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“Our weather-augmented wind-farm concept provides wind operators with unprecedented situational awareness and intelligence.”

▸ How does Vaisala’s “weather-augmented wind farm” approach help revolutionize wind-energy operations?

Unfortunately, too many wind farms underperform compared to their actual capacity and what was expected in the preconstruction phase due to unknowns surrounding wind and weather.

Wake losses, wind variations, and high turbulence are familiar impacts. However, changing weather conditions such as visibility, lightning, precipitation, icing, hail, humidity, and air density also significantly influence energy production, reliability, safety, and operational costs at remote wind-farm sites. While many wind-farm systems underperform and are overdesigned to account for this unpredictability, a better way exists.

Our weather-augmented wind-farm concept provides wind operators with unprecedented situational awareness and intelligence to optimize wind turbines’ performance, cost and reliability, and increases energy production. At a 300-MW wind farm, just 1 percent of additional production results in \$350,000 a year. Integrating wind Lidars, meteorological sensors, lightning detection, and advanced analytics equips project owners and operators with the real-time intelligence necessary to optimize assets, minimize downtime, mitigate costly repairs, and drive efficiency throughout the entire wind-farm life cycle.

By empowering decision makers to revolutionize energy operations and expand onshore and offshore wind farms to new frontiers, we help the wind industry meet the most pressing energy and climate challenges of our time.

▸ How does a 360-degree view of atmospheric conditions across wind farms differ from what has been done in the past?

Today, wind farms rely primarily on meteorological mast or turbine sensor data. The challenge is that turbine rotors significantly impact these instruments, creating inaccurate or missing data often not representative of the exact wind

and weather at the site without the evident ability to detect this. As an example, thanks to its advanced wind-field reconstruction, WindCube gives accurate free wind speed and direction. It enables the detection of turbine performance drift.

Integrated on every wind turbine or at the wind farm, and from wind speed and precipitation to forecasted icing conditions or lightning, 360-degree atmospheric awareness helps wind-farm owners and operators fill those gaps to better understand the weather patterns affecting wind farms. Our integrated solution combines nacelle and scanning Lidars, vertical profilers, meteorological sensors, and lightning detection to create a holistic weather-augmented wind farm.

This comprehensive wind and weather insight is used to reduce the impact of many wind and weather uncertainties and helps to increase energy production, availability, reliability, and safety.

▸ What makes up this innovative approach?

Leveraging Vaisala’s 85-plus years of environmental measurement expertise in multiple domains, our 360-degree weather approach incorporates wind Lidars, weather and environmental sensors, and data analytics into the wind-farm ecosystem, delivering previously lacking weather information.

Regardless of the geography or unique weather challenges a wind farm faces, our customizable solution set provides constant monitoring, predictive forecasting capabilities, and data intelligence tools to truly optimize wind-farm production, reliability, and predictability.

▸ What are some of the operational benefits?

The easy-to-install-and-maintain weather-augmented farm solutions seamlessly integrate wind Lidar, weather sensors, and lightning data and connect to either turbine control systems or farm SCADA systems to unlock numerous benefits for wind turbines and wind farms. Those benefits include:



Vaisala's 360-degree weather approach incorporates wind Lidars, weather and environmental sensors, and data analytics into the wind-farm ecosystem. (Courtesy: Vaisala)

✔ Detecting and forecasting wind gusts and rapid changes in wind direction allows for proactive measures to protect turbines against fatigue and extreme loads, reducing costs, and extending their performance.

✔ Conducting quick and accurate Power Performance Testing ensures compliance with expected performance and detects drifts early.

✔ Reducing wake losses by strategically operating turbines and accounting for real atmospheric conditions to maximize overall energy capture.

✔ Improving energy forecasting accuracy enables more reliable trade and power delivery.

✔ Protecting personnel and assets from potential wind gusts, lightning, low visibility, or other inclement weather-related to increase safety and optimize operation windows to minimize downtimes and damage costs.

✔ Monitoring visibility, icing, precipitations, hail, and dust particles enables optimized turbine operations strategies that maximize production during favorable conditions while protecting turbines from damages during severe conditions

✔ **Is Vaisala's solution suite scalable depending on the size and needs of a wind farm?**



Absolutely. We've designed our weather-augmented wind-farm solution set to be fully customizable based on each wind farm's unique atmospheric conditions, size, layout, and key challenges.

Our flexible combination of different types of wind Lidars, weather sensors, and digital products can be tailored to address specific issues such as wake effects, wind gusts, icing, and blade erosion or provide comprehensive monitoring across the entire site. This flexibility and scalability ensures wind operators get the right-sized environmental intelligence solution — regardless of size or whether the project is onshore, offshore, in a desert region with complex terrain, or a northern region affected by extreme cold.

► What solutions does this approach offer at the wind-farm level? At the turbine level?

At the wind-farm level, the approach deploys vertical profiling Lidars for continuous wind monitoring, scanning Lidars for wake management and ramp forecasting, and nacelle Lidars for performance optimization. It also includes precipitation and visibility sensors, ceilometers for icing conditions, lightning detection data, and integrated digital solutions.

Delivering this level of insight helps improve the operation window planning, anticipate and mitigate weather-related production losses, improve performance monitoring and production forecasting accuracy, and enhance future farm designs and production estimates through more accurate research and development. On the turbine level, our approach integrates nacelle-mounted Lidars for turbine control

and contractual PPT (Power Performance Testing), ultrasonic wind sensors, pressure/temperature/humidity sensors, visibility sensors, precipitation monitors, and lightning forecasting data into control systems. The benefits for turbines include reduced loads, increased reliability and availability, longer lifetime, minimized material costs, and improved performance.

► With the interest in offshore wind rapidly growing, can this technology help move it forward more rapidly and efficiently? How so?

Regarding offshore wind, everything is bigger — wind-farm sites, turbine rotors, project and operational costs, and revenues. Given these impacts, the harsh maritime environment, and tight offshore operating windows, any benefit is multiplied by the size of the farm, turbine energy generation potential, and the fact offshore operations are that much more expensive.

Consequently, Vaisala's weather-augmented wind-farm approach ideally supports the accelerating offshore wind sector in the U.S. and globally by providing unprecedented atmospheric monitoring that captures the full complexity of offshore sites. Whether enhancing site selection through detailed weather insights for optimal location decisions, informing safer and more efficient installation and service processes, mitigating risks, or maximizing operational performance, this level of environmental intelligence enables better project planning and execution as more wind farms are constructed in waters farther from shorelines.

► What has been the industry response to these advancements from Vaisala?

The wind-energy industry very much likes to reduce uncertainties and has responded positively to advancements across the ecosystem, recognizing the challenges in addressing underperformances across wind farms caused by inadequate wind and weather data intelligence.

By providing detailed weather and operational insights that equip operators to pinpoint issues and take corrective actions, this unique approach helps operators optimize individual turbines and entire wind farms. With detailed knowledge of wind and weather conditions enabling better forecasting and planning, operators can reduce uncertainties and increase confidence in energy outputs.

DNV, for example, highlighted in a recent white paper that nacelle Lidar-based power curves offer similar accuracy as best-in-class met mast PPTs (Power Performance Testing)—for a fraction of the cost. Operators also appreciate the cost savings from reduced maintenance and improved efficiency.

By addressing critical industrywide challenges, Vaisala helps improve project efficiency and profitability as the transition to renewable energy sources continues accelerating worldwide. ↴

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