Scanning lidar in wind energy

Key applications and benefits

eBook

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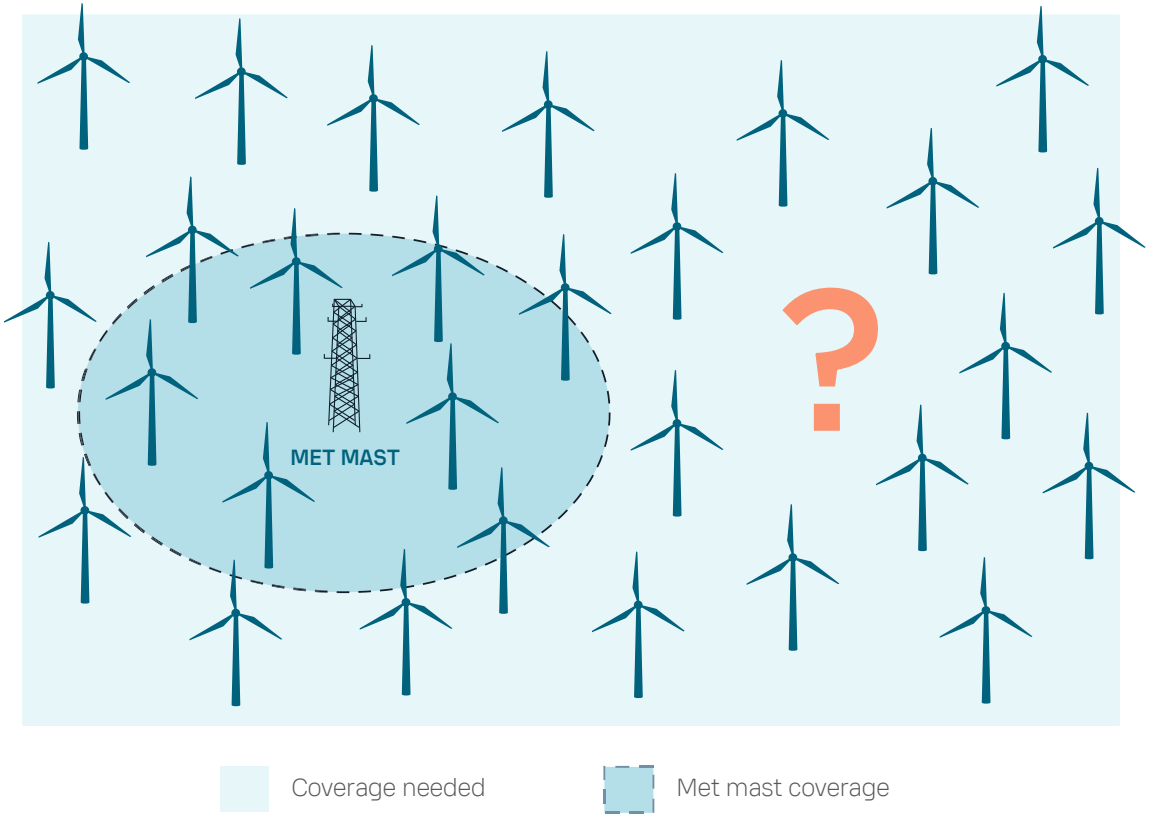
When certainty is the most valuable resource

In wind energy, millions of dollars depend on developers' and operators' ability to reduce risk and establish certainty. But certainty is hard to come by, whether it's in wind measurement and performance estimations, power assessments, wake and blockage impacts, or other factors.

That's because, all too often, the available wind data is based on historical records, outputs from met masts that likely don't cover the whole operating region or rotor sweep of today's modern turbines, and extrapolations that can introduce bias.

It's like building a puzzle with some of the pieces missing. You might be able to identify the general picture, but you can't understand the details.

In wind energy, the details are where money is made and lost.



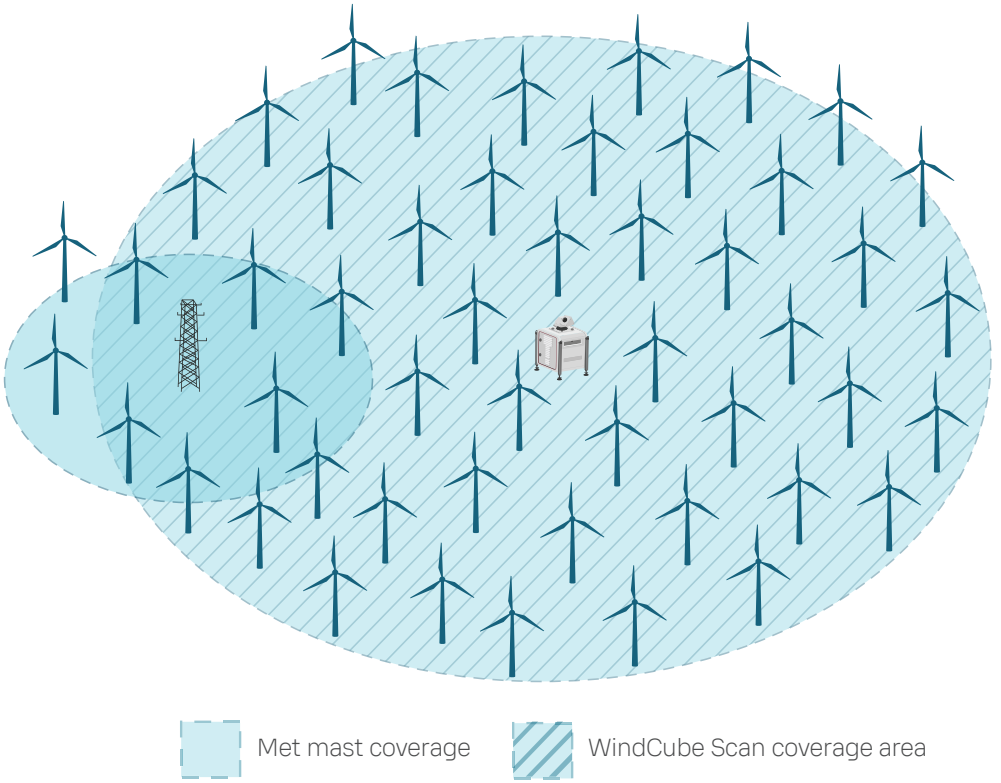
The arrival of scanning lidar

Lidar is not new to wind energy. By now, users across the globe have deployed and validated thousands of lidar units — particularly vertical profilers — for various purposes. They have emerged as the ideal supplement (and sometimes replacement) for met masts and other traditional wind assessment methods.

But today, progressive companies — especially offshore developers — are also using scanning lidar for an even fuller, 3D understanding of the wind environment.

In part, scanning lidar is a response to recent trends in wind energy. Wind parks, particularly in Europe, are being built closer to each to other and are influencing each other's energy production. Offshore projects are also becoming more common, complicating wind resource assessment and other processes. Additionally, today's turbines are much larger than those of even 10 years ago, which brings both potential and risk. Their performance and bankability are becoming harder to assess.

This ebook explains the principles and key applications of scanning lidar — and shows why it's becoming some companies' new secret weapon in the quest for certainty.

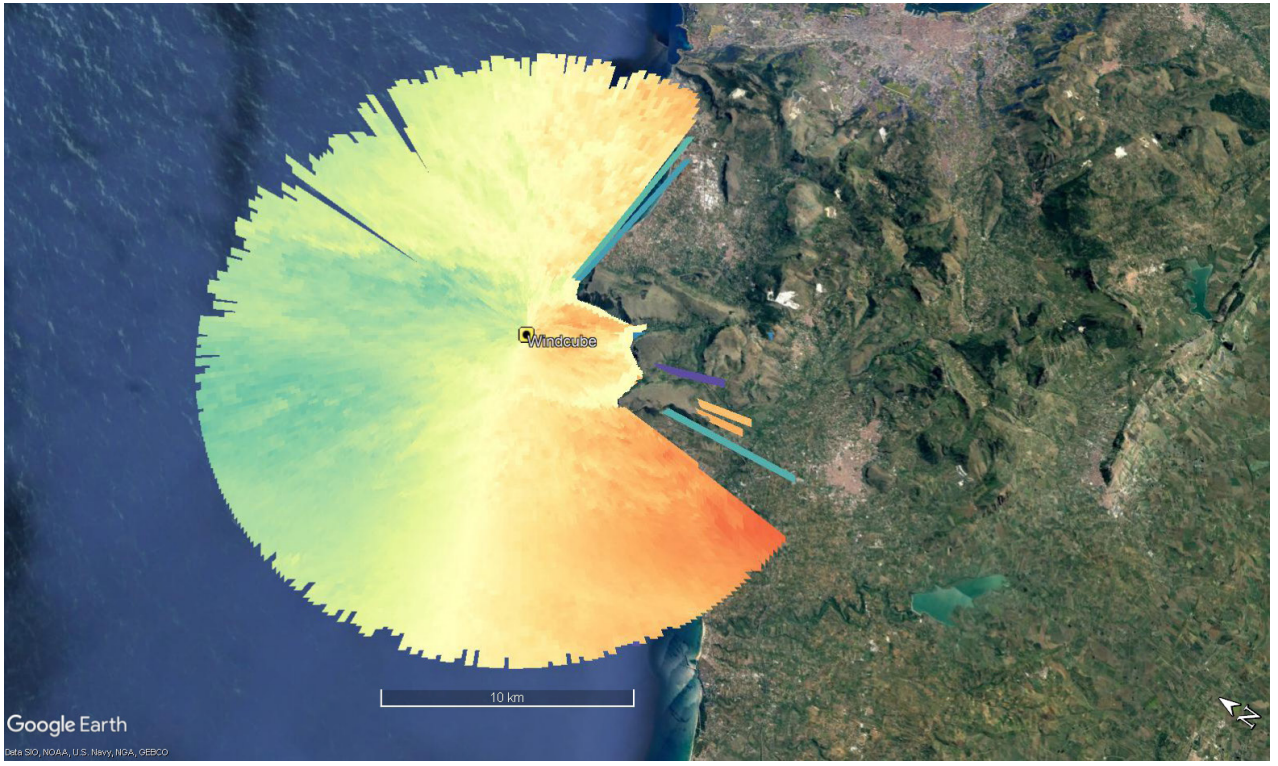


How scanning lidar works

Like a vertical profile lidar, scanning lidar uses laser pulses that are sent into the atmosphere and reflected by aerosols or particulates traveling within it. When the light is backscattered and returned to the lidar unit, the Doppler shift can be calculated, providing an accurate wind speed measurement.

Unlike vertical profilers, however, scanning lidar units measure across 360° using several scanning patterns, up to ranges of 18km in the case of Vaisala's WindCube® Scan, which is covered in detail later.

This provides 3D spatial wind awareness and, among other benefits, allows operators to assess several turbines at once. This creates enormous efficiency, increases wind assessment certainty, and improves both the quality and the quantity of available wind data.



Reducing spatial uncertainty

Improving certainty, decisionmaking, and bankability

Wind developers are familiar with using mathematical models to estimate the wind characteristics of a farm site. However, these models are usually based on several limiting assumptions and are missing the true complexity of the atmosphere, as well as complex terrain and weather effects.

As a result, relying on traditional models requires some educated guesswork on the part of the developers.

Scanning lidar dramatically reduces this guesswork, allowing developers to check and refine existing wind models. Because the lidar provides so much more localized data and less spatial uncertainty, developers can add correction factors to their models and optimize them over time.

This is especially valuable for offshore development, where wind farms are the largest and met masts either don't exist or cannot be installed. Scanning lidar can be operated onshore while measuring offshore areas, or located on remote platforms, dramatically increasing the range and detail of wind data.

The practical outcome of this awareness is reduced vertical and spatial uncertainty. Planners can make better turbine selections (creating financial and performance benefits through the life of the site) and understand the performance impacts of neighboring wind sites. They can also validate and improve other measurement outputs, improving the financial viability of a project.

More and more offshore developers are choosing scanning lidar to fill important gaps in their wind data.

Case studies

WindCube Scan 400S campaign

For 6 weeks, ENGIE used a WindCube Scan 400S conveniently deployed on the shore to measure offshore in the Southern Coast of France.

Challenge:

Spatial uncertainty from mesoscale models is up to 2.5%, and every uncertainty has a financial impact.

Solution:

Calibrate the mesoscale model with WindCube data.

Results:

Significant error from the model was detected near the coast, so a correction factor was added.

WindCube Scan 400S campaign

For 4 months, Carbon Trust and RES used several lidar measurements on the shore to measure offshore in the Dublin Bay.

Challenge:

Spatial uncertainty was a problem here as well, likely creating negative financial impact.

Solution:

Use different scanning lidar configurations to measure spatial variation in wind resource offshore.

Results:

Spatial uncertainty can be reduced to 1.3% by using scanning lidars.

Managing turbine and farm interactions

Understanding complex influences

As today's turbines increase in size and power, one turbine can have a significant effect on another. Multiply those effects by the turbines on an entire farm and the downstream consequences can be large — even on neighboring wind farms.

To address this, developers need a reliable understanding of wake effects and the ideal wind farm layouts. This allows them to avoid performance sacrifices within their own farm, plan expansions more effectively, and mitigate problematic interactions with neighboring farms.

Scanning lidar provides a real-time check of multiple turbines' wake effects, which allows customers to optimize design and construction. If developers and operators do their wake assessments early, they can choose different turbines or yaw angles to optimize the secondary turbines' performance.

The startling costs of blockage and wake effects

Lidar is finally helping developers and operators understand the costs of blockage and wake effects, which can rise to the millions or billions over time. Only with a solid understanding of these complex influences can operators protect their investments and get the most from their wind farms.

Case studies

WindCube Scan 100S campaign

For 4 months, a WindCube Scan 100S was used on the FINO1 platform in Germany in order to analyze the performances of a wind turbine from the Alpha Ventus wind farm.

Challenge:

A significant part of the Annual Energy Production (AEP) uncertainty comes from models.

Solution:

Make high-resolution measurements with a scanning lidar and calibrate the wake models.

Results:

A near-wake and a far-wake model were proposed, and the scanning lidar allows operators to bridge the gap between the models and the data observed.

WindCube Scan 200S campaign

For 6 months, Goldwind used a WindCube Scan 200S to characterize the wind field within part of a wind farm.

Challenge:

AEP and wind farm layout deduced from a model can have high uncertainties.

Solution:

Use a scanning lidar unit to characterize the wake effect of several wind turbines.

Results:

The influence of multiple wakes was analyzed, and a wind turbine was observed to be in the wake area of another wind turbine. This identified an important AEP loss not considered in the development phase, and identified ways to improve wind farm design and operation.

Innovating for higher performance

Innovations coming to wind energy

With so much flexibility and wind knowledge provided by scanning lidar, the industry is evolving rapidly. Two important examples are short-term forecasting and power curve testing.

Short-term forecasting

In R&D studies, properly placed scanning lidar units reliably give operators 5–10 minutes of advanced notice if a storm or wind disruption is headed toward the wind farm. This could benefit operators as well as power grid managers, potentially allowing them to proactively manage energy production and its introduction into the grid.

On the operator end, this warning time might allow for adjustments (or even shutdown) of turbines ahead of a dramatic wind or storm event.

Power grid managers, noticing a surge or drop in wind farm production, might anticipate what other power source might be used to compensate in the short term.

Power curve testing

Power curve testing can be burdensome for developers and operators. But with scanning lidar, several turbines can be assessed at the same time — dramatically lessening the burden and providing better data. The lidar also provides simplified installation and operation. It is often used onshore or on a platform for offshore measurement, since it can measure up to 18km, making it mobile and simple to install and maintain.

Scanning lidar provides an important baseline understanding of the entire turbine fleet. Over time, operators can spot-check turbines to see how well they are performing against estimates. One related benefit is that, as OEMs start to sell performance upgrades, operators can use their baselines to judge whether the upgrade is worth it.

For short-term measurement campaigns, a rented scanning lidar permits customers to obtain baseline data and then either return or reassign the lidar units, reducing financial outlay.

Case studies

WindCube Scan 100S campaign

For 3 months, SSE used a WindCube Scan 100S on the transition piece of a wind turbine in the Greater Gabbard wind farm in the UK in order to make a power curve verification.

Challenge:

In cases where there is no offshore met mast to do power curve verification, installing one can be very costly. A nacellemounted lidar also might not be an option due to wind turbine warranty constraints.

Solution:

Obtain hub-height measurements with the scanning lidar from the transition piece.

Results:

The power curve assessment was successful, and the study suggested that PPT for several turbines can be performed at the same time with just one lidar unit. The lidar data was shown to be equivalent to met mast data.

WindCube Scan 100S campaign

For 3 months, Oldenburg University used three WindCube Scan 200S units for short-term forecasting offshore.

Challenge:

Grid operators require accurate and short-term forecasting of electricity production, and the electricity market requires high reactivity.

Solution:

Use three scanning lidar units to measure up to 6km distant and forecast near-coastal wind conditions with lead times of 5 minutes.

Results:

The scanning lidar units are likely to decrease uncertainties compared to statistical models, since any wind changes are measured directly and not assumed (or missed completely), as with models.

WindCube Scan

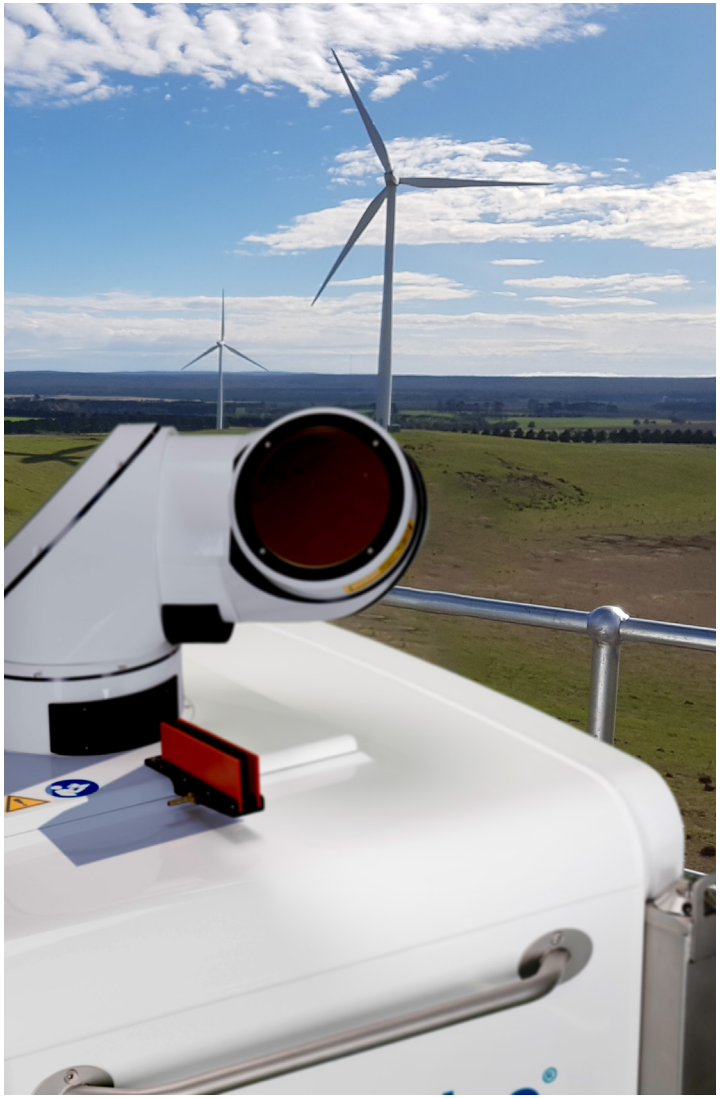
Long-range wind awareness for certainty and decision-making

WindCube Scan is the industry-standard scanning lidar. It provides full 3D scanning up to 18km and multiple scanning patterns, making it ideal for many campaign types. Built on proven, reliable WindCube technology, the system provides outstanding uptime, reliability, and user-friendly software.

The system is well-suited for short-term development campaigns or long-term operations, and its rugged, industrial design withstands extreme environments. Importantly, its data is easy to export, understand, and put to use.

WindCube Scan series specifications

	200S	400S
Typical wind measurement range	8 km	10 km
Maximum acquisition range	>15 km	>18 km
Scanner rotation speed	Up to 50°/s	
Accumulation time	From 0.1s to 10s	
Data transfer	Graphical User interface / FTP / SSD swap /API/4G connectivity	
Data format	NetCDF data format	
API type	REST web API	
API functionalities	Lidar scan configuration and monitoring; status/activities/logs monitoring; data download (JSON stream and NetCDF files)	
Dimensions	830 x 1008 x 1355 mm (L × W × H)	
Weight	220kg	
Temperature range	-40° to +55° C	
Power consumption	1100W maximum average power with brief peaks up to 1600W	



Conclusion: Toward awareness and certainty

Wind energy is changing. Larger turbine designs, big offshore wind farms, and plenty of other factors are disrupting the field — but there are new tools for obtaining certainty in an environment where even 0.1m/s of wind speed can amount to millions (€) of gain or loss.

WindCube units are in service around the globe with some of the world's largest wind energy players, as well as plenty of smaller, emerging ones. They provide the rich data that developers, operators, manufacturers, service providers, and many more stakeholders need to make better decisions and maximize the return on their investments.

Support and services you can count on

Wind energy isn't just about technology. It's about having the backing of a global partner that can directly support your business end-to-end, with complementary services, robust customer service, and consultation. Today, WindCube lidar technology is also backed by Vaisala's 80 years of experience and worldwide services.

Learn more about how scanning lidar can help you improve certainty, efficiency and bankability.

WindCube®

The gold standard

WindCube® is the iconic and trusted gold standard in wind lidar. The turnkey product suite offers innovative, reliable, and highly accurate solutions for thousands of customers across the globe. Borne from a passion to advance the field, WindCube continues to take wind energy ever higher through a commitment to four guiding principles:

- Trustworthy, superior metrology
- Unrivaled thought leadership
- Innovative lidars from a one-stop shop
- Easy, reliable global solution

Why Vaisala?

We are innovators, scientists, and discoverers who are helping fundamentally change how the world is powered. Vaisala elevates wind and solar customers around the globe so they can meet the greatest energy challenges of our time. Our pioneering approach reflects our priorities of thoughtful evolution in a time of change and extending our legacy of leadership.

Vaisala is the only company to offer 360° of weather intelligence for smarter renewable energy, nearly anywhere on the planet. Every solution benefits from our 85+ years of experience, deployments in 170+ countries, and unrivaled thought leadership.

Our innovation story, like the renewable energy story, continues.

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