

# Measuring the unpredictable

with the Vaisala WindCube Scan

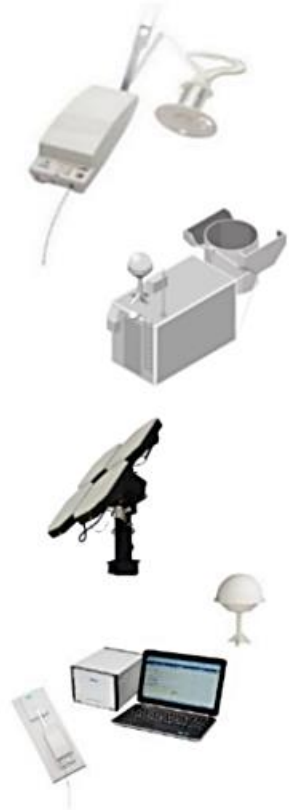
Robin Conseil

**VAISALA**

Workshop Minute Scale Forecasting for the Weather Driven Energy System  
10-11 April 2024 - DTU Risø Campus

# Environmental measurement technologies

Soundings



Pressure, wind, humidity, multiweather



Visibility, Present weather



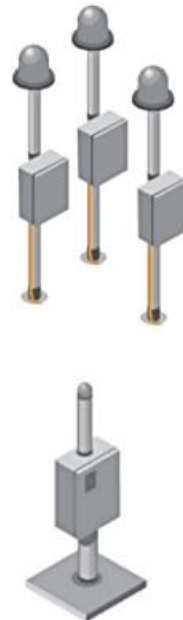
Ceilometers



Remote wind measurement



Lightning sensors



Road and aviation weather systems



Weather radars



Air quality sensors



# Vaisala and wind LiDAR technology

WindCube  
Vertical Profiler Lidar



- Ranges: 40 to 300+ meters
- 12 user-defined range gates
- Speed Accuracy: <math><0.1\text{m/s}</math>
- Buoy version

WindCube Scan  
Long-Range Scanning Lidar



- Typical operational range: 6km, 8km, and 10km
- Maximum range: 18.9km
- Configurable scanning patterns
- Radial wind speed accuracy: <math><0.1\text{m/s}</math>

WindCube Nacelle  
Turbine-mounted Lidar



- Range: 50 to 450+ meters
- 10 user-defined range gates
- Speed Accuracy: <math><0.1\text{m/s}</math>
- Hub height measurement

WindCube Nacelle  
Feedforward Turbine  
Control Lidar



- Range: 50 to 200+ meters
- 10 user-defined range gates
- Integrated to turbine control system

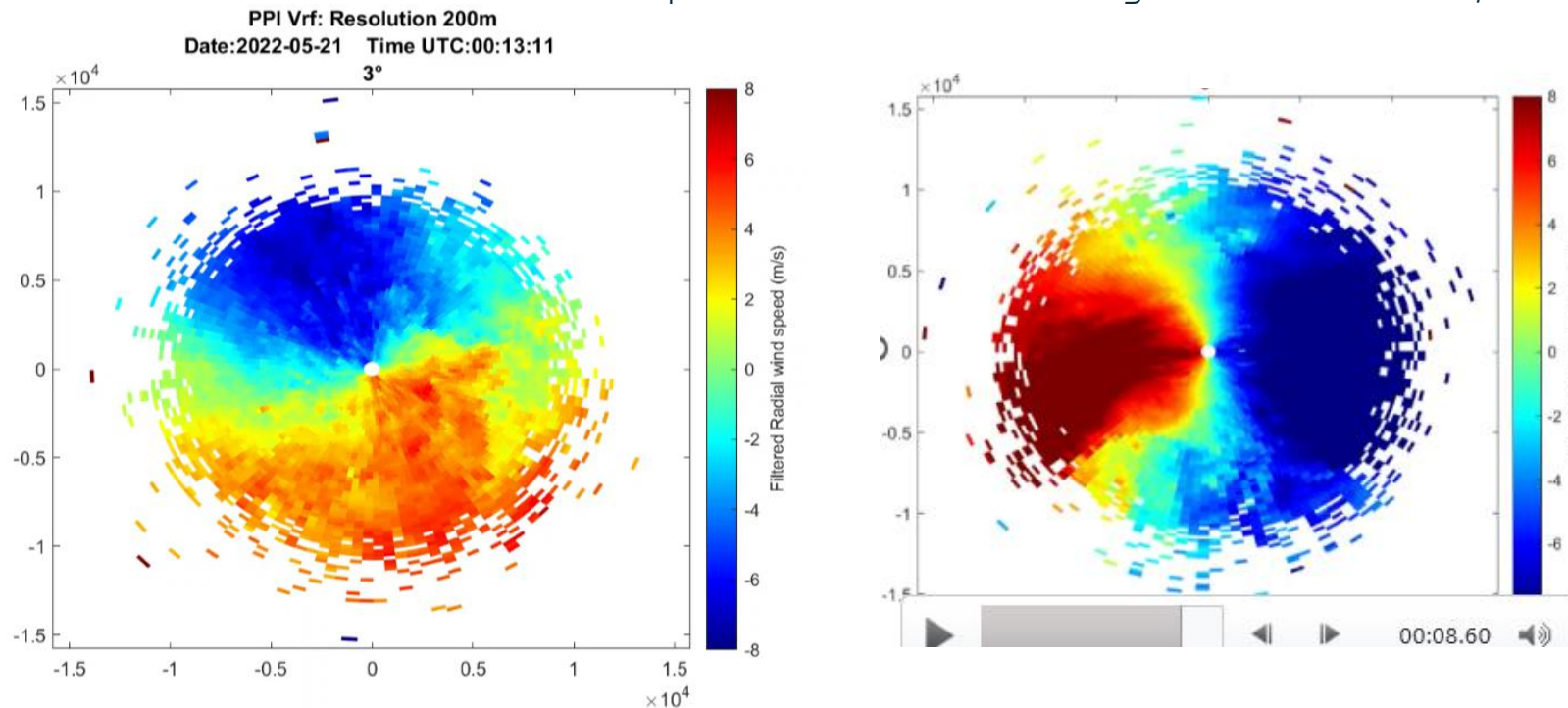
GROUND BASED

NACELLE MOUNTED

# Anticipating Wind Changes with the Vaisala WindCube Scan

- Sudden wind regime changes in speed or direction are difficult to predict and can severely affect the operation of renewable power plants. By using the Vaisala WindCube Scan ability to measure the incoming wind up to a distance of 10/15km, threats can be detected 5 to 20minutes in advance.

Abrupt Wind direction change detected 10km/20min in advance:

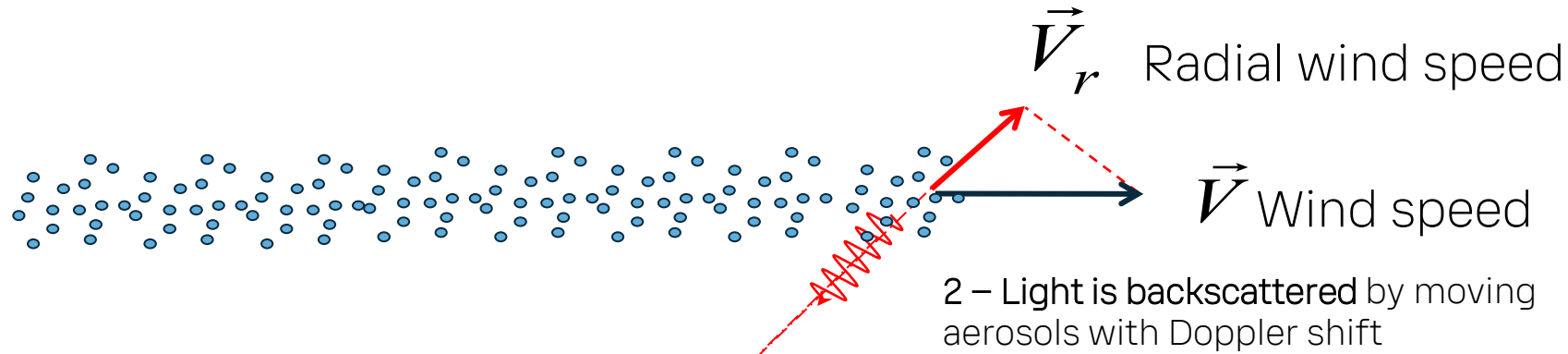


# WindCube Scan V2.1



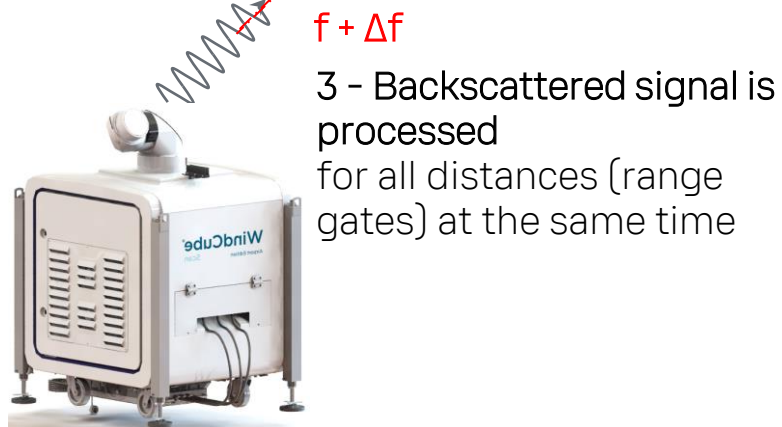


# Pulsed heterodyne Doppler LIDAR principle



1 - LASER pulses sent in the atmosphere with reference frequency  $f$

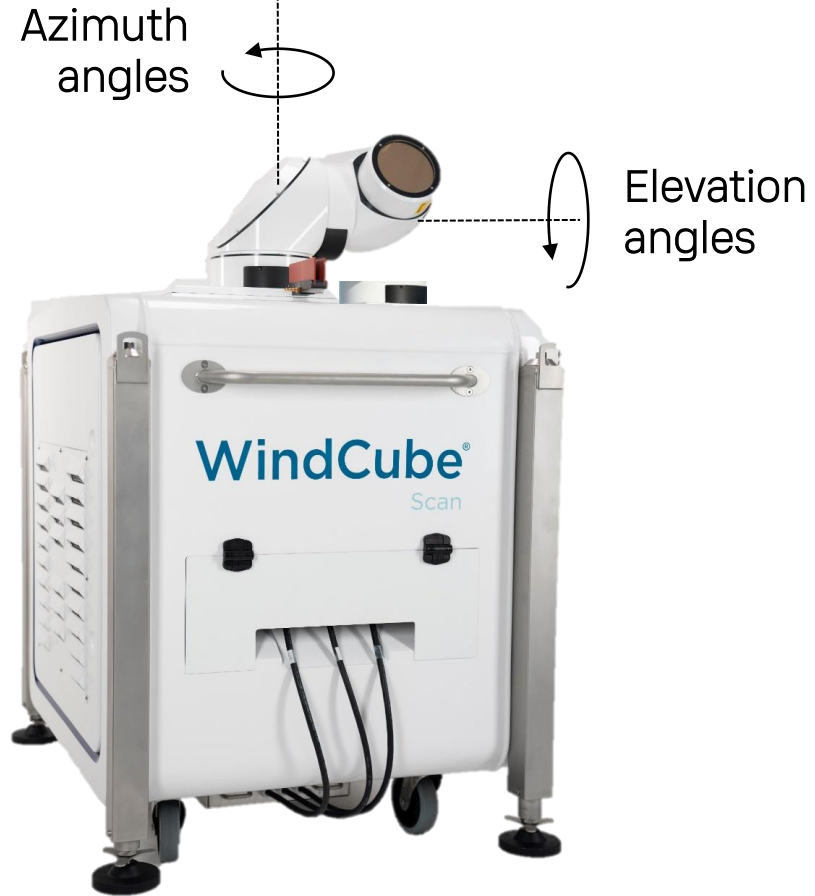
→ The Doppler shift is proportional to the radial wind speed.



# Improved scanning head - defrost



V2.0



V2.1  
launched end of 2022



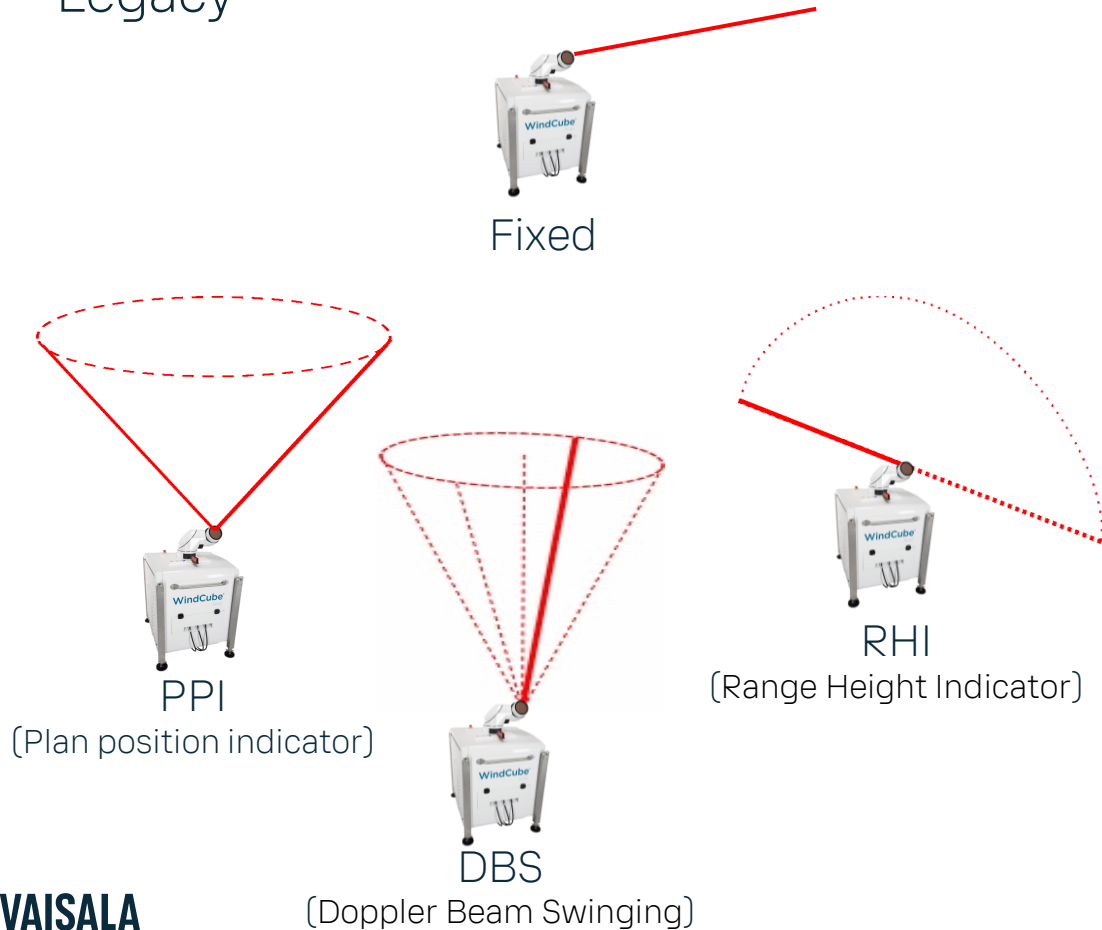
Heating OFF



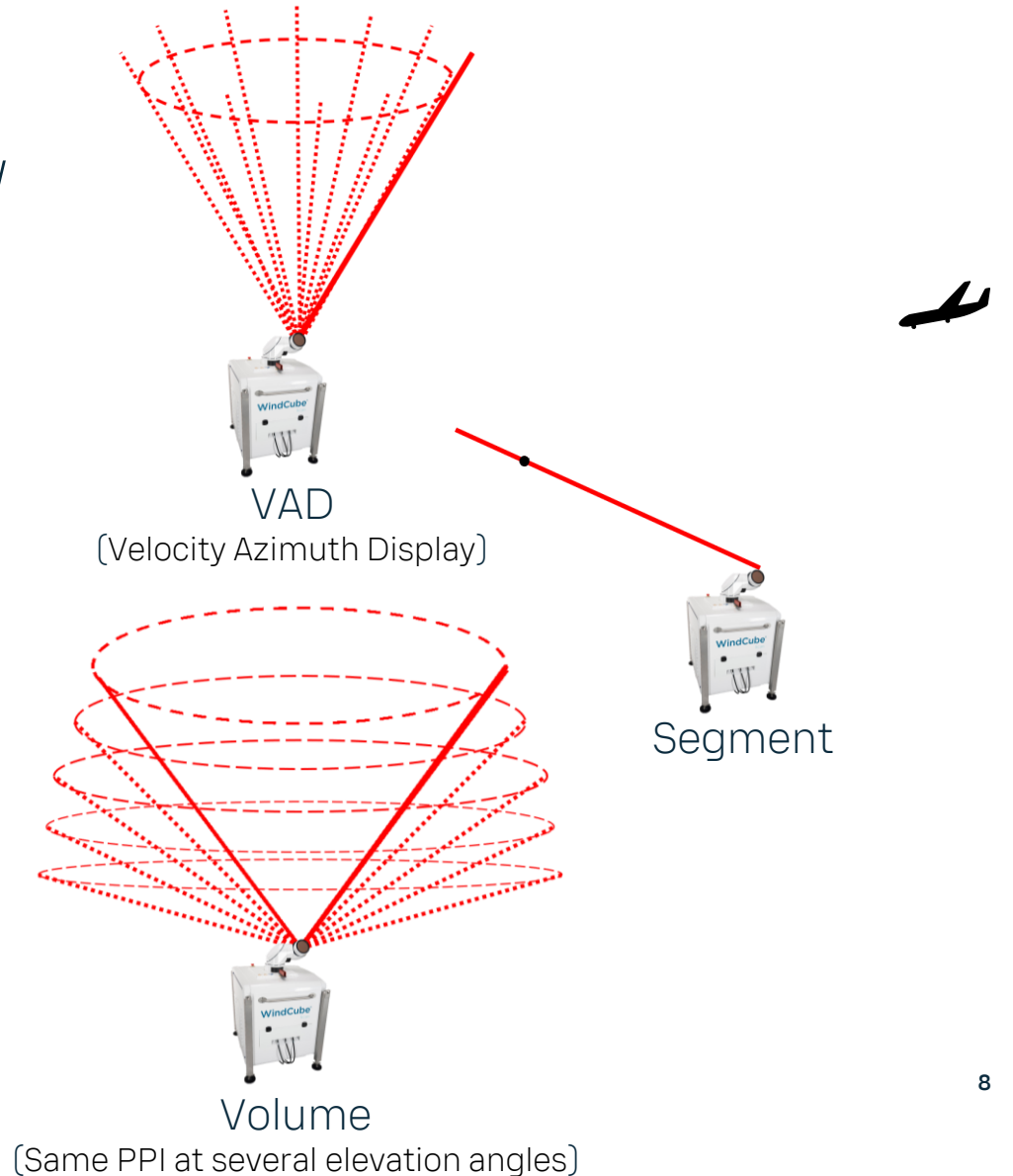
Heating ON

# Improved scanning head – new scans

- Legacy



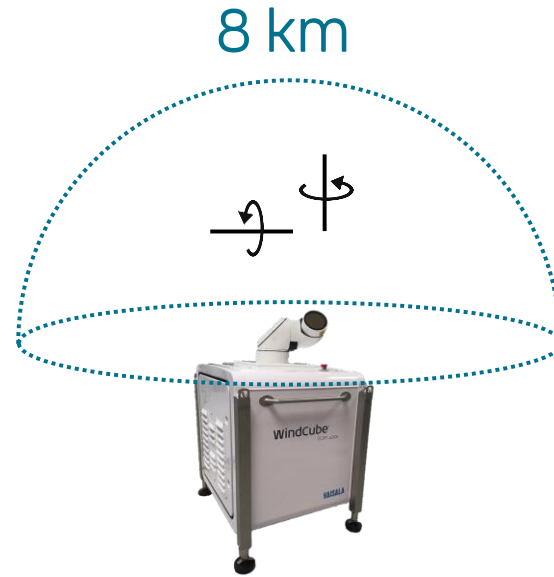
- New



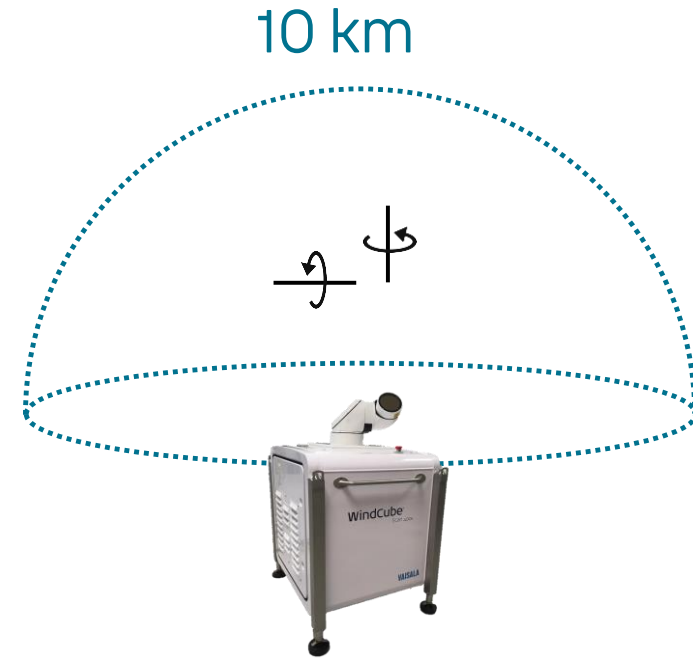


# Improved laser chain

- Maximum operational range improved for 200S
- High resolution modes (25 and 50m) available for 400S



200S



400S

Modes:

V2.0	V2.1	
25m	25m	} +TP
50m	50m	
75m	75m	
100m	100m	
	150m	

V2.0	V2.1	
	25m	} +TP
	50m	
75m	75m	
100m	100m	
150m	150m	
200m	200m	

# New PC – dual drive

- Additional SSD for data storage redundancy and instantaneous data export (swap)

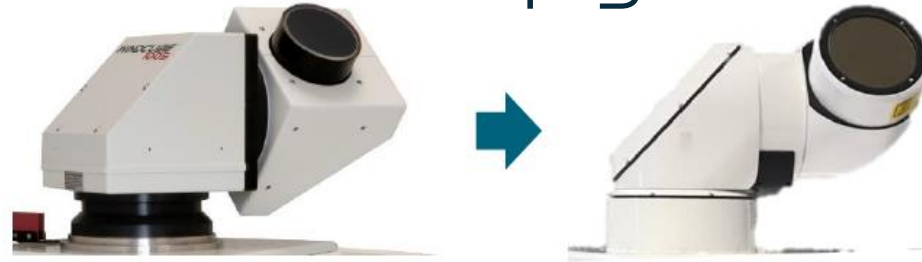


# New thermal management

- Temperatures range extended from  $[-30^{\circ}\text{C}, +45^{\circ}\text{C}]$  to  $[-40^{\circ}\text{C}, +55^{\circ}\text{C}]$
- Lidar average consumption reduced from 1600 W to 1100 W



# Hardware & Software Upgrade from V2.0



- **Eligibility**

The scanning head upgrade is compatible with the previous hardware version 2.0 (serial numbers 105 and from 109 to 323).

- **Content**

- A new scanning head (heated window and requires almost no maintenance)
- A new internal PC and its 2 SSD
- The latest version of the LiDAR software (new scans)

- **Deployment**

- The upgrade lasts half a day and can be performed onsite

- **Impact on maintenance and warranty**

- No scanning head swap during the heavy maintenance -> price is decreased approximately by 50%.
- the price of the warranty extensions, after a scanning head upgrade, will be decreased by approximately 50%.



# Concentrated PV and thermal storage application



RayGen

Carwarp – VIC – Australia

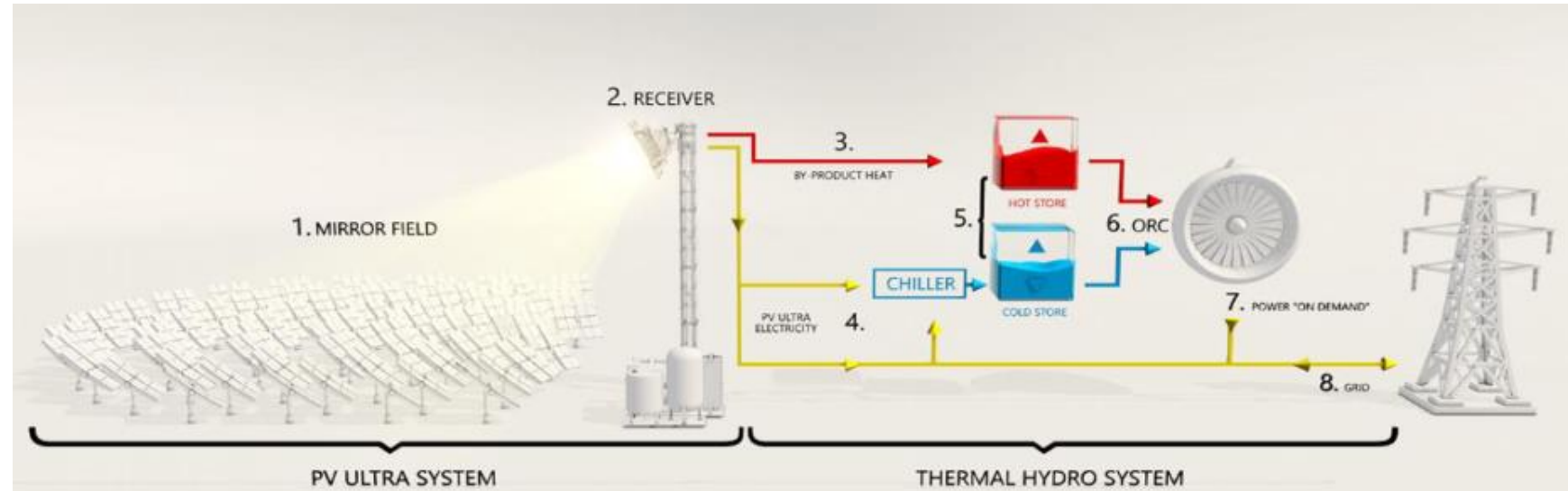
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[raygen.com/carwarp/](http://raygen.com/carwarp/)



# RayGen test facility in Carwarp, VIC Australia

- Four solar towers each generate 1MW of electricity and 2MW of heat. Two 17,000m<sup>3</sup> water pits store enough thermal energy to drive a 2.8MW ORC turbine for 17 hours (50MWh).



<https://raygen.com/technology/>



# Protection of the heliostats from wind gust



Heliostat mirrors in operation

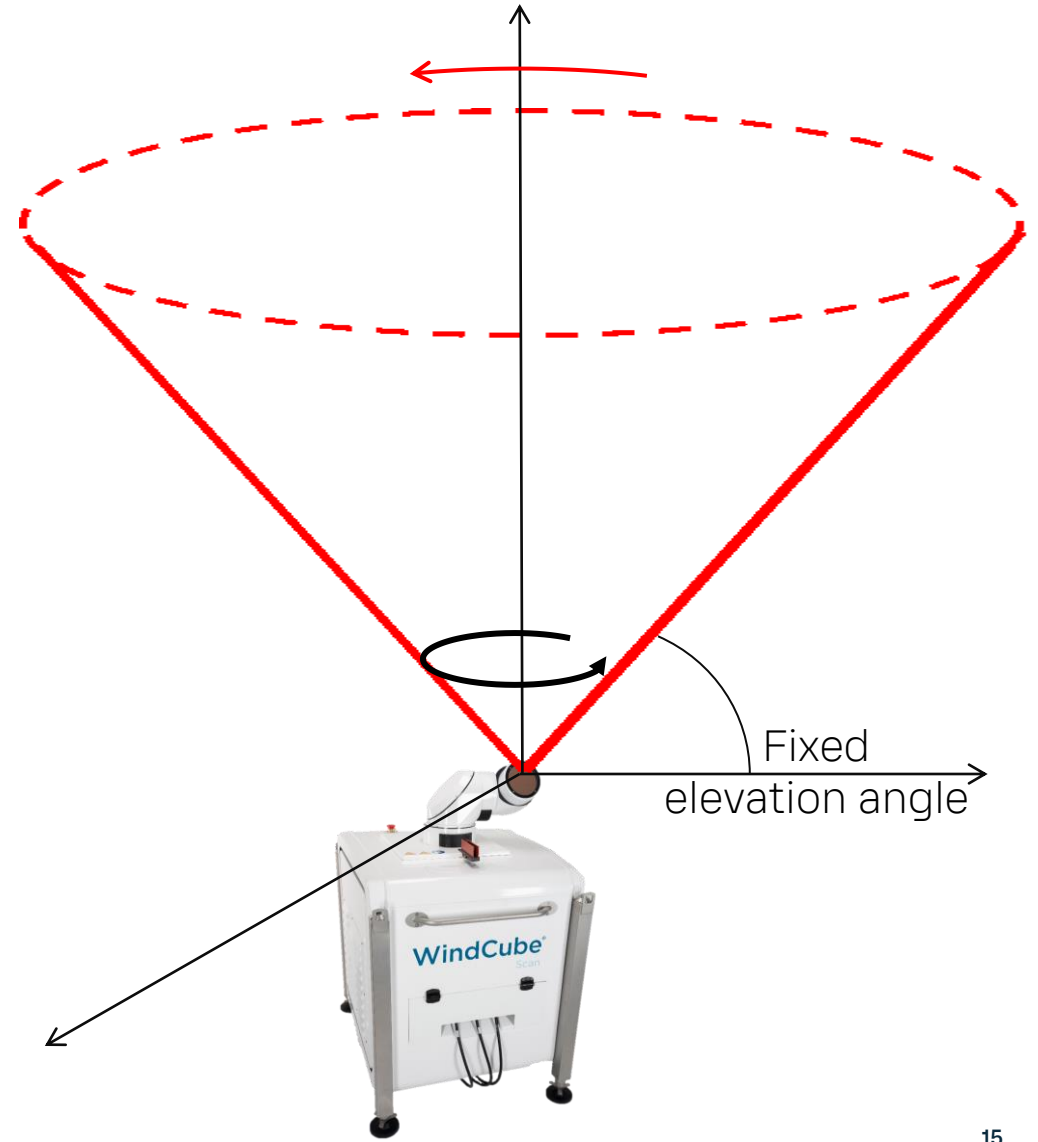
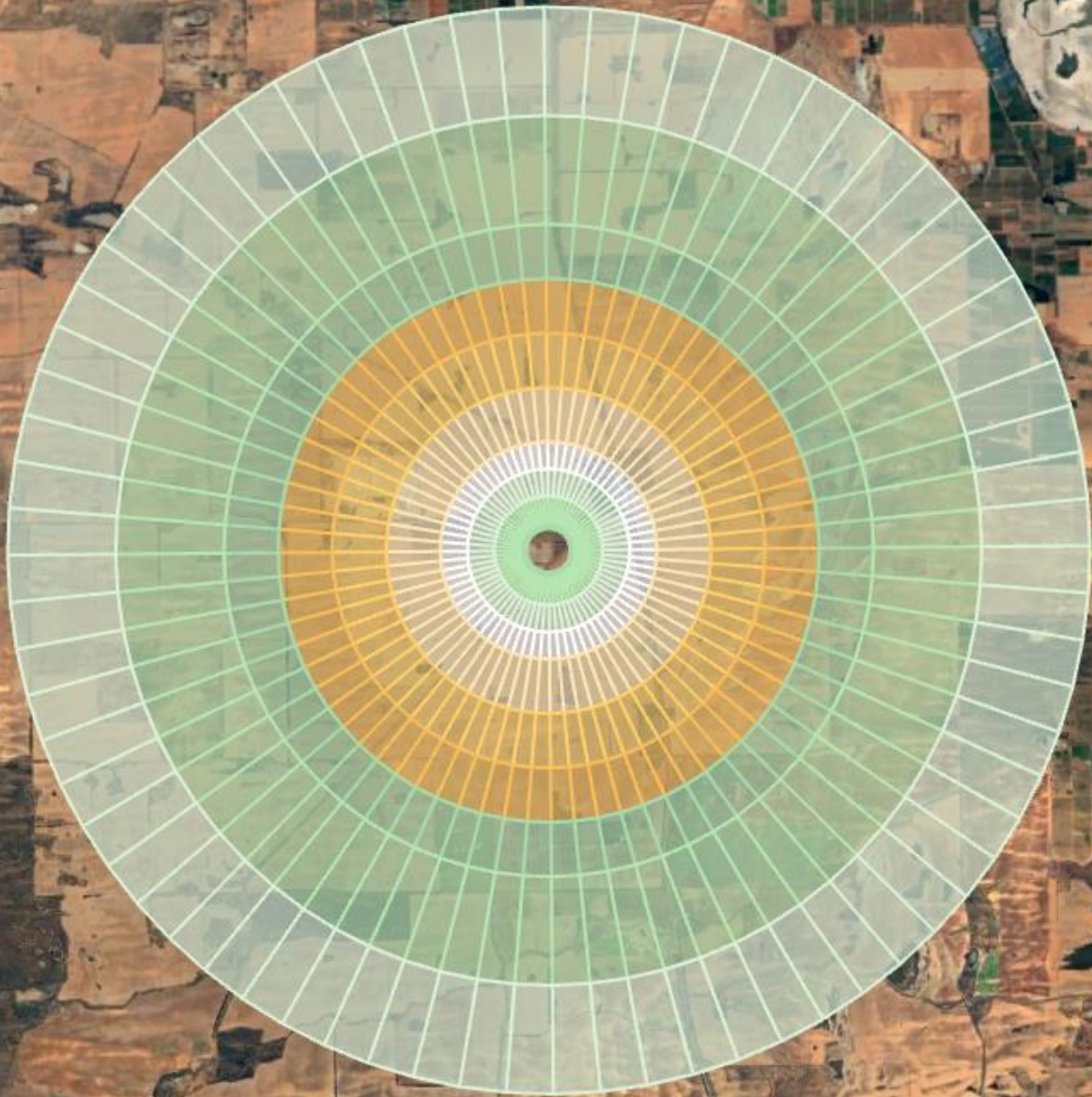


Stowed position

Heliostats take up to a few minutes to move to their horizontal 'storm-stow' orientation – whereas wind speed can increase almost instantaneously. By detecting incoming wind gust 10km in advance, heliostats move to stow position before the wind becomes excessive.



# LiDAR measurement at low elevation...



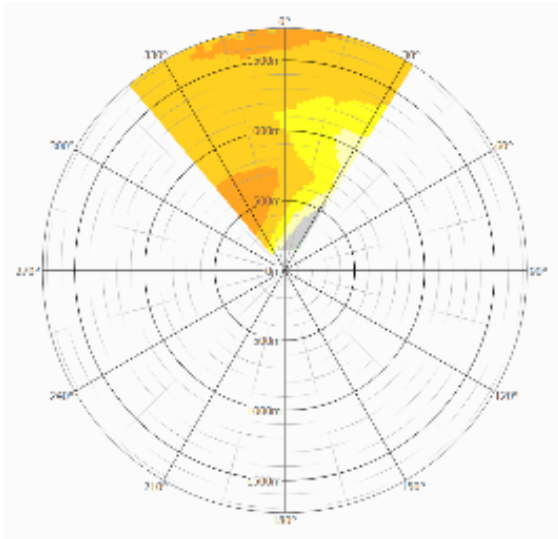
Plan Position Indicator scan (PPI)



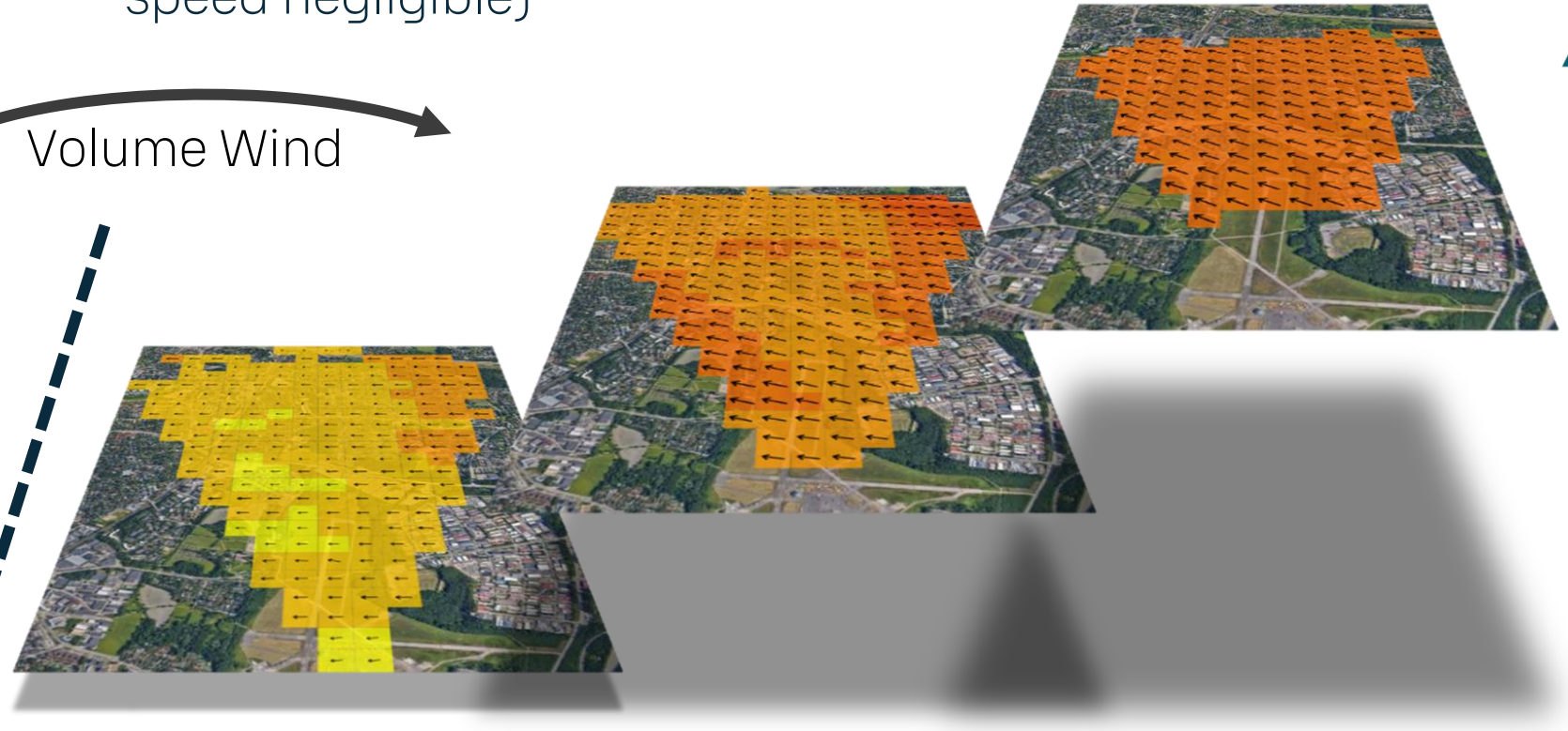
# ...to map the horizontal wind speed with the **Volume Wind** post-processing tool.

Volume Scan or PPI with different elevations

2 hypothesis (local wind homogeneity and vertical wind speed negligible)



Volume Wind

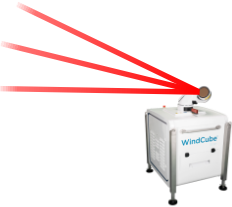


# Volume Wind Process

*Your own analysis*

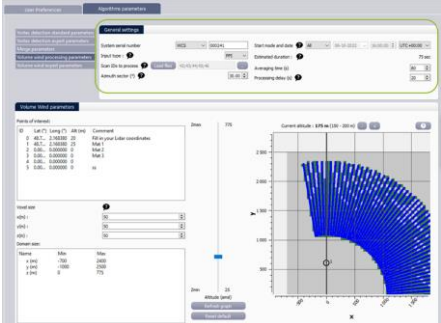
NetCDF files  
Cartesian and polar

*Representation of wind direction and intensity with a map layer*

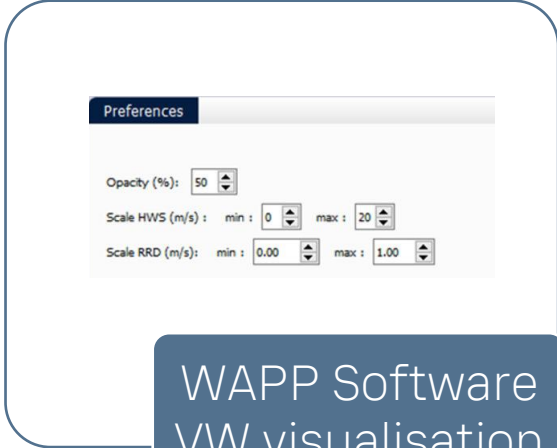


WindCube Scan Data

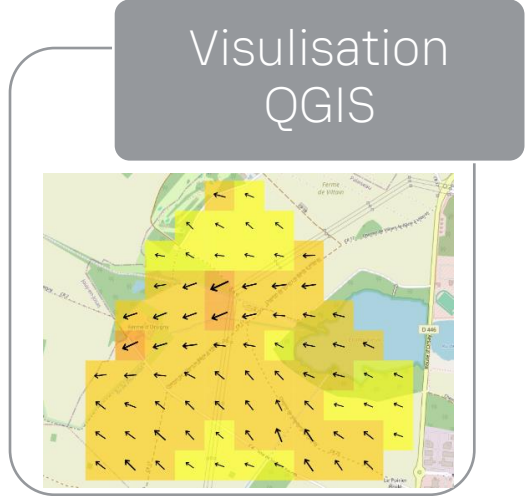
WAPP Software Volume Wind



WAPP Software VW visualisation



Visualisation QGIS

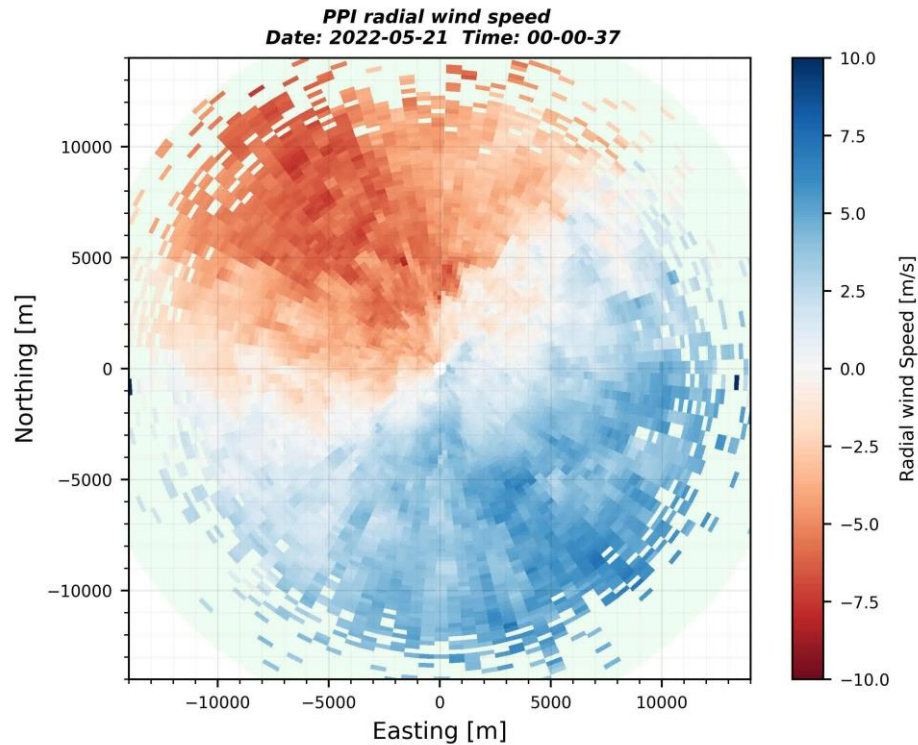


NetCDF files  
PPI or Volume

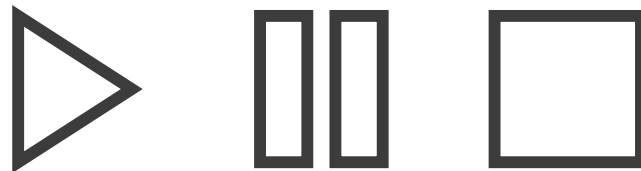
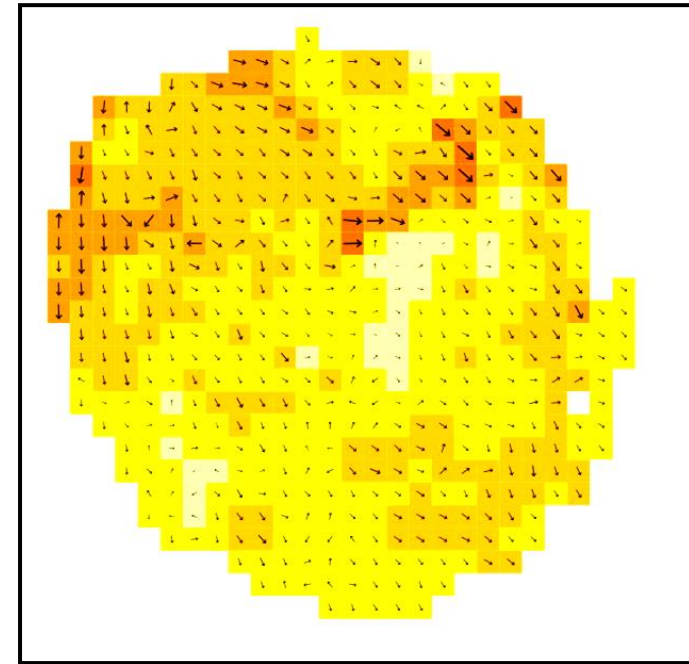
Files compatible  
with QGIS

# Volume Wind output example

Measured Radial Wind Speed



Reconstructed Horizontal Wind Speed



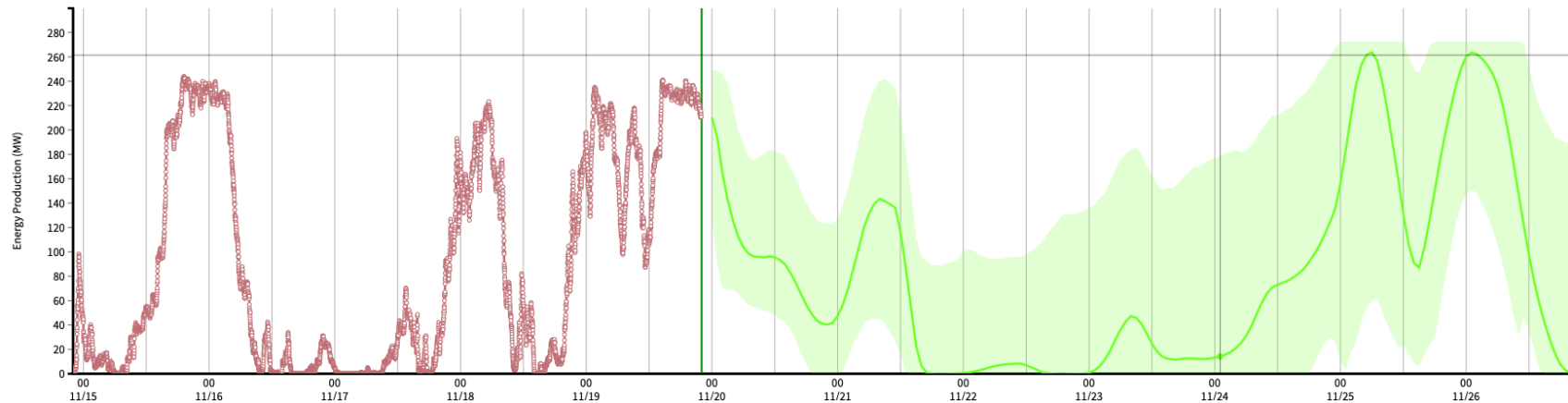




# Weather confidence for energy

<https://www.xweather.com/>

Focused on forecasting for individual projects (like this 270 MW wind farm shown here) and entire markets (like all of Texas/ ERCOT).



# Thank you!

**VAISALA**



**Q&A**

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