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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.

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Contents

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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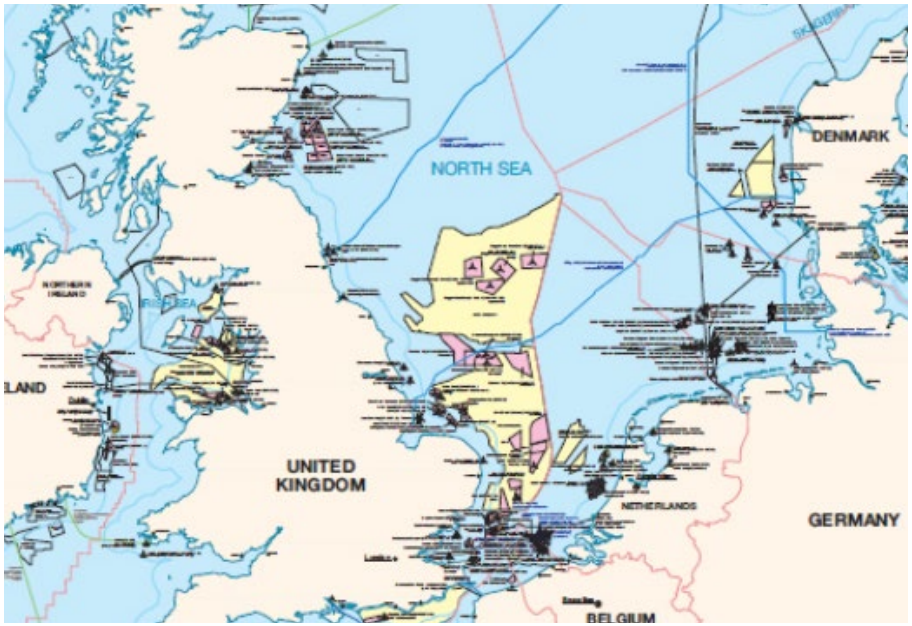

Into the North Sea and beyond

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.

Projects summary

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

"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.

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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.

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 the team at NREL and ENGIE Green used WindCube Nacelle to evaluate a wind farm control strategy.

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 and ENGIE Green recently completed a collaborative project at one wind farm in France. In this experiment, realized in the scope of the research project SmartEole, they developed improved methods of wind farm control that will make other wind farms more dynamic, adaptive, and efficient.

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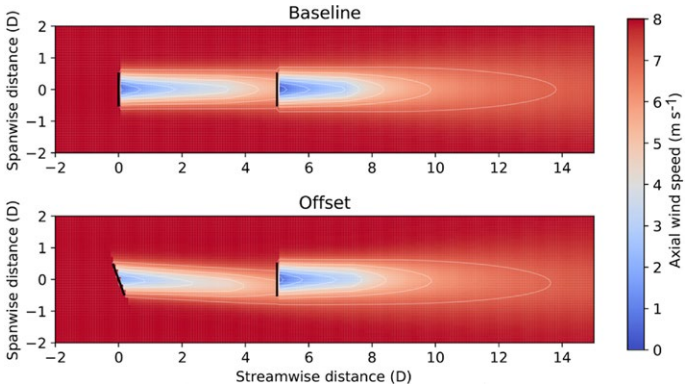
Going (slightly) against the flow

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.



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**

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.

For this trial, ENGIE Green and NREL 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.

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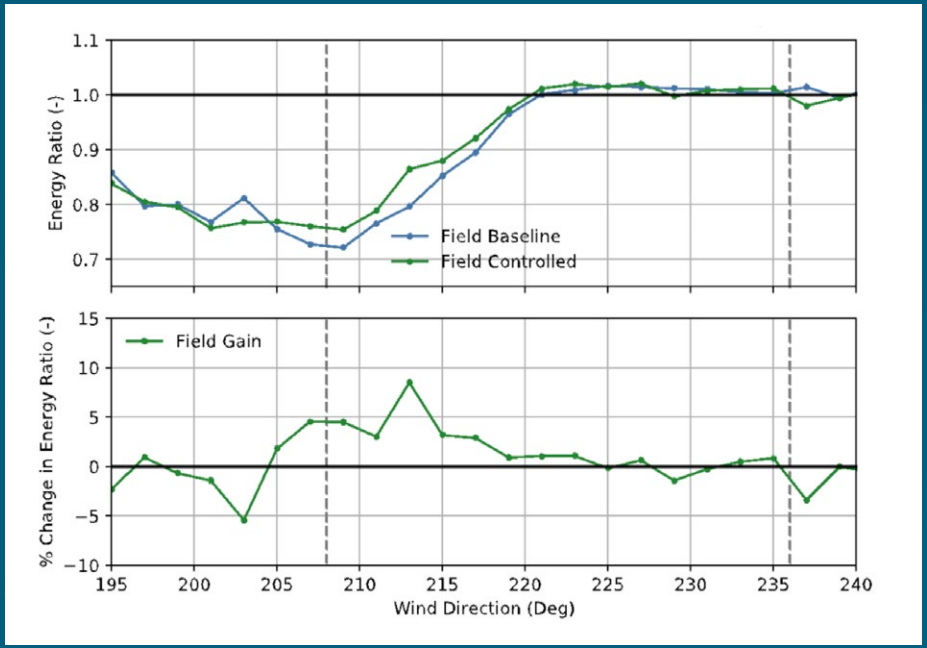
More power, please

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



NREL and ENGIE Green 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 in waked conditions.

Additional insights

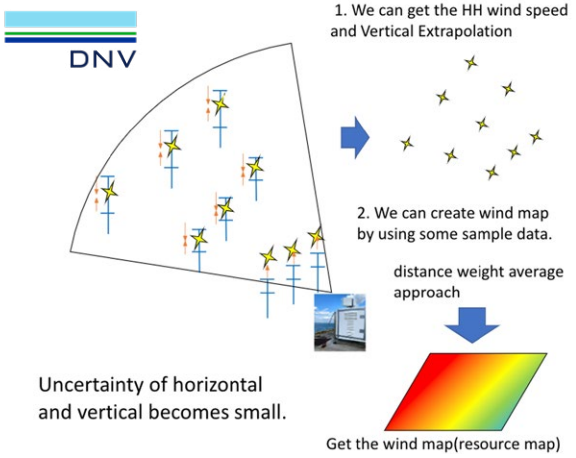
Along the way, the wind vane used to measure misalignment was shown to create a small amount of directional bias, and nacelle-mounted lidar provided comparative data for addressing the issue. Simley and his team increased their understanding of directional bias using wind vanes which allows them to optimize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

This experiment 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.

An industry first

This was the first case in which scanning lidar was accepted and used for wind farm certificate 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 Vaisala for renewable energy?

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 renewable energy solutions are guided by several key priorities:

Thoughtful evolution

Remain a pioneer in renewable energy, always providing sensible, trusted solutions at the leading edge of R&D.

Smarter at every stage

Provide end-to-end weather and environment solutions and critical insights throughout the renewable energy life cycle.

Legacy of leadership

Extend our proven track record and global trust to reach more customers in more ways.

Vaisala is the only company to offer 360-degree renewable energy solutions — from sensors and systems to digital services and actionable intelligence — nearly anywhere on the planet (and even on Mars). Every Vaisala solution benefits from our 85+ years of experience, pioneering deployments in 170+ countries, and unrivaled thought leadership.

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

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