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An industry of innovators

How WindCube® lidar is accelerating research and creating change in wind energy

Today, WindCube® lidar is everywhere in wind energy. It is enabling forward-thinking companies around the globe to explore new frontiers and make this industry more dynamic and efficient.

This eBook explains two offshore wind resource assessment projects and an onshore turbine control study, all of which rely on the versatility of several WindCube technologies: WindCube, WindCube Nacelle, and WindCube Scan.
They demonstrate how some of wind energy's most innovative leaders are pushing the industry ever higher.

On-demand webinar

Click below to view the supporting webinar featuring the experts and case studies discussed in this eBook

"How lidars are supporting wind industry innovation"

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No platform, no problem

How floating lidar enables resource assessment in distant waters

Julia Gottschall,
Senior Scientist
IWES and Wind Resource

Technologies:
WindCube Offshore

In Germany and other parts of Europe, crowded land areas and increasing energy demand are pushing wind developers to look farther offshore. One of their most glaring challenges is obtaining reliable wind resource assessments in maritime locations where met masts and other technologies are either impossible, or prohibitively expensive, to set up.

The answer, Fraunhofer has found, is buoy- or ship-mounted vertical profiling lidar positioned at the proposed site. These incredibly flexible lidar units are ideal for reducing uncertainty and filling in gaps in wind data.

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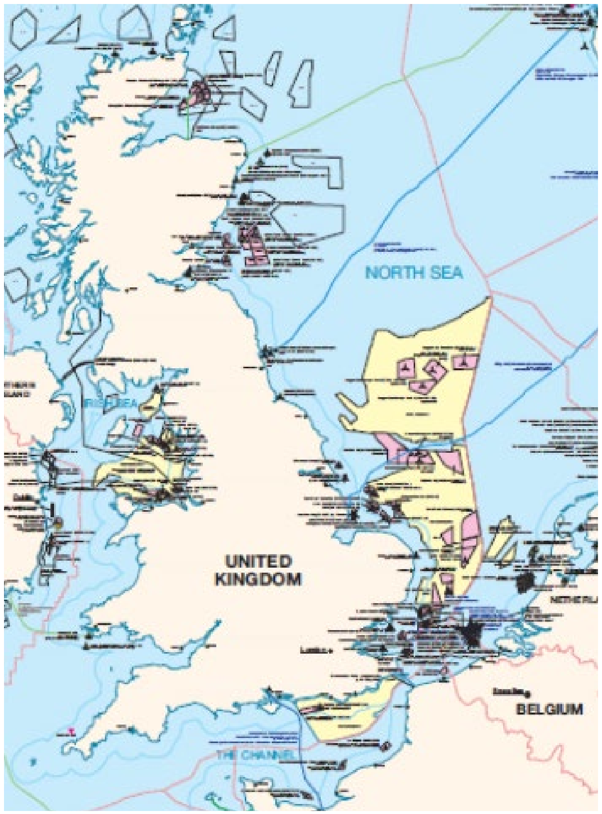

Into the North Sea and beyond

The yellow regions are areas of strong interest for further wind development. These areas, far from shore, are especially well-served by Floating Lidar Systems (FLS).

Floating lidar's powerful incentives

Gottschall says there are substantial incentives for wind developers to use more floating lidar systems. One of these is cost, since floating lidar has matured enough to be both highly accurate and resource-efficient. Another is flexibility, since lidar is often the only technology that can perform in distant offshore locations, and it can be moved and reused as often as needed.

"I haven't seen too many floating lidars during trials with this [wide] range of wind speeds," Gottschall says, "and we can say that the system not just survived, but also showed quite good performance in this stage-2 [pre-commercial] trial."

In those trials, buoy-mounted WindCube Offshore lidar units showed greater than 95% availability.

Fraunhofer's first floating lidar deployment was in the North Sea in 2013, and the number of floating lidars deployed has risen steadily since then.
Over that time, Fraunhofer has seen impressive performance in accuracy and availability.
The volatile North Sea is an excellent proving ground, in part because wind speeds routinely exceed 100km/h (62mph).

Gottschall notes that floating lidar's potential range of meteorological and wind energy applications is almost limitless. For example, with so many ships on the seas at any moment, ship-mounted lidar can be a great way to provide repeated, detailed wind data in regions of water that typically have little or no direct wind measurement taking place.

Projects summary

Location: **North Sea**
Lidar units currently deployed: **20+**
Methods: **Buoy-mounted, ship-mounted**
Purpose: **Wind resource assessment**

All aboard

Fraunhofer also uses lidar for ship-mounted deployments, which can provide convenient ways to increase the amount of data available on common shipping routes.

Today, Fraunhofer has more than 20 floating lidar deployments focused on wind resource assessment, integrating various systems and approaches. Gottschall and her team are increasingly convinced that floating lidar is the future of offshore resource assessment.

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Next-generation turbine control

Creating more dynamic, adaptive wind farms

Eric Simley, Researcher
National Renewable
Energy Laboratory (NREL)

Technologies:
WindCube Nacelle

In the last 10 years, nacelle-mounted lidar has revolutionized Power Performance Testing (PPT) and other applications for wind farm operations. WindCube Nacelle, for example, is now augmented by WindCube Insights — Analytics software, a cloud-based tool that allows operators to perform quick, simple, and transparent PPT, with IEC-compliant filtering, AEP calculation, and uncertainties reporting.

Simley and his team at NREL wanted to push WindCube Nacelle even further.

Operators have often tried to implement turbine control practices to improve energy capture and increase efficiency, but this requires extreme precision and a lot of data to work with. NREL recently completed a collaborative project with Engie Green at one of their wind farms in France, at which they developed improved methods of wind farm control that will make other wind farms more dynamic, adaptive, and efficient.

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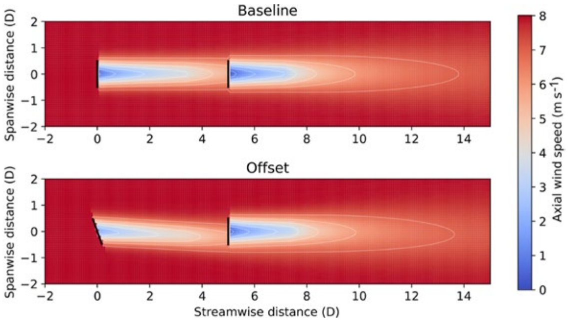
Going (slightly) against the flow

This graphic visualizes the slight changes created by an intentional yaw offset. Because the desired offset is usually very small, nacelle-mounted lidar is used to obtain precise wind data ahead of the turbine.



Optimizing wake steering

The control strategy they implemented is wake steering, in which upstream turbines are intentionally misaligned from the wind direction, causing their wake to deflect away from downstream turbines. Although this practice creates a small reduction in efficiency for the upstream turbines, that reduction is more than compensated for by the increase in efficiency for the downstream turbines. Simley reports that this strategy can increase annual energy production by 1-2%, which can translate into substantial financial gains.

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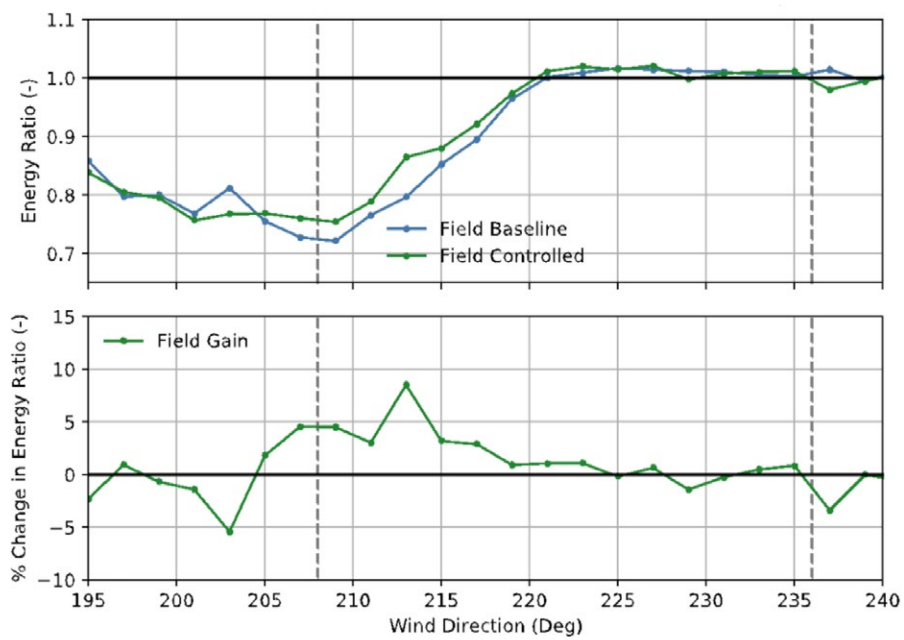
For this trial, Simley's team implemented wake steering control on an upstream turbine whose wake affected a second turbine 3.7 rotor diameters downstream. WindCube Nacelle lidar was mounted on the upstream turbine to measure inflow conditions, and a wake steering controller used a wind vane on the turbine to measure the yaw misalignment (the lidar was also used to validate the wind vane). The most desirable misalignment amount is a function of wind direction and speed; the higher the wind speed, the less yaw misalignment required.

Projects summary

Location: **France, onshore**
Turbines involved: **2**
Distance between turbines: **3.7 rotor diameters**
Maximum yaw offset: **20 degrees**
Production increase: **20% in peak conditions**

More power, please

The green line shows the power increase (combined upstream and downstream turbines) when wake steering was implemented.



The NREL team found that, under peak conditions, energy production for the downstream turbine increased by an impressive 20%, while the corresponding energy reduction for the upstream turbine was 3-4%. Overall, Simley reports a 5% net increase could be typical.

Additional insights

Along the way, the wind vane used to measure misalignment was shown to create a small amount of directional bias, and nacelle-mounted lidar provided comparative data for addressing the issue. Simley and his team increased their understanding of directional bias using wind vanes and optimized their yaw offsets accordingly.

NREL's work has produced more effective, data-driven strategies for implementing turbine control around the globe — and for getting more power out of wind farms that are already up and running.

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Power in crowded waters

Offshore wind resource assessment using long-range 3D scanning lidar

Atsushi Yoshimura, Assistant Manager
Green Power Investment (GPI)

Technologies:
WindCube Scan

The Japanese government, motivated by its ambitious commitment to eliminate greenhouse gas emissions by 2050, requires that new wind farms are extremely efficient (estimates say that the country will need to produce 130GW of wind capacity to meet its carbon-neutrality target).

As a result, offshore wind developers place great emphasis on resource assessment and turbine placement studies. To meet these requirements and obtain government backing, Yoshimura and GPI deployed WindCube Scan, mounted on the shoreline, to produce full 3D wind profiles over the water and at long range.

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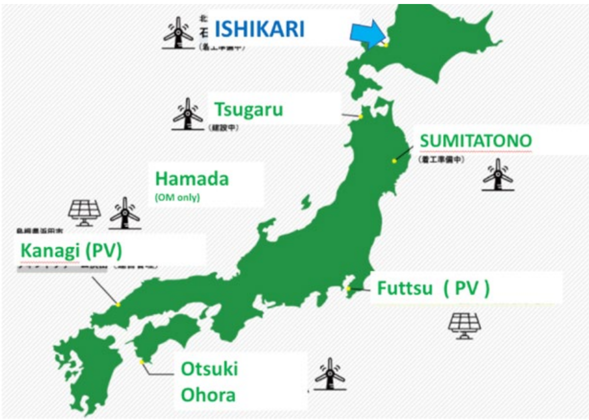


Surrounded by wind

Japan is an appealing region for wind developers, as long as they can successfully integrate with other industries and meet governmental requirements.

GPI is the owner of Japan's largest wind farm, named Tsugaru, and the company is currently developing the Ishikari offshore wind farm, where this study took place. Like other farms in the Japanese market, Ishikari will likely encounter extreme wind, lightning, and earthquake risks, further highlighting the importance of placement and design..

Creative solutions

Japan's wind farm certification body, ClassNK, requires developers to satisfy certain important conditions:

- Measurement height of a cup anemometer must exceed 2/3 hub height
- Measurement period must exceed one year
- All turbines should be located within 10km of measurement points

In this case, anemometers attached to a met mast could not have satisfied these requirements, so Yoshimura and his team proposed an innovative solution in which a WindCube Scan unit created a "virtual anemometer" whose height and distance from the proposed turbine location was within the requirements.

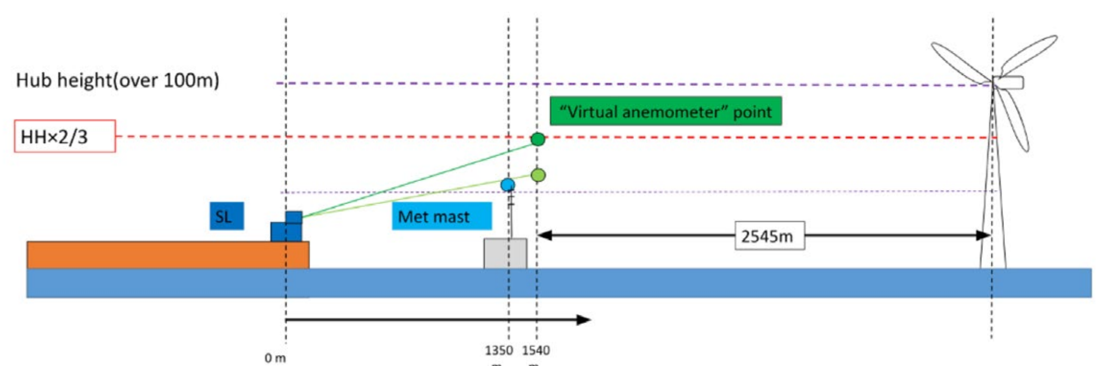
ClassNK accepted the proposal, and by comparing the lidar's data with the met mast's data at the chosen "virtual anemometer" point, GPI discovered very high correlation and accuracy.

Projects summary

Location: **Japan, near-shore**
WindCube Scan units: **1**
Duration: **34 months**
Paired with: **1 met mast**

During the wind resource assessment, Yoshimura and his team paired a scanning lidar with a met mast for optimized cost-of-measurement and reduced disruption to other users of the waterways. A met mast was installed at the wave breaker line (another first for GPI), and its wind data was combined with the lidar data to provide validated wind profiles at and above hub height.

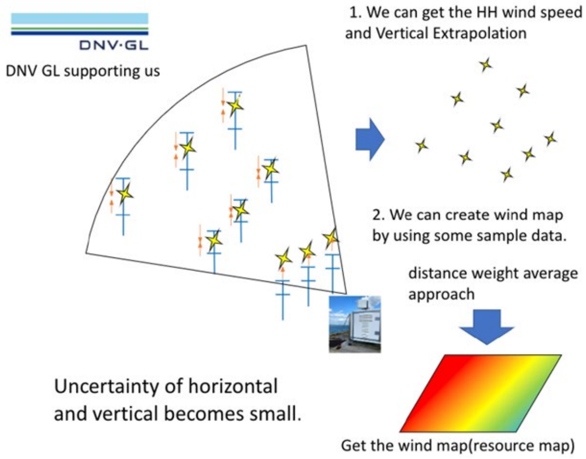
Yoshimura is quick to recognize the financial benefits of using scanning lidar alongside a met mast. "We can get so many measurements by using one WindCube Scan unit," he says. "It's extremely cost-effective" compared to other measurement methods.



An industry first

This was the first case in which scanning lidar was accepted and used for wind farm resource assessment by ClassNK, and GPI is currently evaluating the WindCube Scan 400S for more projects at even longer ranges. The company is also exploring combining several lidar units (a practice referred to as dual-lidar or triple-lidar) to further enhance offshore wind resource assessment.

With this kind of early success in a difficult market, the entire Japanese wind industry is poised to start using lidar like never before.



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Why Leosphere, a Vaisala company?

We are modern innovators, scientists, and discoverers who enable our customers to harness the power of wind energy in new ways. We are driven by passion, relentless curiosity, and the desire to create a better world, as evidenced in our commitment to four guiding principles:

Trustworthy, superior metrology
Our solutions are backed by the best science and metrology, and validated by the most demanding testing and certifications in the industry. Our contributions make wind energy smarter.

Unrivaled thought leadership
Our years of experience, impressive global client roster, and plethora of industry breakthroughs demonstrate that we are the iconic gold standard in wind energy.

Innovative lidars from a one-stop shop
Customers know we have the right suite of solutions for their needs in wind energy — taking them ever higher by adding value at each step of the project lifecycle.

Easy, reliable global solution
We make our clients' lives easier. Our easy to use, turnkey WindCube product suite enables customers to harness the power of wind energy efficiently and affordably.

As a result, Leosphere, a Vaisala company, is the iconic and trusted gold standard in wind lidar. Our turnkey WindCube product suite offers innovative, reliable, and highly accurate solutions for thousands of customers across the globe. All of this has enabled us to be catalysts for change and ambassadors for wind energy, always advancing the field and those we serve.

windcubelidar.com

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