VAISALA

Permanent lidar for wind energy farms

Technical Guide

Optimize performance at every stage

Onshore and offshore, wind lidar is replacing meteorological masts (met masts) for accurate wind measurements: It's more cost-efficient, safe, and fast to deploy — perfect for today's growing turbines. The benefits easily carry over into every phase of operations.

Permanent lidar enhances the efficiency, safety and profitability of wind farm operations throughout the entire lifecycle, making it a valuable tool for the renewable energy industry. It is a reliable solution for providing continuous, accurate, real-time wind measurements.

After a Wind Resource Assessment has been completed, a permanent lidar can operate standalone or alongside a met mast to provide wind measurements for several applications, helping to optimize performance, minimize safety hazards, lower maintenance costs, and reduce OPEX and CAPEX expenses.

At-a-glance: Applications at the turbine and farm level

- Safely operate cranes during installation
- Monitor performance, diagnose underperformance
- Optimize performance
- Monitor meteorological conditions
- Run real-time diagnostics
- Ensure safe operation and maintenance
- Validate configuration after maintenance or modification
- Conduct Power Performance Testing (PPT)
- Detect yaw misalignment
- Implement accurate curtailment
- Forecast energy production
- Diagnose Nacelle Transfer Function (NTF) drift
- Research wake and farm control
- Optimize renewable energy in the electrical grid

Wind intelligence for data-driven success

Vaisala 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

WindCube as permanent lidar

WindCube acts as a virtual met mast with the ability to measure wind parameters remotely, eliminating the need for physical meteorological towers. It also includes PTH and rain weather sensors, making it a complete solution for all your requirements. Configurable measurement gates (height or distance) enable any application.

Vaisala provides unsurpassed services and support anywhere in the world including onsite maintenance to maximize uptime, preventive maintenance with optional warranty extension, training, easy installation, and global technical support.

Wind lidars
WindCube vertical profiler
WindCube Scan
WindCube Nacelle
WindCube Offshore

Operations and life management
Permanent wind monitoring
Weather and light obstruction monitoring
Power performance testing
Retrofit and performance increase
Site O&M
Offshore ship operations for maintenance
Minutes/hour/day ahead forecasting
Repowering

Choosing the right WindCube lidar

There's a WindCube for virtually any permanent lidar application.

WindCube vertical profiler

WindCube is the new standard for wind measurement throughout the industry. Validated by hundreds of independent studies and accepted by all international standards and guidelines, it is augmenting and replacing legacy met masts.

WindCube measures the complete wind profile at 20 simultaneous heights, covering the rotor sweep of even the largest turbines. This ensures extremely high data availability and accuracy across heights.

WindCube Scan

WindCube Scan reliably and affordably provides full, 3D wind mapping and multi-purpose analyses that are indispensable to onshore and offshore projects. The industry's tool of choice for reducing spatial uncertainty, it is valuable at any stage of a wind farm project, from prospecting to operation.

WindCube Scan is fully configurable for multiple uses, including monitoring, atmospheric cross-sectioning, and wind profiling. It can also measure multiple turbine locations at once, creating huge efficiencies in operational assessment.

WindCube Nacelle

Suitable for any turbine type and rotor diameter, WindCube Nacelle provides a complete picture of the wind profile at unprecedented ranges from 50 to 700m (long-range version). By measuring from 10 to 20 distances simultaneously each second, it provides outstanding data quality and availability — making it the routine choice for contractual PPT and the default system in many turbine supply agreements. It is the first nacelle mounted lidar classified according to the IEC 61400-50-3 standard and enables PPT on any wind turbine, onshore and offshore.

WindCube Offshore

WindCube Offshore equips the WindCube vertical profiler with a robust casing for integration into floating buoys and other harsh offshore locations, such as lighthouses, substations, and vessels. With offshore wind development accelerating, WindCube Offshore provides the ideal ruggedized option for Floating Lidar Systems (FLS).

Compass

Included with every WindCube lidar, Compass is the cloud-based weather intelligence platform for renewable energy that puts you in control. This comprehensive suite for data management, visualization and collaboration addresses the industry's most pressing weather-related challenges, enhancing data insights and productivity.

Permanent lidar applications

Conduct Power Performance Testing

WindCube Nacelle as a permanent lidar is mounted on the wind turbine nacelle, providing simultaneous measurements at all selected measurement distances.

WindCube Nacelle can measure from 50 meters up to 700 meters. It provides precise wind speed and direction at the turbine's hub height and reduces PPT uncertainty by providing real-time data. This continuous, real-time monitoring ensures faster power curve completion and identification of under-performance. You can also optimize your wind farm and wind turbine performance by making use of other parameters that the lidar can provide, like vertical shear and veer, Rotor Equivalent Wind Speed (REWS), and Radial Turbulence Intensity (TI).

Correct yaw misalignment

Detecting and correcting any yaw misalignment of an operating turbine can lead to significant AEP gain and potential loads reduction. Compass software is proven to identify yaw misalignment based on lidar wind direction and nacelle orientation data from SCADA. It also provides wind sector analysis.

WindCube Nacelle as a permanent lidar is the solution to the challenges posed by turbine yaw misalignment. It is a reliable tool for performance monitoring and optimization throughout your turbine's lifespan.

Monitor nacelle transfer function and correct turbine anemometer drift

Improve your performance with WindCube Nacelle PPT for quick and easy Nacelle Transfer Function, and correct any drift in nacelle anemometer measurements for appropriate implementation of turbine operating conditions.

WindCube Nacelle enables continuous monitoring of any drift or malfunction of nacelle wind measurement.

Continuous local weather observation for safe operations

Harsh, severe, and unpredictable weather conditions can pose serious safety risks. Many wind farm-related operations such as construction, installation and maintenance activities can be conducted safely with data such as wind speed and direction. The wind lidar acts as a guide for the operations team to make effective decisions for greater safety.

Energy production forecast

Leave the wind lidar permanently onsite for continuous measurements and obtain accurate look-ahead energy forecasting for your site. Local measurements are required to refine the weather model. Make the most of this solution to optimize your revenues and minimize any penalties with accurate production forecasting.

Reference and independent measurements to monitor energy production and identify under-performance

Detect any under-performances with continuous accurate wind measurements. Reliable in severe weather conditions, WindCube Nacelle and WindCube Scan provide data for wind direction changes, wind ramp, and detect gusts or any inhomogeneity across a wind farm. This valuable information helps operators balance grid connections and optimize production.

Independent wind measurement for curtailment and grid curtailment compensation

With accurate wind speed and wind direction, permanent lidar helps reduce curtailments and increase production. It can provide independent and accurate wind measurements from which you can claim compensation due to grid curtailment. It is ideal for grid operators who require accurate energy production.

Wake measurements and farm control

Each turbine produces a wake effect resulting in reduced wind speed and increasing turbulence, ultimately resulting in energy losses in down-wind turbines. Wake studies and measurements are crucial factors that help in evaluating energy production and wind farm optimization. Research has revealed that a large part of energy underproduction comes from wake losses or wake modeling uncertainty.

WindCube Scan provides high resolution measurements to reduce these uncertainties, bridging the gap between models and observations and enabling farm optimization though dynamic farm control.

Offshore wind farm development and operation

Lidar is a major advantage over met masts for its accuracy, reliability and safe operation. WindCube Offshore lidar is purpose-built to withstand harsh marine conditions and is easy to deploy.

Once installed on the turbine for contractual power curve at commissioning, WindCube Nacelle can be left on the turbine to continuously monitor any drift, diagnose under-performance, and optimize curtailment management.

Case study: Effective wind forecasting

Researchers from Jeju National University and Mokpo National University published a paper that highlights the importance of having an effective wind forecasting technique.

They conducted a 1.5-year study on a 400 MW offshore wind farm with 111 wind turbines to examine diverse applications and features in the short-term forecasting models. Researchers developed a 3-h wind power forecasting model using WindCube lidar data, SCADA data and deep-learning algorithms. The model that integrated lidar and SCADA data showed a more limited increase in prediction errors compared to other models.

Learn more and download the paper:

Accuracy of a Short-Term Wind Power Forecasting Model Based on Deep Learning Using Lidar-Scada Integration: A Case Study of the 400-Mw Anholt Offshore Wind Farm

Craning operations during installation

Understanding wind and weather-related events in advance is critical for ensuring safe crane lifting operations. Lidar provides precise data on current and upcoming wind conditions across a broad area so you can plan crane operations efficiently.

Electrical grid management

Lidars are gaining acceptance as a successful replacement for grid signaling, reducing the operational expenses and safety hazards of deploying met masts. WindCube is trusted technology for providing accurate, real-time data at the required time intervals.

Growing acceptance of lidar data for grid management

In some countries like Ireland, Transmission System Operators (TSOs) request meteorological data in areas with high weather uncertainty to support grid reliability, safety, and efficiency. Wind lidar provides real-time measurements of wind speed and direction at various altitudes, improving wind power forecasting and grid stability during changing conditions.

Independent System Operators (ISO) in the USA are also increasingly accepting the use of remote sensing technology such as lidar as an alternative to met masts to collect wind turbine data. Each Regional Transmission Organization or ISO operates the electricity market and manages the reliability of its transmission grid.

Operating guidelines for ISOs require the Interconnection Customer with a wind-based Variable Energy Resource to provide site-specific weather data. Remote sensing devices are now accepted to collect this data and provide it to the ISOs.

Performance analysis and reporting

The detailed and continuous wind data collected by lidar can be used to perform advanced analytics to assess wind farm performance. This analysis can identify underperforming turbines and other issues that might be impacting efficiency. Accurate wind data is also essential for reporting to stakeholders and regulatory bodies.

Wind farm research

Beyond all other applications, permanent lidar transforms wind farm research to expand wind energy investigations by providing critical data across four main areas:

- Wake steering and farm control
- Forecast and grid management
- Independent energy yield monitoring and forecasting
- End of life and repowering

At the end of a wind farm's operational life, wind lidar can assist in the decision-making process for repowering (replacing old turbines with new ones).

Technical requirements

The following technical requirements apply to all WindCube wind lidars.

Communication protocol for sending real-time data: WindCube and WindCube Nacelle have CAN bus and Modbus® RTU as well as TCP, which are compatible for sending real-time (radial) wind speed and direction data and make it easy to create a SCADA interface. The WindCube Scan API allows for lidar setup and tracking, including status monitoring and data downloading.

Wired connection: WindCube lidars are equipped with RJ45 ethernet connections.

Cybersecurity requirements: The use of a fixed IP address and port for WindCube lidars allows for the configuration of a firewall. A VPN can be set to secure connection.

WindCube key technical specifications

WindCube vertical profiler	WindCube Scan	WindCube Nacelle

· High accuracy and low uncertainty
· Measurement from 40m to 400m
· 20 user-defined measure-ment ranges
· Simultaneous measurement at all distances
· Constant measuring probe
· 5 beams
· 1 Hz beam swap frequency
· 35W nominal consumption
	· Versatility
	· PPI: 360° monitoring
	· RHI: constant azimuth angle scan
	· DBS: vertical wind profiling
	· Real-time detection and tracking
	· Range gates length from 25 m to 200 m; up to 10 km range (with 400S version)
		· High accuracy and low uncertainty
		· Measurement from 50 m to 450 m / 700 m
		· Constant measuring probe
		· 10 to 20 user-defined measurement ranges
		· Simultaneous measurement at all distances
		· 4 beams
		· 1 Hz beam swap frequency
		· Key data output:
		  · Hub height wind speed and direction
		  · Shear
		  · Veer
		  · TI
		  · REWS
		  · Pressure, temperature, humidity, rain, and hail (with optional PTH sensor)

Unrivaled global service and support

Industry-leading warranties and support options

Vaisala offers the best warranty in the industry, as well as robust service and support. For example, our on-site repair option for the WindCube vertical profiler ensures continued operations and eliminates logistical constraints.

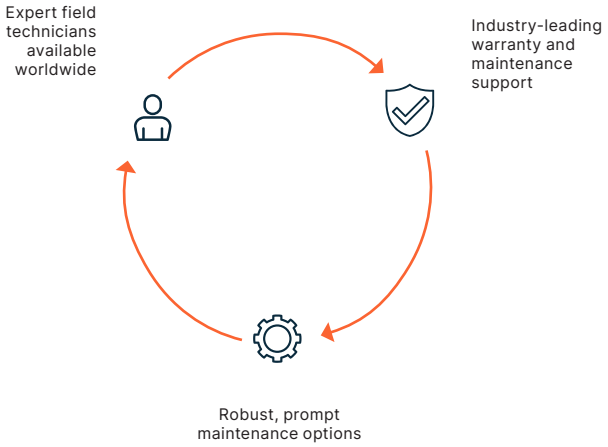
Our support includes ongoing training, with convenient online refreshers through our e-learning platform. These anticipate frequent questions and ensure you get the most from your WindCube.

When you purchase a WindCube lidar, we provide an excellent experience from the point of sale to onboarding, lidar shipment, training, installation, measurement campaign, data analysis and more. Our dedicated technical support team (including partners) ensures global support.

Vaisala is able to offer this support because our technologies are so reliable, and because we have invested in a global support network that is unlike any other lidar provider. This provides value well beyond accurate wind data, since when you select WindCube lidar, you also gain the trustworthiness and peace of mind that only we can provide.

Delivering value every step of the way

Vaisala provides the most comprehensive solutions and service available, no matter where you are. In addition to our two WindCube factories, we maintain seven global WindCube service centers and offer a variety of solutions that make deploying and operating lidar even simpler.



Easy, reliable global solution: Robust support offerings

- Extensive training, including online training refreshers, on-site or remote for WindCube vertical profiler
- Full maintenance capabilities that maximize operation continuity
- Installation and system integration support
- Technical and scientific support

Innovative lidar solutions from a one-stop shop: Turnkey offerings

- Customer-oriented software for data management
- and performance monitoring
- Standalone power supplies and satellite communication solution or WindCube vertical profiler 4G remote communication
- Winter kit for WindCube vertical profiler
- Data analysis software
- Post-processing tools and algorithms

The customer journey: from purchase to decommissioning

With the expertise of our Technical Support and Field Engineers, Vaisala's customer success management team is ready to help you make the most of your permanent lidar applications. Our local service providers and partners can also support your wind farm operations, from identifying the most relevant location to safe and secure installation, including on-site training for operation and maintenance.

The permanent lidar customer journey

1. Identify the best location for safe and secure installation, to cover wind farm layout for each specific location
2. Complete training for operations and maintenance
3. Integrate the lidar with the SCADA data monitoring system
4. Collect and monitor real-time data
5. Complete maintenance and inspection
6. Conduct data analysis: WindCube Insight Analytics supports WindCube Nacelle data as a post-processing tool
7. Perform regular maintenance checks and inspections
8. Decommissioning / Repowering / Retrofitting

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 nearly 90 years of experience, deployments in 170+ countries, and unrivaled thought leadership.

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

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