TASK 32 REPORT 2020

Wind lidar for wind energy applications

As wind turbines get larger, go offshore, and contribute ever more to our electricity supply, we need more information about the wind. Conventional anemometry—cup anemometres mounted on masts or turbines—simply cannot provide the level of detail that is needed to measure wind resources at 200 m or higher, monitor wakes, or make control decisions.

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That's where remote sensing of the wind using lasers—wind lidar—comes in. With wind lidar, we can measure wind conditions several kilometres away, allowing us to replace cup anemometres in existing applications, but also enabling new approaches to operating wind turbines.

IEA Wind Task 32 is focused on identifying and mitigating the barriers to the adoption of wind lidar for wind energy applications. We do this by bringing stakeholders together and identifying what needs to be done as a community to overcome those barriers. Our tools include supporting new research initiatives by our members, communicating results from existing work, and helping connect people. We're aiming for a growth of wind lidar adoption from about 1% of all applications today to about 10% in 2025.

The Task brings together approximately 1,000 researchers, lidar vendors, service providers, consultants, wind plant developers and wind turbine OEMs from across the globe (Table 1). Industry participation in 2020 was around 65%.

Progress and achievements

Task 32 is helping drive the use of wind lidar in new locations. In 2020 Task 32 created two new working groups to investigate the use of wind lidar. One, led by Nergica and carried out in collaboration with Task 19, looks at the use of wind lidar in cold climates. Another, led by Energiewerkstatt, looks at the use of wind lidar in complex terrain.

Wind lidar are often used in flat or rolling terrain, or in forested regions. There are several guidance documents that cover this (including a new update from Task 32 in 2020), but there is a lack of science-based guidance for mountainous regions, where complex flow can cause differences between lidar and point measurements. Working with data from five sites, the complex terrain working group used ten different methods to convert the lidar measurements into what would be expected from a cup. This is an essential step to establishing confidence for the use of lidar in very complex terrain. Results will be published later in 2021.

TABLE 1. COUNTRIES PARTICIPATING IN TASK

Table 1. Task 32 Participants in 2020

	Country/Sponsor	Institution(s)
1	Austria	Energiewerkstatt, Ventus Engineering
2	Canada	DNV GL, Nergica, UL
3	China	Nanjing Movelaser Co., Ltd. XEMC-Wind
4	Denmark	C2Wind, Copenhagen Offshore Partners, DNV GL, DTU, EMD International A/S, JMC, METEK Nordic ApS, MHI Vestas, Ørsted, Siemens Gamesa Renewable Energy, Suzlon, Vestas, Windar Photonics A/S
5	France	EDF Renouvelables, Engie Green, EPSILINE, IFPEN, LEGI, Leosphere, LHEEA (CNRS)—Centrale Nantes, RWE, UGA, VALEMO, Velocita Energies
6	Germany	Air Profile GmbH, anemos GmbH, Association of German Offshore Wind Farm Operators, Deutsche WindGuard Consulting, DLR e.V., DNV GL, EnBW, ENERCON, Federal Maritime and Hydrographic Agency, Flensburg University of Applied Sciences, Fraunhofer IWES, GE Wind Energy, GEO-NET Umweltconsulting, Goethe University Frankfurt, Guidehouse WTTS, GWU-Umwelttechnik, IAV, Industrial Science, Innogy, Metek, Mitsubishi Electric Europe, Navigant WTTS B.V., Nordex, Offshore Wind Consultants, sowento, Technical University of Munich, TEG, Tractebel, UL, U. Oldenburg, U. Stuttgart, Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW)
7	Japan	Green Power Investment, Kobe University, MELCO, Mitsubishi Electric Corp., National Institute of Advanced Industrial Science and Technology, Pacifico Energy, Shizen Energy Inc.
8	The Netherlands	AES Corp, Delft University of Technology, ECN part of TNO, TU Eindhoven, Siemens Gamesa Renewable Energy, Vattenfall
9	Norway	Equinor, University of Bergen
10	Switzerland	Meteotest
11	United Kingdom	Black & Veatch, Carbon Trust, DNV GL, EDF, Frazer-Nash, FTI Consulting—Clean Energy, Metoceanology, Natural Power, Nexus Power, Nordex Group, Oldbaum services, RCG, Red Rock Power, Renewable Dynamics, RINA, RWE, ScottishPower Renewables, Shell New Energies, SSE, The European Marine Energy Centre, The Renewables Consulting Group, U. Manchester, U. Strathclyde, Vestas, Wind Farm Analytics, Wood, ZX Lidars
12	United States of America	Altosphere, DNV GL, E.ON Climate & Renewables, Envision Energy Inc., GE Renewables, Mitsubishi Electric Research Labs, NREL, NRG Systems, Principle Power, Sandia National Laboratories, UL, UC Boulder, UT Dallas, Vaisala, Vortex FDC, Wood

TASK 32 ALSO ACCEPTED OBSERVERS FROM AUSTRALIA, BRAZIL, INDIA, PAKISTAN, AND SWEDEN.

It is very difficult to get accurate, long-term wind resource measurements in cold climates using traditional met towers. These are vulnerable to icing and require power supplies for continuous operation. By contrast, wind lidar are often simpler to maintain and operate, but may have their own challenges. The joint Task 32 / Task 19 working group on wind lidar in cold climates has been documenting the opportunities and challenges of using wind lidar in cold climates and will publish results in 2021.

Wind lidar can also be integrated into wind turbines to help control them, which can reduce loads and increase energy conversion. However, this adds costs and complexity to the wind turbine system. In 2019 Task 32 and Task 37 (Systems Engineering) held a joint workshop on optimizing wind turbines with lidar-assisted control using systems engineering. The results of the workshop were published in 2020, highlighting the possible applications and perspectives [1].

The COVID-19 pandemic prevented our usual schedule of in-person meetings. We used the opportunity of switching to online events to reach more people than ever before, hosting around 15 task-level events during 2021 that reached over 500 participants. We also launched a Task 32 library to capture our publications (https://zenodo.org/communities/ieawindtask32/), and launched our new website at http://www.iea-wind.org/task32. As a result, we continue to make progress towards our strategic goals [2].

Highlight

Task 32 collaborates with many different groups to ensure the adoption of wind lidar based on evidence. We work with other Tasks to ensure relevance, such as Task 19 for wind lidar in cold climates, Task 36 for wind lidar for forecasting, and the new wind-farm control task. We also work closely with the IEC to initiate and formulate standards; certification agencies to develop new processes, for example for wind turbine controls; and with industry groups such as the industry-led Consortium for the Advancement of Remote Sensing (CFARS) to generate industry-wide consensus. Together we form a technology transfer pathway from idea to end user that has enabled the confident use of wind lidar for many wind energy applications.

Outcomes and significance

Wind lidar were first commercialised in the early 2000s. Task 32 estimates that by 2020 around 2,000 vertical profiling lidar are in use on land; around 1,000 on wind turbines for yaw monitoring, power performance testing, and wind turbine controls; and floating lidar systems have almost completely replaced masts for new offshore wind farms. This rapid growth has been made possible by the research coordinated by the Task, our guidance documents, and the collaboration we have fostered across the wind lidar and wind energy communities.

By 2025 we expect at least 10% of new turbines to be equipped with wind lidar, and wind lidar to be replacing a quarter of masts internationally. Task 32 will support this in future by driving to make lidar easier to use on land and offshore, and easier to integrate into the new digitalised wind energy sector.

The improved communications methods we developed in 2020, together with close cooperation with other groups involved with the widespread adoption of wind lidar—the IEC, CFARS, and certification bodies—allows us to more effectively reach our stakeholders and support the deployment of wind lidar for wind energy.

Next steps

Our working groups on wind lidar in cold climates and wind lidar in complex terrain will continue in 2021, making progress towards our long-term goals of helping users to deploy wind lidar confidently at any location.

We are also planning new initiatives, including a round robin event to compare turbulence estimates from nacelle-mounted forward-looking lidar with reference devices in simple terrain, and events to make progress on the use of forward-looking nacelle-mounted lidar for inflow characterization in all flow conditions. Together these will allow nacelle-mounted forward-looking lidar to be used for wind turbine and wind plant operations anywhere.

The Task will apply for an extension at the end of 2021.

References

[1] Simley et al (2020). IEA Wind Task 32 and Task 37: Optimizing Wind Turbines with Lidar-Assisted Control Using Systems Engineering. Download from doi.org/10.1088/1742-6596/1618/4/042029.

[2] Clifton et al (2020). IEA Wind Task 32: Collaborative R&D Roadmap. Download from doi.org/10.5281/zenodo.4030701.

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