



LEOSPHERE
A VAISALA COMPANY

The business outcomes of lidar:

Advances in bankability,
data quality, and flexibility



Lidar has arrived. The business results are in.

In the last 15 years, as the wind energy industry has evolved, lidar has gained acceptance and enthusiasm in all corners of the wind energy industry. And the move toward lidar for both onshore and offshore uses continues to gain momentum.

In years past, the industry has been slow to adopt remote sensing, in part because it was solely committed to traditional met masts. But today, lidar isn't just accepted — it is necessary.

Technology for today

In 2000, a typical turbine hub height was 60m. Today, hub heights are routinely double that. Experience tells us that erecting a met mast above 60 meters is difficult and costly, and extrapolating wind measurements far beyond the structure's height introduces error and uncertainty.

Lidar, on the other hand, measures at great heights and across the entire rotor sweep. Lidar units can also be placed almost anywhere without permitting or construction delays, giving users the data they need conveniently, reliably, and affordably.

This is only one of the business-critical problems lidar solves.

Leosphere's suite of WindCube® lidars — the most trusted and prevalent lidars on the market — provide the reliable, powerful data that manufacturers, wind developers, and operators need the most. Due in large part to WindCube's innovations, lidar has evolved past previous limitations and is pushing wind energy to new heights.

"The higher the turbine hub heights we're getting, the more uncertain extrapolating shear is from met towers. Today we have at least one WindCube at every development project."

Phillip Hurlbut
Meteorologist, Pattern Development

Breaking down the business outcomes

Phase	Lidar capabilities	Business outcomes
Development/funding	<ul style="list-style-type: none"> Accurately assess wind characteristics for almost any geography, whether onshore or offshore Efficiently provide compliant and validated data with drastically enhanced flexibility and time-to-deployment 	<ul style="list-style-type: none"> Quickly and confidently confirm the bankability of a wind site, securing funding and expediting development Reduce risk and improve performance forecasting
Operations	<ul style="list-style-type: none"> Demonstrate wind farm performance over time, dependably informing corrections or optimizations Reduce fatigue and loads on critical components 	<ul style="list-style-type: none"> Recover and enhance profit otherwise lost through non-optimized configurations Optimize and manage the entire wind farm system in cohesive campaigns Increase the lifespan of key components
All phases	<ul style="list-style-type: none"> Perform reliable contractual and operational PPT according to industry best practices 	<ul style="list-style-type: none"> Maintain compliance and carry out PPT in ways never before possible Reduce uncertainty, improve decision-making and performance optimization Reduce risk, the cost of wind farm projects — and, ultimately, the cost of wind energy
Positioning in the wind energy marketplace	<ul style="list-style-type: none"> Supplement or replace met mast systems, solving for past limitations Open new opportunities for offshore and complex terrain measurement 	<ul style="list-style-type: none"> Demonstrate innovation to stakeholders Pioneer new wind energy sites and approaches



Lidar in the real world

With thousands of real-world deployments validated by industry experts, lidar users have a solid understanding of its most distinguishing benefits — some of which go beyond the data it provides.

Wind energy leaders report that lidar gives them a multi-use tool whose flexibility is unmatched and whose wind data is equal to or superior to what met masts offer. Lidar units are mobile, compact, and non-disruptive to landscapes and environments. They can be used temporarily and are easy to repurpose after their initial job is done. And, they offer distinct health and safety benefits over met masts. All of the above contributes to lidars providing exceptional value over long service lives.

Lidar benefits at a glance

Data validated over thousands of deployments and large-scale studies

Removes the need to rely on flow models for vertical extrapolation; free of hub height limits

Limited permitting, easy and fast deployment

Little or no on-site construction required

Low profile, sturdy; withstands extreme weather

Reduces time needed to assess sites for suitability

Deployable in remote, offshore, or complex terrain

Capital asset that can be redeployed at no extra cost at multiple sites

Economical to operate and maintain

Consistent performance in hot and cold weather, and icy conditions

Increased safety for workers



All about data

One of the top concerns related to lidar is the accuracy and acceptance of its data — and, subsequently, how effectively it improves a wind energy project's likelihood of success and long-term performance.

A few years ago, this was a difficult question to answer. But now that lidar has been put to use around the world on projects large and small, we have learned several key things:

"If we're not using remote sensing devices, we're at risk to actually introduce bias. For most of these met masts, we've seen what we call shear relaxation — a .9% over-prediction when we use the mast alone, and 1.8% in energy."

Philippe Pontbriand
Energy Resources Director,
RES Americas, Inc.

- Lidar data, on its own, is rigorously tested and proven to be as accurate as met mast data. It is compliant to IEC and other regulatory standards.
- In many situations, lidar is an ideal complement to met masts — filling in gaps in the data, validating and expanding measurements, and drastically reducing uncertainty.
- The range of data available from lidar is extensive, as is the processing power of lidar units and their related software. These factors improve users' situational awareness and allow for previously unattainable benefits, like out-of-the-box power performance testing according to industry best practices.
- Lidar, like any recent advancement, comes with modern, cloud-based management and analytics tools, making its insights more widely accessible and easier to manage.
- The reliability of lidar systems has greatly increased — to the point where lidar is now considered more reliable than met masts. Extensive field experience has driven continuous improvement in the design, testing, and assembly of lidar's technology and system components.

Leosphere's leadership and experience



1800+
wind data campaigns
delivered for energy
yield assessment

0.2%

Mean bias error in
our wind due diligence
validation study





Leosphere lidar solutions: Improving wind energy efficiency for all project stages

Further information and data sheets available for all solutions at www.windcubelidar.com.

WindCube®

The industry standard for accurate, bankable data

Highlights:

- Ground-based wind profiler that covers the entire rotor sweep of today's larger turbines, providing accurate wind measurement up to 200+ meters over 12 simultaneous heights
- Deploys safely, quickly, and easily — no expensive construction or permitting necessary
- Full IEC compliance and data validated by hundreds of independent studies
- Bankable data to secure funding, reduce the cost of equity, and minimize risk
- Embedded FCR correction for direct measurement in complex terrain
- Includes WindCube Insights cloud-based data management system

Applications:

- Wind resource assessment
- Power curve measurements
- Power performance testing
- Performance verification
- Site suitability and calibration
- Blockage effects
- Grid-loss compensation



Vertical profiling lidar purpose-built for buoys and harsh marine environments

Highlights:

- Provides all the benefits of the WindCube industry reference lidar
- Designed with a robust casing specifically for offshore environments, while providing all of the benefits of the WindCube industry reference lidar
- Integrates into floating buoys and withstands tough marine conditions for platform placement in lighthouses, substations, and vessels
- Commercial buoys integrated with WindCube lidars validated in accordance with the Carbon Trust roadmap of acceptance
- Cost-effective solution deploys safely, quickly and easily — no expensive construction or permitting necessary

Applications:

- Wind resource assessment
- Operations
- Optimization
- Research



3D scanning for reliable, detailed spatial wind data

Highlights:

- Versatile, 360-degree, long-range configurable Doppler lidar system
- Suitable for onshore and offshore development and operations
- Provides large-scale, detailed knowledge of wind conditions, coupled with minimal cost of operation
- Multiple scanning patterns with an operational range of up to 19.7km; typical measurement ranges up to 3km, 6km, and 10km (depending on model)
- API for configuration and data access

Applications:

- Wind resource assessment
- Site suitability and calibration
- Wind turbine wake and wind farm blockage effect
- Short-term forecasting



Long-range wind turbine performance testing and optimization

Highlights:

- Mounts temporarily to turbine nacelle or fully integrated by manufacturer
- Compatible with all turbine types and suitable for even the largest hub heights and rotor diameters
- Lightweight and easy to install and maintain
- Measures wind conditions simultaneously at 20 points ahead of the turbine, with the industry's longest range of up to 700m
- Captures wind data simultaneously at 20 measurement distances
- Continuous wind direction alignment; reliable contractual and operational power performance testing (PPT) according to industry best practices and the upcoming IEC standard
- High correlation with IEC met mast measurements; optimizes energy production, lowers costs, reduces loads, and improves turbine design
- Well-suited for contractual or operational PPT, turbine underperformance diagnosis and corrections, and verification of turbine upgrades

Applications:

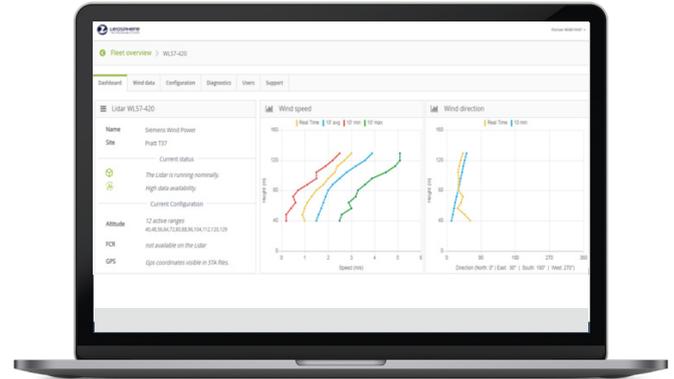
- PPT
- Warranty power curve
- Yaw misalignment correction
- Nacelle transfer function calibration
- Fatigue and extreme load reduction
- Wind turbine design and production enhancement
- Wind turbine class upgrade



Actionable, at-a-glance data analysis and reporting for WindCube

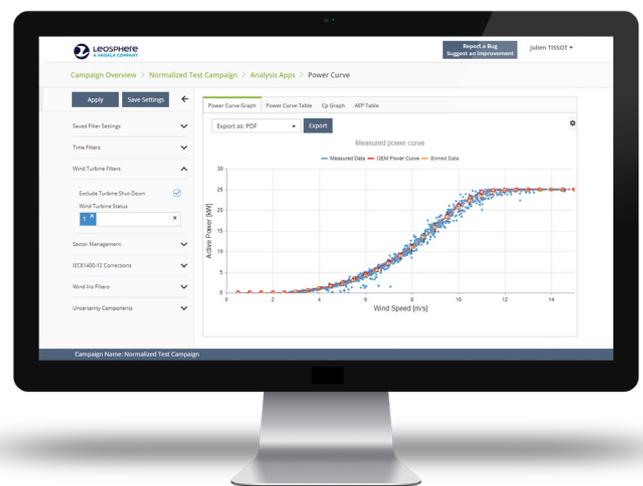
Highlights:

- Secure, cloud-based, and user-friendly, with customizable, real-time alerts and notifications providing enhanced system visibility and reduced response times
- Extendable from one WindCube campaign to full fleet management, so it can grow with users' operation without new procurements
- Simple data export and access capabilities provide business-critical insights immediately, on any device
- Flexible user access rights for security and functionality across an entire team



Efficient power performance testing and analysis

- Makes reliable PPT available to any user of WindCube Nacelle
- Produces ready-to-use IEC tables and annual energy production (AEP) calculations in just a few clicks, and offers built-in templating for using SCADA data from any type of turbine
- Proactively displays which IEC paragraph/standard it is referring to while in use
- Provides improved data visibility and decision-making for the whole wind farm, whether used for development or ongoing operations



"As one of the largest met mast manufacturer and equipment service providers in China, in order to ensure service quality, we have been using and in search of the best sensor products in the industry, which requires the equipment to have better performance, higher accuracy, and more reliability. Leosphere is definitely the world leader in the existing lidar companies, and we still firmly choose WindCube as our main product."

Wang Shangkun

Lidar Business Director, Leviathan Energy



Why Leosphere, A Vaisala Company?

Leosphere WindCube lidars are the most widely used remote sensing solutions in wind energy. Trusted by developers, operators, manufacturers, service providers, and many more stakeholders, they provide the reliable data and business outcomes companies need to thrive.

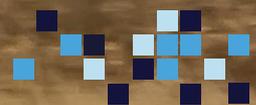
Thousands of WindCube units are in service around the globe today with some of the world's largest wind energy clients, as well as plenty of smaller, emerging ones.

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.

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

www.windcubelidar.com



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