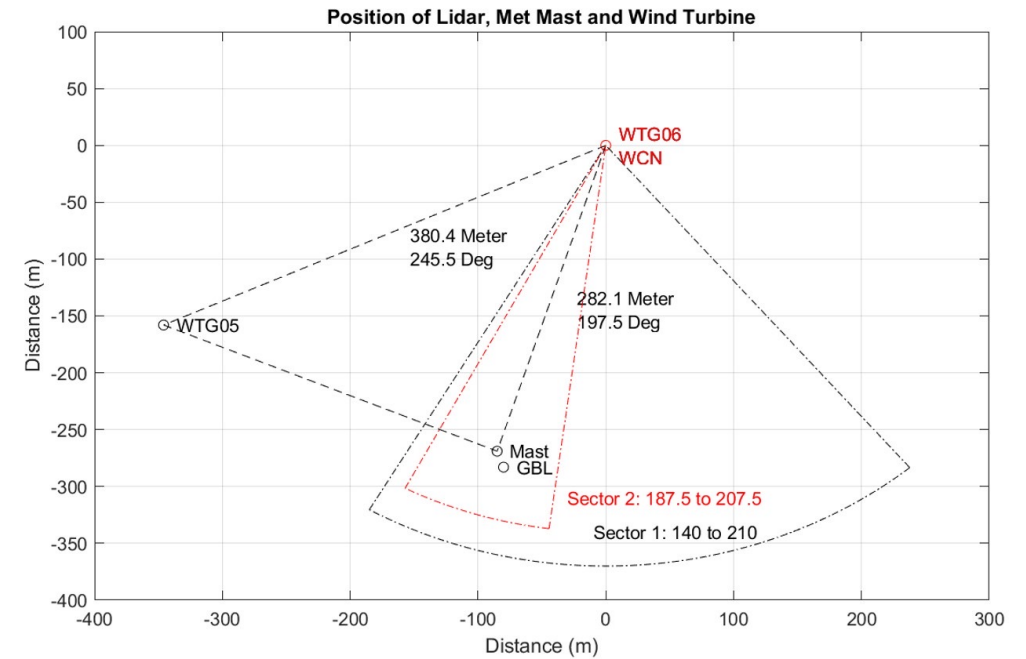


## Valid IEC wind sector: 140°- 210°



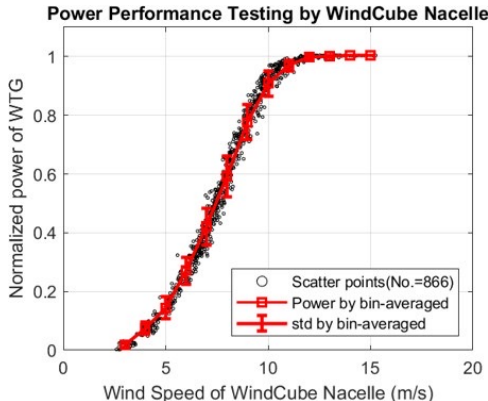
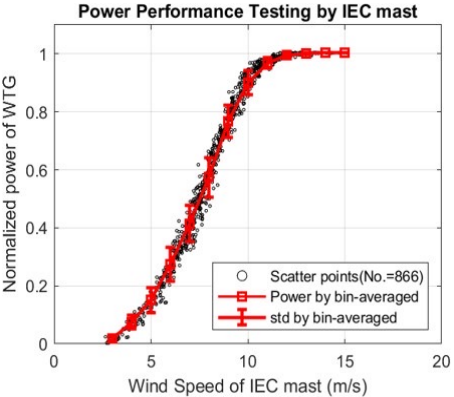
## Key takeaway

- Better wind speed correlation between the reference instruments and the nacelle lidar when using the smaller wind sector



# Power curve comparison

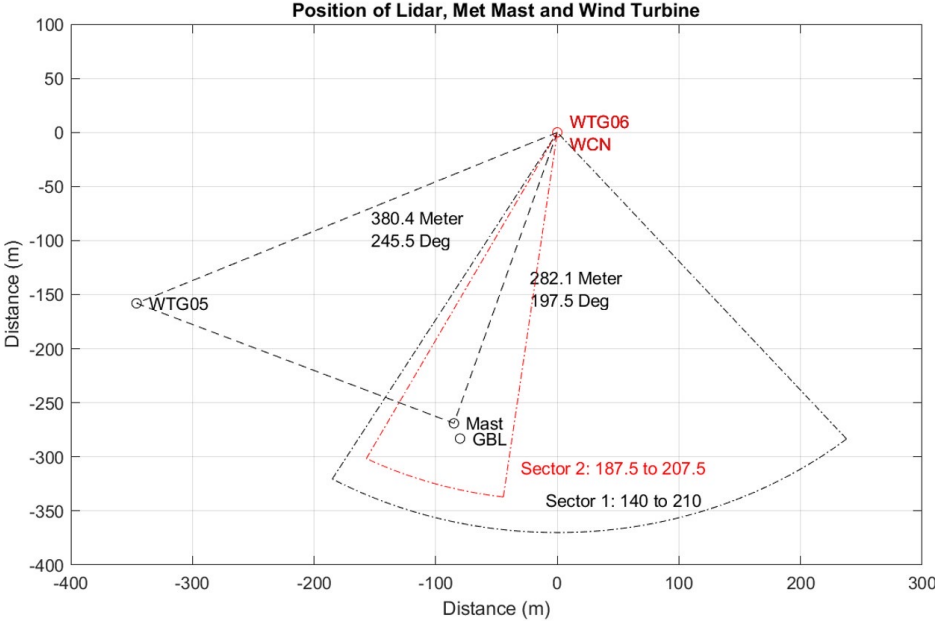
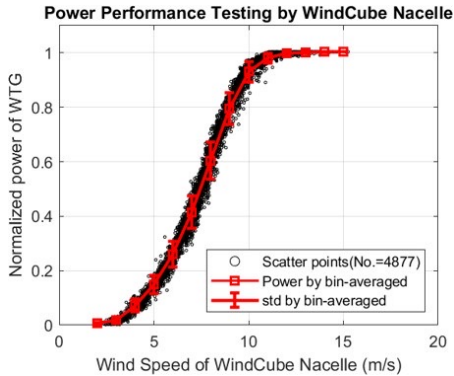
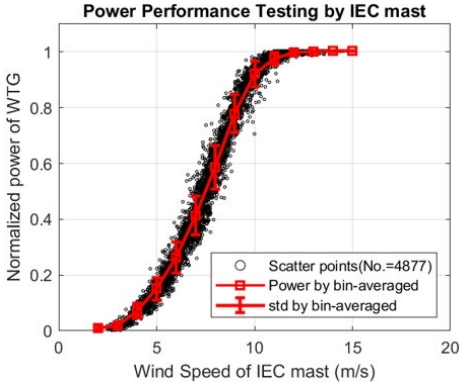
## Reference instruments centered wind sector: 187°-207°



## Key takeaway

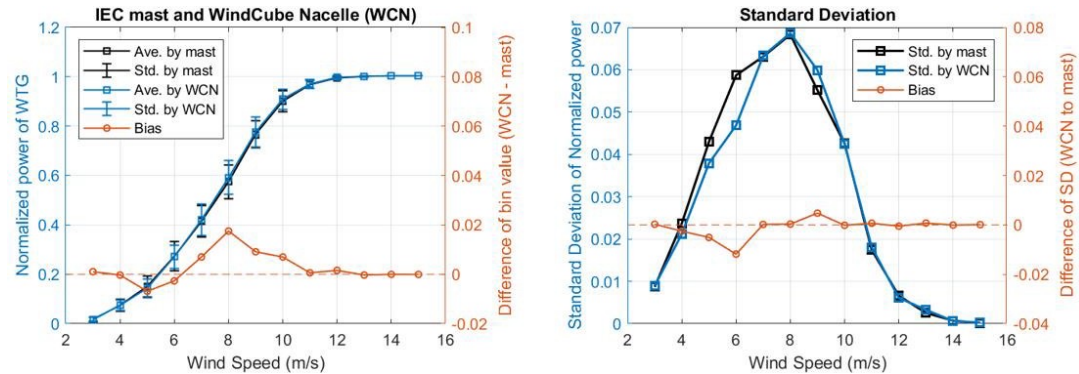
- Lower scatter observed for Nacelle lidar for the larger wind sector
- As it is always measuring in front of the turbine, Nacelle lidar is more representative of the wind hitting the turbine due to better spatial coherence for larger wind sectors

## Valid IEC wind sector: 140°- 210°



# Power curve comparison

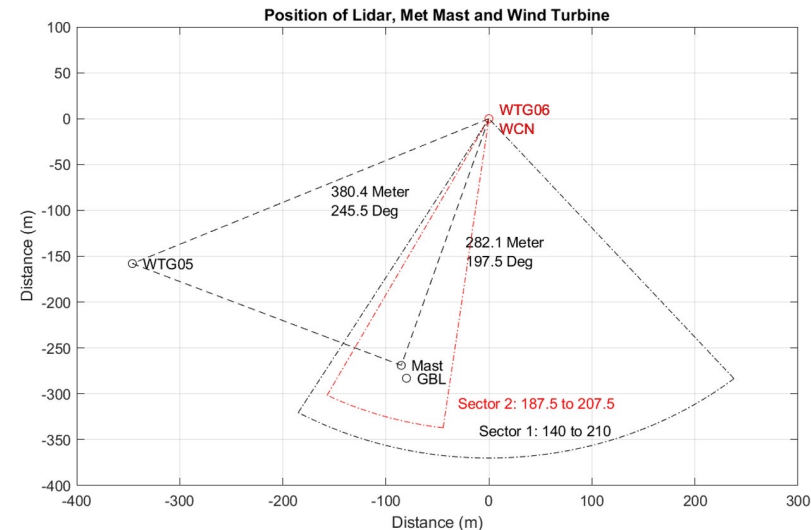
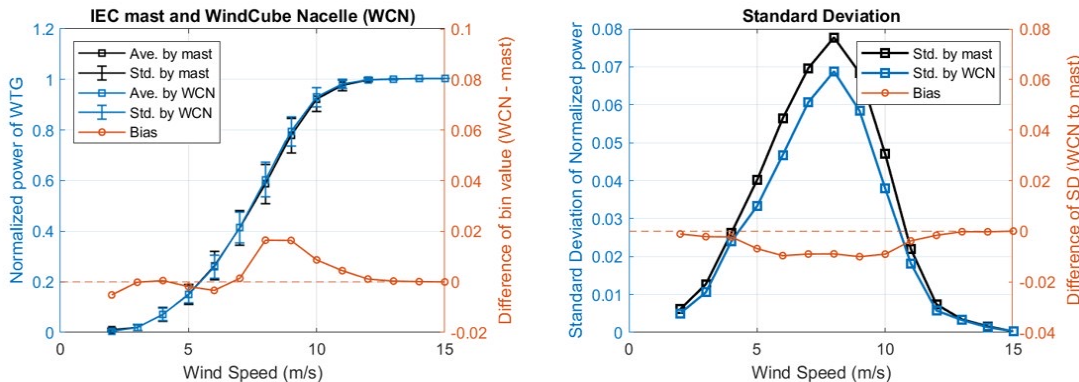
## Reference instruments centered wind sector: 187°-207°



## Key takeaway

- Bin-wise difference between the two power curves is  $< 2\%$  for both sectors.
- Power curve standard deviation is smaller for the nacelle lidar, especially when comparing the results for the wider wind sector.
- Can be explained by the better spatial coherence of Nacelle lidar measurements in the larger wind sector.

## Valid IEC wind sector: 140°- 210°

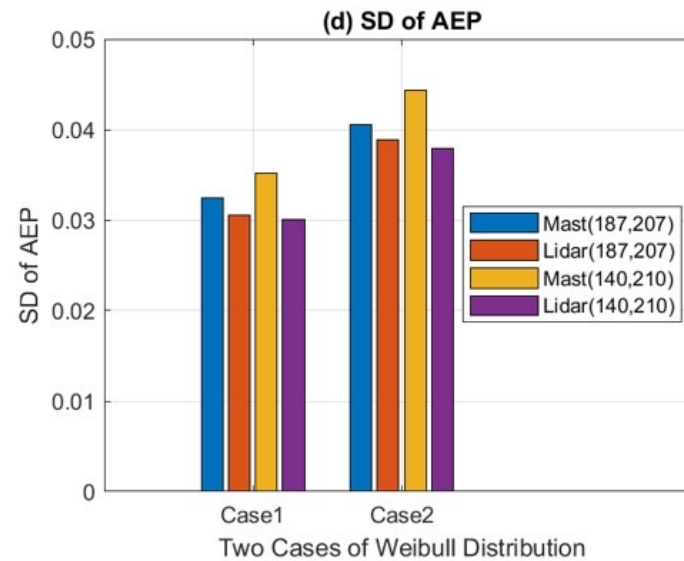
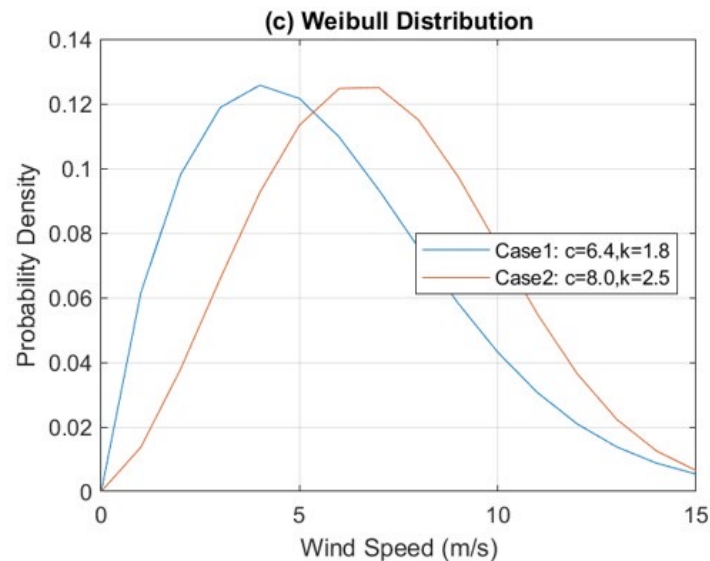


# AEP standard deviation

## Key takeaway

	Mast(187,207)	Lidar(187,207)	Mast(140,210)	Lidar(140,210)
Case1	0.032	0.031	0.035	0.030
Case2	0.041	0.039	0.044	0.038

- AEP standard deviation measured with the met mast is bigger than when measuring with the nacelle lidar.
- AEP standard deviation measured by the nacelle lidar is smaller when using the larger wind sector.
- This also highlights the better spatial coherence of the nacelle lidar measurements.





# Conclusion

- **Accurate measurements** compared to other IEC-compliant measurement instruments.
- **Lower uncertainty** due to better spatial coherence of nacelle lidar measurements.
- Pulsed lidar measurement capabilities can be used for other applications: **shear, veer, TI, REWS, yaw misalignment, NTF, blockage effects, etc.**
- **Ease of installation:** half of a day, following GE turbine installation guidelines.
- **Accepted** by developers, manufacturers, and consultants that are gaining more and more experience with the technology.

**Industry is getting ready for PPT using nacelle-mounted lidars on operational basis in preparation of IEC-50-3 standard release**



# Conclusion

## Alex James, Lead Performance Engineer - GE Renewables:

*“For GE, this study will be a key piece of the experience needed to incorporate nacelle-mounted lidar (NML) into our power curve warranties. The results are encouraging that NML can be a viable means to obtain quality wind field data, particularly the observed decrease in power curve standard deviation.”*



GE Renewable Energy

## Hong Liu, Engineering Senior Advisor - ENGIE North America:

*“For ENGIE, this study provided us with key information to optimize our power performance measurements program and gain some experience in using nacelle-mounted lidar to support operations and project development.”*



# Thank you

Contact: [robin.cote@vaisala.com](mailto:robin.cote@vaisala.com)

## Special thanks:

- Zhi LIANG, Vaisala
- Luke SIMMONS, DNV
- Hong LIU, ENGIE North America
- Alex JAMES, GE Renewables

**VAISALA**