



The offshore frontier

Modern lidar solutions for offshore wind energy projects



A new set of opportunities — and needs

Offshore wind farms are full of potential. They promise excellent wind availability and energy capture, do not disrupt communities, and are immune to many common performance degradations that come with complex terrain and onshore wind farm crowding.

They do, however, bring a new set of challenges requiring new practices and technology. These challenges include:

- Accurately assessing wind characteristics for large areas and taller turbines
- Obtaining precise wind data on the water, at long ranges from the shoreline
- Operating in harsh, salted environments far from maintenance resources

These challenges are compounded by the fact that met masts are often either impossible or prohibitively expensive to deploy and maintain offshore. Even if it is possible to absorb their high permitting and construction costs, met masts usually cannot measure up to the full height of today's turbines without mathematical extrapolation, which introduces the potential for error. Modeling also has limitations for estimating offshore-specific phenomena that can affect accuracy. Notably, offshore wind farms tend to use the largest possible turbines to maximize the value of each foundation, and they are being placed farther from shore and into deeper waters — making it ever harder to use met masts effectively.

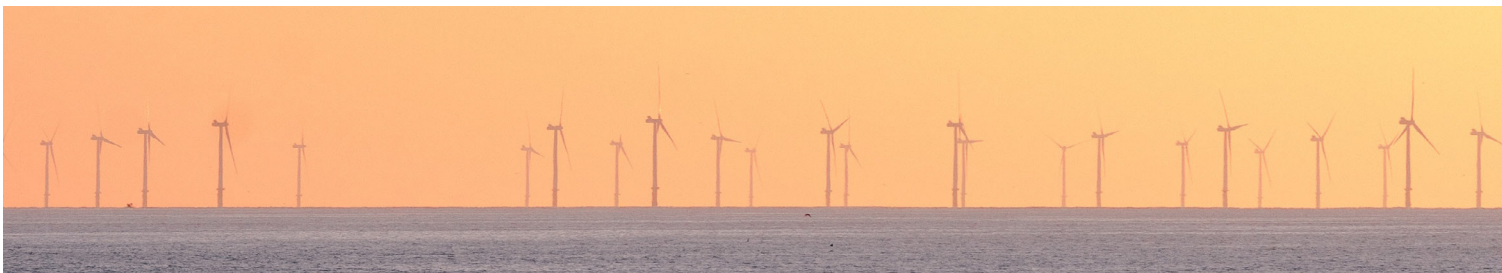
All of these factors have made new, reliable ways of assessing the wind even more critical for offshore projects. Fortunately, remote sensing solutions are already proven, trusted, and ready.



WindCube is made for offshore

Leosphere's WindCube® lidar solutions are the most comprehensive set of offshore-ready measurement technologies in the world. There is a WindCube solution to support nearly every part of an offshore project, from wind resource assessment, pre-construction, and contractual power curve testing to permanent wind monitoring, research and development, and turbine testing and control.

The WindCube series provides single-source solutions for almost any need in offshore development and operations. It helps make offshore wind farms not just technically feasible, but financially sound.



20+



Estimated offshore wind farms commissioned through the end of 2020 supported by WindCube technology

*Planned at time of publication



Offshore use cases for lidar

Lidar is meeting many previously unmet needs for offshore developers and operators. Here are some of the most common use cases for which lidar is especially well-suited.

Wind resource assessment

Wind resource assessment (WRA) is the make-or-break point for any wind farm project, and it is a particularly difficult stage in offshore development. If the wind availability and characteristics cannot be proven to a high degree of certainty, project investment and feasibility are at risk.

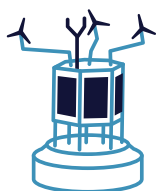
WindCube lidars can facilitate offshore WRA in several ways:



WindCube Offshore **vertical profiling lidar** is mountable on an existing platform, such as an oil station, vessel, or lighthouse. In this setup, it provides direct wind assessment and reduces vertical uncertainty, improving project bankability. This is often the simplest solution with the lowest upfront costs.



Scanning lidar, mounted on a fixed platform or placed onshore at the coastline, allows for full, 3D spatial mapping of the wind field affecting multiple real or potential turbines. With a range of 19km+, WindCube Scan, used in a single-lidar or dual-lidar configuration, can provide ideal wind data of an offshore site even though it is mounted on the shoreline, where it is much easier and cost-effective to operate and maintain.



Floating lidar systems, supported by WindCube Offshore, provide a rugged, versatile option that can be deployed for greenfield assessment nearly anywhere. It is a crucial tool where there are no available fixed platforms. Leosphere works with several buoy integrators who support this solution.

These approaches can be mixed and matched depending on the situation. For example, on a typical greenfield project, a buoy-mounted WindCube Offshore vertical profiler can be placed at the center of a proposed wind farm to reduce vertical uncertainty, while one or several WindCube Scan units provides 3D wind awareness from the shore.

WindCube lidar can also provide critical data for studying and implementing wind farm extensions.



Today's growing turbines

WindCube lidar measures up to the full hub height on even the largest turbines. Not only does this mean that lidar provides directly measured data where met masts would rely on extrapolation, but it also guarantees that lidar will continue to accommodate aggressive turbine growth in the coming years.



Construction and commissioning

WindCube lidars are commonly used during craning and mounting operations because they help ensure accurate placement and installation.

Contractual power curve verification is one of the most important tasks along the road to operation. WindCube Nacelle provides the correct data for IEC-compliant Power Performance Testing (PPT), and WindCube Insights — Analytics software puts it all together into simplified, fully transparent PPT reporting and analysis.

Additionally, WindCube Scan enables users in the construction or commissioning phases to conduct performance assessment of multiple turbines with just one lidar unit.

Wind operations

When used for permanent wind monitoring, lidar can replace a met mast and monitor performance and losses when a turbine is stopped or the farm is off the grid.

Operational PPT is crucial and can be used to verify performance or validate repairs and upgrades. WindCube is especially well suited for troubleshooting and identifying underperformance, since it is quick and affordable to deploy and provides reliable data immediately.

Increasingly, manufacturers consider turbines that are already integrating nacelle-mounted lidar for Lidar-Assisted Control (LAC). This is made possible by WindCube Nacelle's advanced feedforward capabilities. With LAC, anticipatory corrections can be made to individual turbines ahead of oncoming weather, reducing structural stresses and optimizing power capture.

In any case, Leosphere experts are available to collaborate with OEMs and provide customer consultation as needed, ensuring smooth operations and maximum benefits from the lidar technologies.

Research and development

Wind lidar is frequently being used for promising Research and Development (R&D) purposes, which now include wake loss and blockage effect studies, and short-term forecasting.

In wake loss studies, lidar is improving energy production certainty by measuring wake effects away from the turbine. Current models are prone to underestimating the wake loss effect, so improvements here can improve wind farm performance and financial outcomes.

Additionally, lidar has proven capable of providing 5-10 minutes of advanced notice for approaching wind disruptions and storms. This short-term forecasting, when acted upon, can protect turbines from undue strains and enhance energy capture. Once again, the real-time lidar data decreases uncertainties compared to statistical models.

It also supports other research areas, such as wind farm control.

Manufacturing

Some of the world's leading manufacturers use WindCube to create new efficiencies throughout the business lifecycle. With lidar data, manufacturers can better anticipate the customer experience, improving operational results and customer satisfaction.

During manufacturing and prototyping stages, lidar is an excellent testing aid that can lead to better design decisions. It can also improve manufacturers' understanding of operational performance and how it impacts power curve performance.

Finally, lidar can enable more informed, sound actions to reduce fatigue and extreme loads on critical components, increasing the lifespan, value, and marketability of a turbine design.

WindCube technologies and their offshore applications

Leosphere's WindCube lidar systems are comprehensive, compatible, and simple to deploy and repurpose throughout the life cycle of an offshore project. Because they are so easily integrated, they can grow with you as your needs change.



Verified and ready

WindCube lidar meets the latest and most rigorous international verification standards, including ISO9001. WindCube solutions are recognized and verified by IEC standards, and they are recognized and verified by the world's leading independent expert bodies, including DTU Wind Energy, UL, Deutsche WindGuard, UnitTE, and Carbon Trust.

Just as important, Leosphere's scientists participate in the leading standards bodies and have contributed more than 500 authored or co-authored scientific publications at the highest levels of study. Our longstanding partnerships with world-renowned research institutes, and our active support of and commitment to our customer's projects, are further evidence of Leosphere's unique thought leadership and contribution in the industry.

WindCube offshore solution matrix

	Wind resource assessment/Pre-construction				Construction/commissioning	
	Green field	Platform available	Nearshore situation (or close to island, lighthouse etc.)	Farm extension (Impact of existing farms)	Craning (Optimization of ship operations)	PPT - Contractual Power Curve
WindCube Offshore buoy-mounted	■					
WindCube Offshore fixed		■	■			
WindCube Nacelle						■
WindCube Scan			■	■		

	Post-construction/ Operations		Post-construction/Research					
	Permanent wind monitoring (Off grid compensation)	PPT - During Operations	Blocking effect (Understand wind farm layout impacting wind ahead)	Wake losses studies (Understand production losses intra-farm)	Wind farm wake effect (Impact of existing wind farm on neighbors and extension)	Turbine control (Costs reduction, AEP increase)	Wind farm control (Increase of farm production globally)	Short-term forecasting (Monitor upcoming wind minutes in advance)
WindCube Offshore buoy-mounted								
WindCube Offshore fixed	■							
WindCube Nacelle		■				■		
WindCube Scan			■	■	■		■	■

The technologies in brief

WindCube Offshore

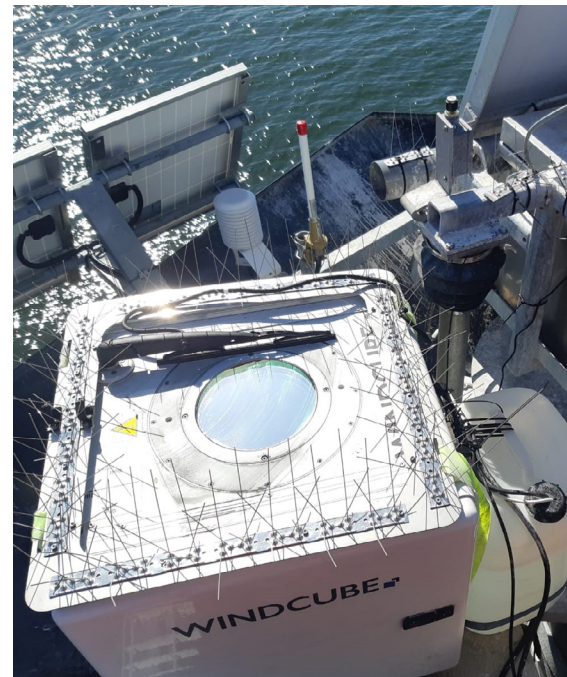
Buoy-mounted or fixed vertical profiling lidar for the harshest conditions

WindCube is the reference lidar for all phases of wind energy development and operations, and it has been engineered 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, this is a timely innovation for consistent, reliable and accurate data, wherever you need it.

Key benefits

- Powerful vertical profiler technology specifically designed for offshore applications
- Reliable, easy to deploy, and mobile for use across the project life cycle, from wind resource assessment to permanent wind monitoring
- Bankable data validated and accepted by relevant international standards and guidelines



WindCube Nacelle

Nacelle-mounted lidar for Power Performance Testing and optimization

Whether temporarily mounted or fully integrated, WindCube Nacelle is widely accepted for contractual and operational PPT and has been proven to dramatically reduce operational costs while increasing efficiency. It is up to 10x faster and provides 10x more data than competing technologies, and its unrivaled range from 50m to 700m enables it to provide a complete wind profile covering the rotor sweep of even the largest offshore turbines.

Its ease of deployment, universal compatibility, and simple structure make it non-intrusive and easy to integrate into any wind energy operation.

Key benefits

- Accurate hub-height wind measurement for any size turbine
- Unprecedented measurement range up to 700m
- Unrivaled, IEC-compliant PPT capabilities when paired with WindCube Insights — Analytics software (see next page)
- Already included in several offshore Turbine Supplier Agreements (TSA)

WindCube Scan

Industry-leading scanning lidar for 3D wind awareness at long range

WindCube Scan reliably and affordably provides 3D wind mapping and wake analysis that are indispensable to modern wind farms. One of the most versatile lidar solutions available, it is fully configurable for several uses, including 360° monitoring, atmospheric cross-sectioning, and wind profiling.

WindCube Scan's 3D mapping and long range make it ideal for offshore measurement campaigns conducted from the shore.

Key benefits

- Industry-leading data quality, availability, and multiple scanning patterns
- Measurement range of up to 19km from the shore
- Outstanding versatility and mobility for many campaign types
- Can be used individually or used with other WindCube Scan and/or WindCube vertical profiling lidars



WindCube Insights — Fleet

Modern, cloud-based fleet management software for WindCube lidar

WindCube Insights — Fleet software allows users to monitor, assess, and manage their WindCube vertical profiling lidar fleets from a modern, easy-to-use interface.

The software is appropriate for all campaign types and fleet sizes, from a single buoy-mounted unit positioned offshore to a large network of lidar units.

Key benefits

- Provides accurate and transparent system performance data and reporting
- Modern, cloud-based interface provides access to the right data quickly
- Permissions and sharing features allow anyone on your team to leverage the tool

WindCube Insights — Analytics

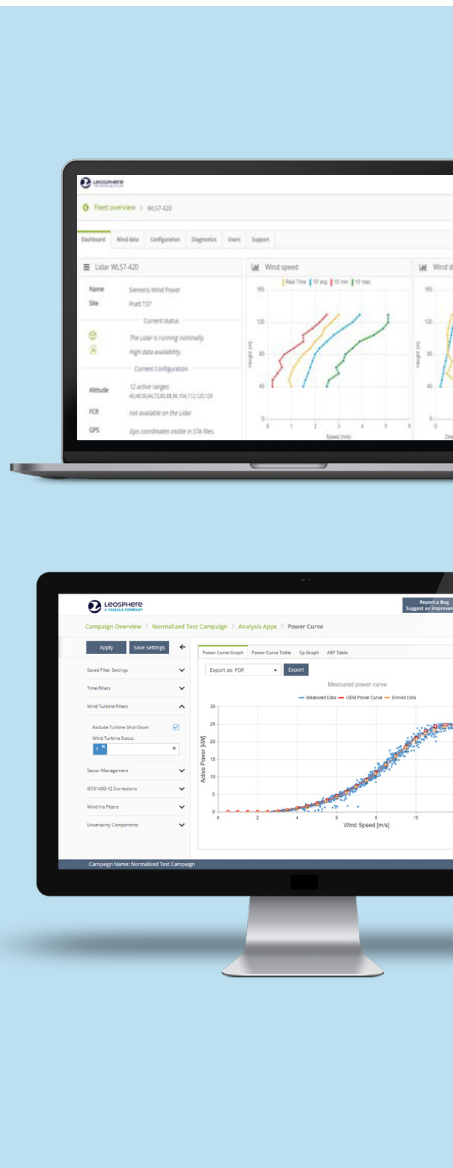
Revolutionary software for WindCube Nacelle providing powerful, IEC-compliant PPT and analysis

Built for WindCube Nacelle operators, WindCube Insights — Analytics provides outstanding PPT, data analysis, and reporting from within a visual, easy-to-use interface. It fills a huge gap in the marketplace, enabling developers, operators, and manufacturers to easily conduct IEC-compliant PPT and get more value from their lidar and turbine technologies.

Since PPT is governed by strict IEC standards, the tool provides users with transparent validations and even lists which IEC standards are relevant while in use.

Key benefits

- Drastically simplifies process of PPT, freeing resources and manpower for other important work
- Allows even smaller or emerging wind energy companies to conduct affordable PPT at various points in the offshore life cycle
- Enhances system awareness, decision-making, and performance



The promise of offshore has arrived

With the right tools and a modern approach, offshore wind farms are feasible and profitable. Learn more about the WindCube series of lidar technologies and bring your offshore projects closer to realization.

Global 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.

Leosphere, a Vaisala company, is the world's most capable and trusted provider of lidar solutions. With two factories and 7 service centers strategically positioned around the world, we are there for every customer with expert guidance and training, as well as timely, correct servicing if needed. Wind energy's most innovative companies look to us not just because of our WindCube lidar, but because they know they're getting a partner they can rely on end-to-end.

2 factories, 7 global service centers



www.windcubelidar.com

