Managing growth: new industry-wide guidelines for accurate Wind Resource Assessment with dual scanning lidar

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Winds of change are gusting in the field of wind energy. Driven by advancing technologies and unprecedented policy momentum globally, wind is poised for significant growth in 2024. As wind energy development accelerates, the need for accurate and reliable wind resource data is greater than ever. Since the turn of the century, the average hub height of wind turbines has nearly doubled as manufacturers design turbines with greater generating capacities. Consequently, traditional measurement methods such as meteorological masts have been almost completely replaced by modern lidar technology, especially offshore.

To meet evolving demands in the face of rapid change, advanced technologies like lidars and new best practices are emerging across all stages of wind farm development. Lidar delivers several advantages motivating this shift including speed and ease of deployment; measuring capabilities with ever-growing hub heights; setup and technician safety; cost, mobility and reusability; accuracy, range and depth of data; and diverse applications over extended service lives.

Lidar is not new to wind energy. By now, users across the globe have deployed and validated thousands of lidar units, particularly vertical profilers, for various purposes. And while vertical profiling lidars remain essential, progressive companies, especially offshore developers, increasingly turn to scanning lidar for an even fuller, and more flexible, 3D understanding of the wind environment.

The rise of scanning lidar

Vaisala's WindCube Scan uses laser pulses sent into the atmosphere and reflected by aerosols or particulates traveling within it. Unlike vertical profilers, however, scanning lidar units measure across 360°using several scanning patterns, up to ranges of nearly 20 kilometers. With scanning lidar, the possibilities are almost endless, providing 3D spatial wind awareness that allows assessment of large areas at once, creating enormous efficiency, increasing wind assessment certainty and improving both the quality and the quantity of available wind data.

Perhaps nowhere is the value of lidar more pronounced than in Wind Resource Assessment (WRA) campaigns. Since the accuracy of a WRA can make or break a wind energy project, having robust and reliable measurement techniques is crucial to avoid significant financial setbacks.

Enter Dual scanning lidars (DSLs), where the intersection of laser beams in a quasi-point measurement mode makes the approach a perfect solution for wind measurements close to the shore.

To help stakeholders across the wind energy sector get the most out of the new DSL measurement approach, Vaisala and DNV collaborated to develop comprehensive guidelines for utilising dual scanning lidars in offshore WRA campaigns. Pooling their combined expertise and collective experience, these leading renewable energy companies provide a reliable compass for stakeholders looking to adopt DSL technologies and methodologies.

The first-of-its-kind guidelines are paving the way for increased usage of DSL solution for offshore WRA and will contribute to the creation of the International Energy Agency (IEA) Task 52 working group that will collate user experience and current practice to form Recommended Practices on use of scanning lidar measurements offshore. Ultimately, the industry's objective is to deliver the IEC 61400-50-5 standard that will include the technical specification on the use of scanning lidars for wind measurements.

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Addressing the challenge of uncertainty

In wind energy, multimillion-dollar projects depend on the ability to reduce project risk and wind measurement uncertainties.

Yes, wind developers are familiar with using mathematical models to estimate the wind's behavior at a specific farm site. However, these models are usually based on limiting factors that can lead to inaccuracies, substantial financial losses over a project's life cycle and, worst of all, project failures. These include historical records; outputs from met masts that likely don't cover the whole operating region or rotor sweep of today's modern turbines; and data extrapolations that can introduce bias.

Obtaining accurate data on wind resources is even more challenging in offshore environments, where wind farms are enormous and met masts are too expensive to install. Scanning lidar, like the WindCube Scan, delivers more localised data and less spatial uncertainty, dramatically reducing educated guesswork on the part of developers and enabling them to check and refine existing wind models and optimise them over time.

Scanning lidar can also operate onshore, or from remote platforms, while measuring offshore areas, dramatically increasing the range and detail of wind data. The practical outcome of this enhanced offshore wind awareness is reduced uncertainty in Annual Energy Production (AEP) and P90/P50 ratio. Dual scanning lidars dramatically improve WRA campaigns by measuring multiple locations and heights in quasi-point measurement mode and creating several 'virtual met masts' for a full wind profile picture.

With DSL, planners can also obtain Turbulence Intensity (TI) measurements for turbine suitability studies and improve other outputs, improving the financial viability of a project.

Best practices are evolving to maximise the value of DSLs for WRA while ensuring data quality. The new Vaisala-DNV guidelines aim to facilitate decision-making and make DSL technology more accessible to potential users.

Guidelines to demystify the dual scanning lidar principle

The basic principle behind dual scanning lidar wind measurements is reconstructing the full horizontal wind vector at a location using the individual LOS wind speed measurements from two separate lidar devices.

Scanning lidars measure the wind speed vector component in line with the laser beam, so the horizontal wind speed and direction need to be reconstructed from multiple beams with different orientations. The wind vector reconstruction using one or more scanning lidars can be done using various methods, geometries and modes of operation, each with advantages, drawbacks and special considerations.

Real-world case studies from renewable energy companies like Green Power Investment (GPI) show dual scanning lidar configurations have improved offshore WRA accuracy by 6% compared to traditional met masts.

GPI believes that dual scanning lidar is key for accelerating offshore wind development and Japan's wind farm certification process. According to Atsushi Yoshimura, manager at GPI, 'The WindCube Scan Dual Ready lidar offering is a game changer. We can get the whole wind picture with scanning lidar. We can create site conditions for wind turbine design load using dual scanning lidar without an offshore met mast or floating lidar system. There are too many good values

to describe scanning lidar, and I cannot find a better partner than Vaisala and EKO. Without their expertise, we would not be able to make this happen'.

Fully realising these benefits depends on following robust practices around campaign design, execution, uncertainty assessment and more.

Typical DSL WRA campaign workflow

Planning and executing successful DSL campaigns

The collaborative guidelines outline a step-by-step workflow for planning and executing offshore DSL wind resource assessment campaigns.

The process starts by defining the required measurement locations based on the wind farm site. Ideal installation positions for each lidar unit are identified to optimise the scanning geometry while considering range limits and terrain constraints. The guidelines then recommend verifying lidar accuracy and performance before deployment through system coordination and beam geometry calculation.

Even in the preliminary design of the layout of a DSL campaign, developers should consider the effect of the beam geometry on the final measurement uncertainty. Proper installation, alignment checks, routine monitoring and data synchronisation help maintain data integrity throughout the campaign.

Verification and uncertainty evaluation to maintain data quality from start to finish

In WRA, accurate and reliable measurements support project investment and feasibility. Proper lidar installation on secure, immobile concrete foundations and on-site calibration help avoid position and orientation changes over time. Regular alignment checks and monitoring inclination sensors enable correcting orientation drifts.

Routine performance monitoring, including synchronisation, laser power and inclination angle checks, is advised to rapidly respond in case issues arise. Following scheduled preventative maintenance helps minimise measurement downtime.

For data processing, the guidelines recommend quality filtering of line-of-sight measurements and assessing data availability of 10-minute averages. Wind vectors should be reconstructed using synchronised, quality-checked data to avoid distortions in wind speed distributions.

The uncertainties of DSL measurements depend on several parameters that can vary from project to project. From LOS wind speed to the elevation angle, Azimuth angle, range and other reconstructed quantities, some parameters are lidar-specific, while others depend on the individual campaign conditions. Consequently, the guidelines include crucial pre- and post-campaign uncertainty assessments and calculations to help decision-makers.

As stakeholders navigate the complexities of uncertainty, the collaborative efforts of Vaisala and DNV, alongside the transformative capabilities of DSLs, provide hope for the future.

Driving the wind energy transition through collaboration

Improving WRA accuracy can reduce project risks and uncertainties, helping the wind industry make projects bankable and profitable.

Vaisala's and DNV's collaborative guidelines represent an essential effort between industry leaders to codify and share best practices for utilising dual scanning lidar technology to enable reliable wind resource assessments onshore and offshore. Promoting standards and education will accelerate the adoption of these innovative technologies, and forward-thinking partnerships like this reflect the proactive mindset needed to continue driving down the cost of wind energy and make the green transition a reality.

With companies across the industry cooperating to advance wind measurement capabilities, the winds of change are driving our ongoing renewable energy revolution forward.

Access the new industry guidelines for dual scanning lidar at www.vaisala.com