

5 November 2018
Minutes of
IEA Wind Task 32 General Meeting 2018

22nd and 23rd October 2018
Mustang Room, BMO Center, Alberta, Canada

About This Meeting

The 2018 General Meeting was held before the CanWEA annual event in Calgary, Alberta, Canada. This meeting aimed at exploring current and future challenges associated with the adoption of wind lidar for wind energy applications. The goal of the meeting was to identify possible solutions to these challenges and ways that Task 32 could contribute.

The meeting was organized by IEA Wind Task 32 together with [Nergica](#), a centre of applied research that stimulates innovation in the renewable energy industry through research, technical assistance, technology transfer and technical support for businesses and communities. Andy Clifton represented the Operating Agent (Stuttgart Wind Energy (SWE) at Institute of Aircraft Design, University of Stuttgart).

The Task 32 Operating Agent gratefully recognizes the support of Nergica and the enthusiastic participation of almost 30 people from across Asia, North America, and Europe. A list of attendees can be found at the end of this document.

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Day 1: Where are we?

Welcome

9:00	Welcome Housekeeping + Introduction Round (Andy Clifton)
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The guests were welcomed and given a short introduction to meeting logistics. This was followed by a round-the-room introduction from each of the participants.

What's going on in Task 32?

9:30	What's going on in Task 32 <ul style="list-style-type: none">• What is Task 32? (Andy Clifton)• Workshop 8: Certification of Lidar-assisted control (Eric Simley, NREL)• Workshop 9: Short-term forecasting (Peter Clive, Wood)• Workshop 10: (Eric Simley, NREL)
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What is Task 32?

Andy Clifton provided an overview of how IEA Wind works, what Task 32 is, what it has done, and how it is financed. It was noted that Task 32 was recently extended and will start Phase III in January 2019. Phase III will run from 2019 to the end of 2021.

More information about Task 32 can be found at www.ieawindtask32.org.

More information about IEA Wind and other Tasks can be found at <https://community.ieawind.org/>.

A peer-reviewed paper about the barriers to the adoption of wind lidar which summarizes much of the Task's results from the period 2013-2018 was published by a group from Task 32 in early 2018. The paper can be found at <https://www.mdpi.com/2072-4292/10/3/406>.

Workshop 8: Certification of Lidar-assisted Control (Eric Simley, NREL)

Eric Simley presented a summary of workshop 8, hosted by DNV GL in Hamburg, Germany in January 2018. The workshop was led by Nikolai Hille (DNV GL) and addressed the barriers to the certification of wind turbines using lidar-assisted control (LAC) and ideas for mitigating those barriers.

Lidar-assisted control of wind turbines is a promising technology for reducing structural loads on wind turbines using preview measurements of the approaching wind to inform the control system. However, there are no standard guidelines explaining how certification of turbines with LAC should be performed. This makes it difficult for turbine manufacturers to assess the value creation of LAC with respect to both fatigue and extreme load reduction. During the workshop, the views on certification with LAC were heard from five stakeholder groups: turbine manufacturers, lidar suppliers, consultants, certifiers, and researchers. After discussing the challenges, ideas for solving the barriers were proposed in group discussions.

The use of LAC mainly affects the certification process during the simulation-based design evaluation stage and type testing in the field. The main challenges in the design evaluation stage include 1) simulating lidar measurements such that enough load-relevant details of the measurement process are modeled and 2) properly simulating and assessing LAC for extreme load reduction. Many of the extreme wind events traditionally used to simulate extreme loads are ambiguous or too simplistic to use for realistic lidar preview measurement simulations and therefore require clarification or redefinition. Furthermore, for both fatigue and extreme load reduction, assessing the value of LAC requires an accurate estimate of lidar availability and reliability (since LAC can only be used when

lidar measurements are available), an area that lidar OEMs can assist with. During type testing, the availability of the lidar should be verified along with the loads that occur with and without LAC.

A workshop report describing proposed solutions for overcoming the above challenges for certifying wind turbines with LAC, and many more, titled “IEA Wind Task 32: Best Practices for the Certification of Lidar-Assisted Control Applications,” was presented at WindEurope 2018 and is published online at <http://iopscience.iop.org/article/10.1088/1742-6596/1102/1/012010>. Additionally, DNV GL is working on publishing their guidelines for certification with LAC, with input from the workshop results.

More information about the workshop, including the workshop minutes, is available at <https://www.ieawindtask32.org/workshop-8/>.

Workshop 9: Short-term Forecasting (Peter Clive, Wood PLC)

Peter Clive introduced this workshop using slides provided by Ines Würth (U. Stuttgart) and Laura Valdecabres (U. Oldenburg).

This workshop was held in June 2018 at DTU together with Task 36. The workshop was led by Ines Würth (U. Stuttgart), Laura Valdecabres (U. Oldenburg), Elliot Simon (DTU Wind Energy), and Mike Courtney (DTU Wind Energy). The workshop explored the need for minute-scale forecasting of wind power in a time horizon up to 60 minutes, and the participants discussed different forecasting methods, the barriers to implementation, and solutions to overcome those barriers.

A paper about the results from the workshop is in preparation for publication in *Energies*.

More information about the workshop is available at <https://www.ieawindtask32.org/workshop-9/>.

Workshop 10: Turbulence Intensity Measurements with LiDARs - Applications to Loads Verification and Site Suitability (Eric Simley, NREL)

Eric Simley presented a summary of workshop 10, hosted by Ørsted in Gentofte, Denmark in September 2018, and led by Ameya Sathe (Ørsted). The goal of the workshop was to understand the barriers that exist for the use of lidars for measuring turbulence intensity (TI) during load verification (the verification of simulated design loads using field measurements) and site suitability studies (assessment of environmental conditions to determine if a site is suitable for wind farm development). If their measurements of TI are acceptable, lidars can serve as a more efficient and cost-effective method for measuring TI for these purposes than met masts. However, at the moment, there are several barriers preventing lidars from measuring TI in a similar way to traditional cup or sonic anemometers (i.e. the TI of the horizontal wind speed at a “point” in space), which are required in the standards.

During the workshop, an overview of lidar TI measurements and load verification was given, as well as presentations from turbine manufacturers, lidar suppliers, consultants, and researchers on the challenges of load verification/site suitability studies using lidar TI measurements. Ideas for addressing these barriers were developed during group discussions.

The main problems with using lidars for TI measurements are volume averaging and cross-contamination between velocity components in the lidar measurements. These issues can be partially resolved by determining theoretically derived correction factors for the lidar measurements, using the Doppler spectrum of the lidar measurements to directly estimate turbulence parameters, or employing machine learning methods. However, many of these correction methods can be site or atmospheric condition-specific, and therefore difficult to apply at all sites. More research is needed to develop standard TI correction methods.

The main barriers to the use of lidar TI measurements for load verification or site suitability studies are 1) lack of guidance on the required level of accuracy needed and 2) lack of standards explaining how to use lidars for TI measurements and how to correct the measurements to estimate traditional “point” TI values. Consequently, the development of a standards document is an important next step.

Another idea proposed at the workshop was to use the strengths of lidars to measure potentially more meaningful values representing the impact of turbulence on loads, such as the “rotor effective” turbulence standard deviation, although such methods would require significant modification of existing standards.

As a followup to the workshop, many participants expressed the intent to develop a roadmap for the use of lidars for measuring TI for load verification and site suitability. The idea of a joint industry project to help create recommended practices is being explored as well.

More information about the workshop including workshop minutes will soon be available at <https://www.ieawindtask32.org/workshop-10/>.

Experience in Canada and the USA

11:00	Experience in Canada and the USA <ul style="list-style-type: none">● CFARS (Philippe Coulombe-Pontbriand)● Nergica (Cedric Arbez)● Breakout & Discussion - what’s unique about using wind lidar in different regions of the world?
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CFARS (Philippe Coulombe-Pontbriand, RES Americas)

Philippe Pontbriand presented the CFARS initiative (Consortium for Advancement of Remote Sensing). CFARS is a consortium formed of major private industry players that want to support advancement of remote sensing by providing a large pool of data and speaking with a common voice regarding acceptance status of RS.

The roadmap of CFARS leading to 2021 has been presented.

Three working groups have been formed within CFARS and are proposed to work closely with the IEA Task 32 on specific projects. (Guidance, Science and Leadership) Some possible collaboration have been identified and will require follow up meetings.

Nergica (Cédric Arbez, Research and Innovation Manager)

Nergica presented its infrastructure and current projects related to lidar. Also, as it was the first time that the Task 32 general meeting was held in Canada, Nergica presented an overview of wind energy in Canada and how issues and adoption vary from province to province. Most of the installed capacity at this time is located in Ontario, Quebec and Alberta.

Breakout & Discussion

The participants were asked to explore the challenges associated with using lidar in different parts of the world, and to consider if they were real or imaginary. In this case, a “real issue” is one that the participants have experienced and is backed up by evidence. An “imaginary issue” is something that is perceived as an issue by some people or groups, but there is evidence that it is not really a problem.

This exercise was intended to help participants explore perceptions about the use of wind lidar for wind energy applications, discover what experience they had to share, and start to consider where the Task 32 community could mitigate these issues.

The participants split into four groups to discuss this question. Results from each group are below.

	<p>Group One</p> <p>This group noted that remote deployments and lack of local producers was a real issue in North America. Low backscatter in clear air (particularly in winter) was seen by some as an issue but not wide-spread.</p> <p>The need to be able to support lots of different languages in Europe was considered a real issue, while the perception that “there are no issues in Europe” was thought to be wrong.</p> <p>Unique issues in Asia included typhoons and terrain.</p> <p>In the rest of the world, access to communications, high deployment costs, and patchy availability of trained labor was felt to be a real issue.</p>
	<p>Group Two</p> <p>Clear air or low aerosol counts was thought to be a real issue in North America by this group (compare to Group One). The perception that lidar remote sensing was not usable for project financing was thought to be an imaginary issue because such data has been used on many occasions.</p> <p>In Europe the continuing need for reliable power was noted as an issue, as was the perception that lidar is “special” or difficult, rather than just being one of many valuable measurement approaches.</p> <p>In the rest of the world, delays in developing and updating standards were noted as an issue. This was reflected in a lack of uniform methods in use by 3rd parties and even within organizations.</p>



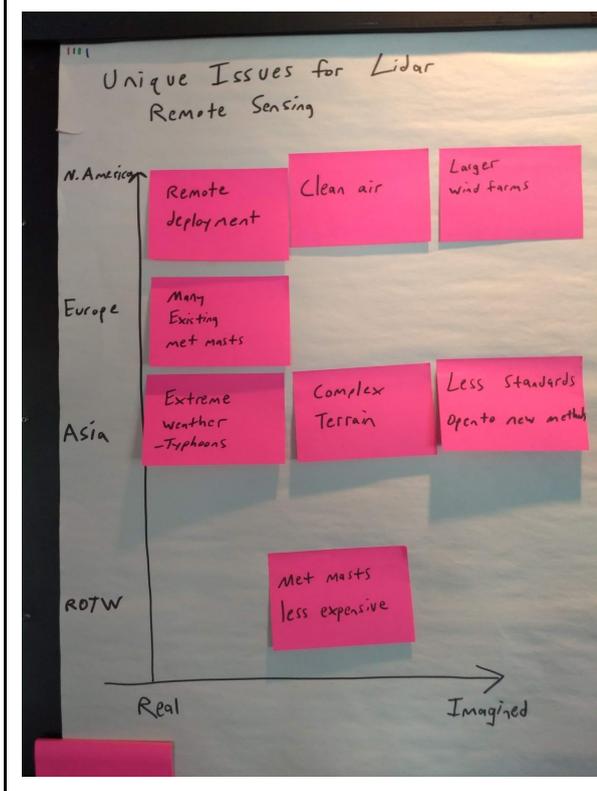
Group Three

Similarly to Group Two, this group noted that the perception that only data from meteorological (met) masts was “bankable” was wrong. They also noted that conditions in Canada were comparable to other parts of northern Europe and Asia, and that lessons learned there could be transferred.

The group was not sure about the availability of expert labor or tall towers for lidar validation in Asia and the rest of the world and therefore identified these as imagined issues.

The lack of data in the public domain about the use of stand-alone lidar for project financing was noted as a real issue in Europe.

After discussion, site (terrain) complexity and site security were noted as real issues in all regions.



Group Four

This group identified similar issues to the others.

They noted that it was not clear if met masts were always less expensive in the rest of the world. However there are some examples of regions where masts are objectively cheap (e.g., €20k for an 80-m tower in parts of south Asia), but the quality of the data is not clear.

In a discussion it was noted that there is no clear answer to the question of “is a lidar cheaper than a met mast” as it depends on so many factors. It was also noted that there may be more value to be extracted from lidar data than is currently the case.

It was noted in the discussions that those things that some stakeholders felt were unique were in fact common to many parts of the world, particularly challenges associated with cold climates, complex terrain, or remote operations. It was also noted that there were some perceptions - e.g. of the “bankability” or not of stand-alone lidar - that were incorrect, as stand-alone lidar has been used on many occasions for financing, particularly offshore. It was also noted that CFARS may be able to provide more evidence of the use of wind lidar for wind energy project financing.

What's new in the world of wind lidar?

13:00	<p>What's new in the world of wind lidar?</p> <p>Results of recent research projects & updates from manufacturers</p> <ul style="list-style-type: none"> ● Lidar performances: 2018 achievements and outlooks (Paul Mazoyer, Leosphere) ● Workshop 7: Complex Terrain (Andy Clifton)
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Lidar performances: 2018 achievements and outlooks (Paul Mazoyer, Leosphere)

In 2018, Leosphere was integrated into Vaisala : Lidar becomes a Vaisala business line. Combining companies strengths will allow for better value for Windcube and Wind Iris users.

On the product side, Leosphere released a new Windcube: v2.1. It has 3 years warranty, FCR as standard and onsite maintenance. Leosphere also released WindWeb software dedicated to Windcube. It allows for fleet management, safer data management and use from any device (iPad, PC,...). Last product news: Leosphere announced it has manufactured 150 TC Wind Iris in 2018. On the metrology side, Leosphere shared results on the vector averaging techniques. It showed a major improvement using vector averaging for the 10-minutes data of Windcube by removing sensitivities of measurement to the turbulence intensity.

Finally, Leosphere presented the coupling of a realistic simulator of Wind Iris turbine control (SimulID®) with aeroelastic simulation (FAST®) of a Lidar assisted control wind turbine. It showed the benefits of capturing a fine Lidar behavior for various environmental conditions (fog, rain,...) for the parametrization of wind turbine controller.

Workshop 7: Complex Terrain (Andy Clifton, WindForS, U. Stuttgart)

This workshop was held at the University of Stuttgart in November 2017, the day before the 2017 General Meeting. The workshop used desktop studies to provide a common reference to explore the use of lidar in complex terrain. The workshop identified challenges around the use of lidar in some situations (related to flow, weather, access, and power) but also the strong potential for the use of lidar for power performance testing in complex terrain. The need to use models to convert lidar data back to point measurements was seen as a major challenge.

Discussion at the 2018 General Meeting included:

- The need to convert lidar data back to point measurements is an example of losing some of the potential value of the lidar data.
- It might be appropriate to carry out some kind of lidar - to - reference comparison exercise or Round-Robin in complex terrain, possibly leveraging data available through CFARS.

Offshore wind update

14:15	<p>Offshore wind Update</p> <ul style="list-style-type: none"> ● Floating lidar for wind resource assessment (Nicolai Gayle Nygaard, Orsted) ● Lidar is how we integrate pre-construction assessments into a unified digital workflow (Peter Clive)
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Floating lidar for wind resource assessment (Nicolai Gayle Nygaard, Orsted)

Floating lidars have become the de facto standard for WRA measurements offshore. In the presentation Nicolai explained the rationale for using floating lidars in general and from a North American perspective, and explain how [the OWA floating lidar roadmap \(Carbon Trust, 2013\)](#) has been instrumental in driving adoption of the technology.

It was noted that although FLS have good survivability during high winds and extreme events there is still a need to understand accuracy in such conditions, as this is important for extreme loads.

Data and maps from the Carbon Trust's 2018 report on floating wind lidar deployments was also shown. This report can be found at <https://www.carbontrust.com/media/676308/owa-floating-lidar-repository-aug-reissue2018.pdf>.

Lidar is how we integrate pre-construction assessments into a unified digital workflow (Peter Clive, Wood)

Pre-construction wind energy assessments and post-construction wind power project operations involve activities that are somewhat siloed. The way the project is represented digitally, in terms of data and processes, at one stage of project delivery, is not necessarily compatible with the representation adopted at the next. This situation has arisen due to historic limitations in the available tools and techniques, such that what was possible at one stage did not necessarily fully address challenges arising at the next.

However, it is acknowledged that significant benefits can accrue from adopting a single unified digital workflow in the delivery of wind energy projects that maximise the visibility of information made available during one stage to personnel delivering other stages. In general, we should try to achieve the earliest possible availability of the highest quality information. In practice this might mean being able to anticipate performance and reliability issues while mitigation is available.

The rich datasets made available by lidar, the opportunity to integrate these data with detailed modelling, and the the possibility of deploying lidar in equivalent, inter-comparable configurations during different stages of delivery, suggest that lidar may be a key enabling technology in the establishment of unified digital workflows.

For example, at the moment we are seeing approximations that were adopted due to historic limitations introducing errors. The cumulative influence of induction zones create a global blockage effect that is not modelled during pre-construction energy yield estimation. Wake losses are seen to be an emergent phenomenon, an attribute of the array, rather than a simple superposition of the wakes of multiple turbines, as the array itself modifies the wind conditions it encounters.

Both of these indicate we can no longer think in terms of pre-construction conditions or simple terrain. The influence of the array means the wind conditions that determine project performance do not arise until after construction, and the array itself constitutes terrain. Historic methods based on met mast capabilities cannot be applied in a consistent manner during all stages of project delivery under these circumstances. Lidar based methods can.

It was noted that the digitalization of wind lidar data and processes was also explored recently in Workshop 12, e-WindLidar at DTU Risoe in October 2018. More information about that meeting can be found at <https://www.ieawindtask32.org/workshop-12/>.

World Cafe

15:10	World Café Discussions in groups around the issues, needs, and solutions for lidar applications, e.g.: <ul style="list-style-type: none">● Resource assessment on- and offshore● Power performance testing● Lidar-assisted turbine control● Plant control● Loads● Wakes● Forecasting● New applications● ...
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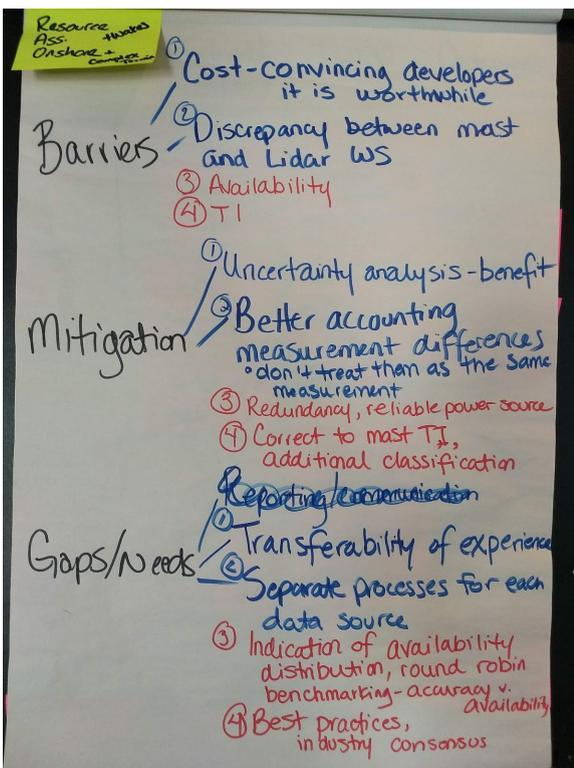
The World Cafe allows people to move between groups to discuss multiple issues. It has been used many times at Task 32 meetings to explore issues and identify possible activities.

Based on discussion through the day, the participants decided to explore the following areas:

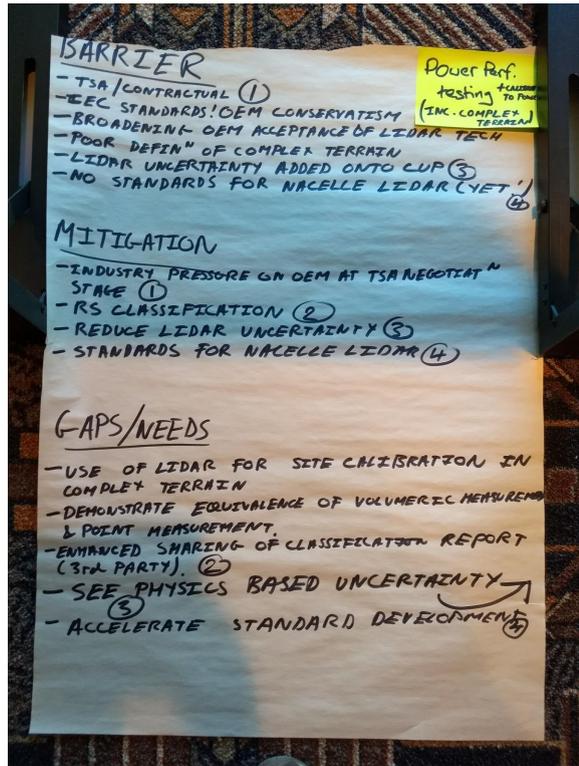
1. Resource assessment
2. Power performance testing
3. Wind turbine- and wind-plant control
4. Lidar meets models
5. Lidar in cold climates
6. Uncertainty modeling.

Groups formed to discuss each area for 15-20 minutes. The groups were asked to identify the barriers to progress in each area, how those barriers could be mitigated, and what was still needed to overcome those barriers (e.g. the lack of a technology or method). The results from each group were discussed in plenum.

Note: It was decided that issues such as complex terrain and wakes that were identified in the morning discussions have different impacts in each of areas 1 to 6, and so would be discussed directly within those areas.

 <p>The whiteboard notes are organized into three main sections: Barriers, Mitigation, and Gaps/Needs. A yellow sticky note at the top left reads 'Resource Assessment Onshore + ...'. The 'Barriers' section lists: 1. Cost-convincing developers (it is worthwhile), 2. Discrepancy between mast and Lidar WS, 3. Availability, and 4. TI. The 'Mitigation' section lists: 1. Uncertainty analysis - benefit, 2. Better accounting measurement differences (don't treat them as the same measurement), 3. Redundancy, reliable power source, and 4. Correct to mast TI, additional classification. The 'Gaps/Needs' section lists: 1. Reporting/communication, 2. Transferability of experience, 3. Separate processes for each data source, 4. Indication of availability distribution, round robin benchmarking - accuracy v. availability, and 5. Best practices, industry consensus.</p>	<h3>Resource Assessment Onshore</h3> <p>It was noted that there has been success in relating lidar measurements to traditional cup anemometry and using lidar as part of a resource assessment.</p> <p>It was also noted though that there are still questions about the value of lidar during resource assessment. One consultant noted that it was a cost-benefit argument that could be shown to clients. In their experience lidar always reduces uncertainty and has a positive impact on project net present value (NPV).¹</p> <p>It was discussed that it may be appropriate for the research community to explore processes from a “what if we had lidar first” perspective. This would allow questions such as the effect of data availability and the meaning of lidar-derived turbulence intensity to be explored.</p>
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¹ See presentation from WSP at <https://www.ieawindtask32.org/?p=2426>.

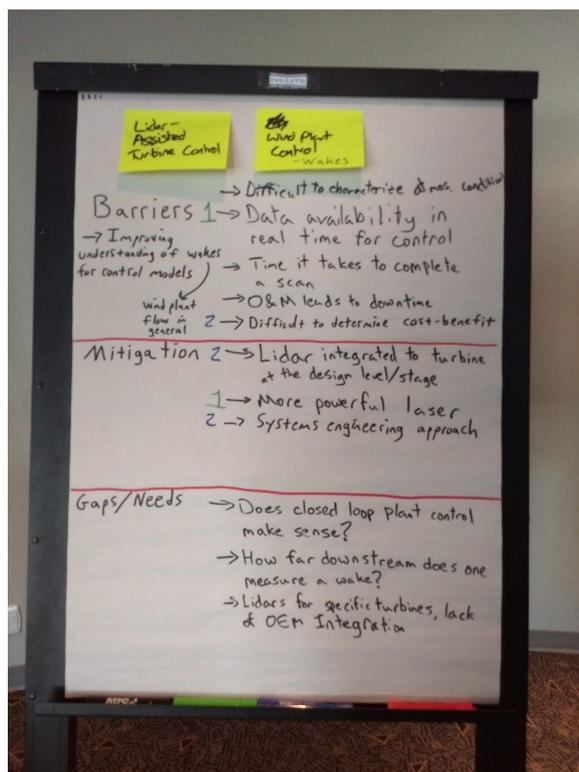


Power Performance Testing

This group noted that some barriers to the adoption of lidar for power performance testing were related to standards (either the lack thereof or how they impact lidar-based measurements). These barriers could be mitigated through working with standards groups.

Another set of issues was related to lack of knowledge about the results of lidar classifications, which could be mitigated by vendors sharing classification reports.

Further challenges related to complex terrain and uncertainty were also noted. Particularly, it was noted that the current approach of comparing lidar-derived wind speed measurements to a cup may be penalizing the lidar, while comparisons to short-range lidar (e.g. DTU lidic) may be more effective as they are not impacted by mast flow distortion.

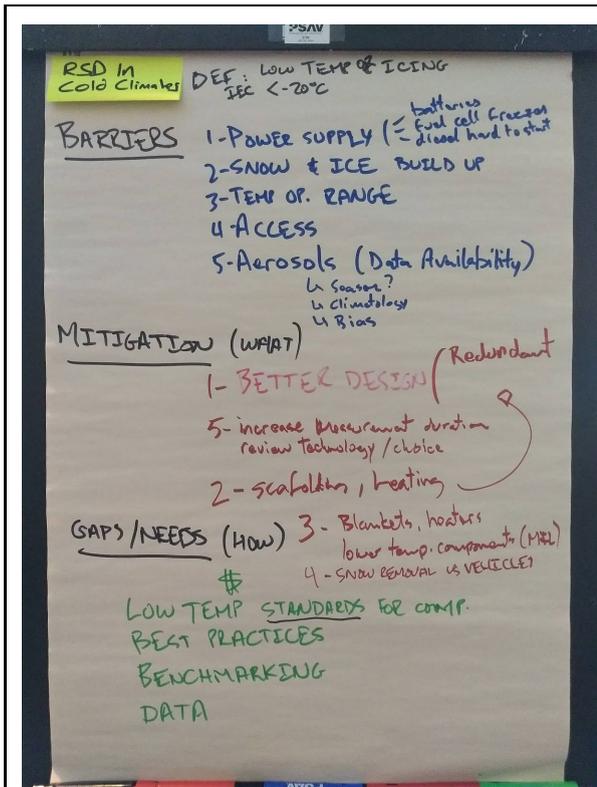


Lidar-Assisted Turbine and Wind-Plant Control

The barriers noted by this group were more technical than in some of the other groups. They included aspects of the flow physics and integration of the lidar with the turbine and plant control systems.

Mitigation opportunities were therefore more about “engineering” solutions than the administrative measures often seen in the other groups.

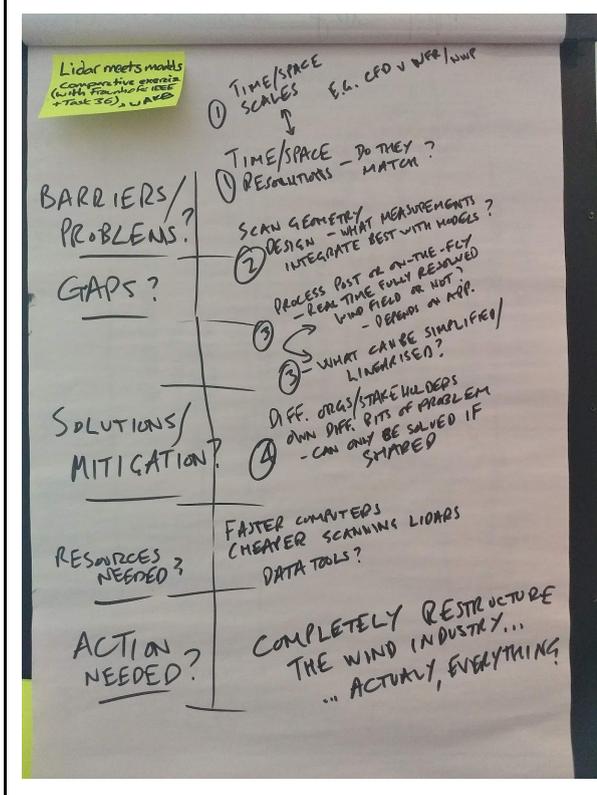
The gaps that were identified were also around fundamental science questions, for example the extent to which closed-loop wind plant control makes sense, or the development of lidar systems for specific turbine types.



Remote Sensing in Cold Climates

This group identified several issues related to deploying and operating lidar in cold climates that can be mitigated through effective campaign management (items 1-4).²

Only the lack of aerosols in the air (item 5) - which in some cases may reduce the availability of data from the lidar - cannot be mitigated through changes in how campaigns are managed. Instead, this issue is related to the how the technology works. Mitigating this barrier will require vendors to engage with users who are experiencing this issue. There may be a role for Task 32 to help understand how widespread this issue is.



Lidar Meets Models

This group noted that measurements and models typically have mismatched temporal and spatial resolution and extents and that there are still questions about what measurement strategies to use. They also noted that models are often expensive to run, which reduces their utility in some cases. If these measurements and models could be made cheaper it opens the opportunity of updating energy and financial models much more rapidly and thus modifying measurement campaigns “on the fly”. This restructuring would require faster computers, cheaper lidar, new data tools and new ways of thinking in the wind industry.

It was noted in discussions that the [RECAST workshop](#) and [Task 32 e-WindLidar workshop](#) in October 2018 also discussed some approaches to these issues.

² N.B. some issues associated with the use of ground-based remote sensing in cold climates were described in RP 15 together with recommendations on how to deal with these. RP15 can be found at <https://community.ieawind.org/publications/rp>. However, that document did not consider lidar on the nacelle or transition piece and so there may be a need for new guidance.

<p>Physics-based uncertainty</p> <p>Uncertainty of RSD & Cup</p> <p>Barriers</p> <ul style="list-style-type: none"> • Lack of guidance outside of ppt • simplified assessment (linear regression) • uncertainty of the reference cup • many environmental variables • lack of connection between uncertainty and 6-minute data availability <p>Mitigation</p> <ul style="list-style-type: none"> • physics based model of sensitivity + uncertainty • Establish non-linear/complex relationships - nnet, etc. • replace reference ↓ calibration uncertainty • Contribute to 61400-15 <p>GAPS + Needs</p> <ul style="list-style-type: none"> • Advanced LiDAR simulator for each system 	<p>Uncertainty Modeling</p> <p>It was noted that the current approach of estimating wind lidar uncertainty by comparison to a cup inevitably increases wind lidar uncertainty. The development of wind tunnel lidar calibration facilities to mitigate this was discussed.</p> <p>It was also noted that there was a need to better understand the causes of lidar uncertainty, particularly so that measurements in new conditions could be given an appropriate uncertainty. The use of physics-based sensitivity and uncertainty models that capture nonlinear effects may help mitigate this. Such an approach may allow data selection based on uncertainty for some applications, such as power performance testing.³</p> <p>The lack of an advanced lidar simulator for each type of system was noted as a gap.</p> <p>It was discussed that Task 32 could develop a framework for uncertainty.</p>
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Poster Session

17:00	<p>Let's talk!</p> <p>Poster and networking session</p>
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A poster and networking session was held. Three posters were presented:

1. Dong-Hun Ryu and Chae-wook Lim: Wind Lidar Line of sight (LOS) wind speed calibration with wind tunnel.
2. ...
3. ...

The posters and presentations are available at the meeting website at www.ieawindtask32.org

³ The idea of a dynamic uncertainty model based on the physics of the lidar and the state of the atmosphere measured by the lidar was presented at the 2016 General Meeting in Glasgow by Jennifer Newman (NREL). More details can be found in e.g. <https://www.nrel.gov/docs/fy17osti/68796.pdf>. It is not clear if this concept is being developed further at this time.

Day 2: Where are we going?

Mitigating barriers in 2019

9:00	<p>Mitigating barriers in 2019 New ideas, techniques, and solutions for wind lidar</p> <ul style="list-style-type: none"> ● Results from the Windfield Reconstruction Round-robin and plans for next steps (Nicolai Gayle Nygaard, Ørsted) ● The AWAKEN Project (Andy Scholbrock, NREL)
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Results from the Windfield reconstruction round-robin and next steps (Nicolai Nygaard, Ørsted)

Task 32 has conducted a round robin on wind field reconstruction in the wind turbine induction zone. The presentation explains the background for the round robin, how it was organized and a first look at high-level results.

Lessons learned from the round robin include:

- phone calls to support the RR were very useful in helping the participants
- induction factors can exceed the Betz limit

A workshop is expected in late 2018 or early 2019 to review the results.

The AWAKEN project (Andy Scholbrock, NREL)

The Americian WAKE ExperimeNt (AWAKEN) project will be led by NREL. It will look at wind flow phenomena within and around an onshore wind farm with a focus on addressing the challenges that face the majority of the wind farm installations in the Midwest of the United States. The project will involve a major field campaign across a wind farm and is currently in the planning phase. Remote sensing will be a major component of the instrumentation to be used, and NREL is actively seeking other research institutions to collaborate in this open-source project (with the intent to have a similar framework to the Perdigão experiment). The field testing for this project is slated for the 2020/2021 timeframe. It was noted that the AWAKEN project uses a verification and validation (V&V) framework, and therefore an initial part of the project was to identify and rank phenomena of interest. This allows a “Phenomena Identification and Ranking Table” or PIRT to be constructed, which can help guide the experiment.

Please contact Patrick Moriarty at NREL for more information.

Roadmapping

10:00	<p>Roadmapping for 2019 and beyond Exploring ideas and plans for Task 32</p> <ul style="list-style-type: none"> ● What’s going on elsewhere? ● What can Task 32 do? ● What might the outcomes be?
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Andy Clifton introduced the session. The goal of the session was to develop a roadmap that could be used to help make progress in the themes that were discussed and presented over the previous day. The participants agreed that four main themes could be identified. A facilitator was asked to lead discussions in each theme. The themes and facilitators were:

1. Resource assessment (facilitator Lynn Nakaska)
2. Power performance testing (Luke Simmons)
3. Turbine- and wind-plant control (Eric Simley and Andy Scholbrock)
4. Data, methods, and tools (Peter Clive, Alexandra Arntsen).

The roadmap should also include external activities that could be important for this theme.

The roadmaps from each group are presented below together with notes from the discussion. The roadmaps included external influences, what Task 32 could do, and what the outcomes might be. The roadmaps were split over the next 3 years, which is the duration of the next phase of Task 32.

	<p>Resource Assessment</p> <p>The main external influence was thought to be the development of the IEC 61400-15 standard, which was expected by 2020. It was suggested that Task 32 should try to contribute to -15.</p> <p>It was suggested that there may be benefits to treating lidar data as lidar data, rather than just assuming it is just a source wind speed. This would allow more data to be extracted from the lidar measurements than is currently usual.</p> <p>The issue of the use of lidar in complex terrain was discussed. It was suggested that it may be appropriate to better define terrain complexity in terms of the complexity as it impacts turbines, models, and measurements, and encourage experts in each field to define complexity as appropriate.⁴</p>
	<p>Power Performance Testing</p> <p>The main external influences on power performance testing were the patchy adoption of the 2017 IEC 61400-12-1 standard, the success of the PCWG inner and outer range approach, and the restructuring of the IEC standards in to the IEC 50-3 family.</p> <p>Three possible Task 32 workshops were identified. These included 1. re-evaluating the assumptions behind the 2017 IEC 61400-12-1 standard and the need for a short met. mast (S.M.M.), 2. power performance testing in complex terrain and the use of measurements in the induction zone to mitigate flow heterogeneity, and 3. site calibration using ground-based lidar.</p> <p>It was suggested that developers carrying out site calibrations using towers could supplement these with ground-based lidar as well and share results in the third workshop.</p>

⁴ N.B. A qualitative approach to recognizing complex flow was developed by members of Task 32 in 2015. It is discussed in Section 3 of NREL Report [NREL/TP-5000-64634](https://www.nrel.gov/docs/2016/06/64634.pdf).

	External	Task 32	Outcome
2019	CL-WINDCON	Lidar-Assisted Control Systems Eng. Optimizing Cost of Energy -w/ Task 32? Round Robin LAC Simulation	Journal Paper Conference paper presentation
2020	CFARS	Wind Plant Control w/ Lidars - Open loop - Closed loop - Best use of lidars	Wake measurement Recommended Practice
2021	AWAKEN	Lidar layout for measuring wakes - wind farm blockage - wind farm wakes - wake interaction - Impingement Improve wake models using lidar measurements - atmospheric conditions	
Longer Term		LAC Simulation tools - what should they include?	

Lidar-assisted Turbine and Plant Control

Several steps were suggested to support the adoption of lidar assisted control (LAC) of wind turbines and wind plants. These included a round-robin comparison of current simulation approaches, and recommendations about how best to simulate LAC in future. It was also suggested that it may be possible to provide guidance about lidar locations for different control and measurement applications. All of these could be supported through Task 32.

It was noted that although turbine control is now mainstream, wind park control will take time because of the effort associated with it. Further implementing turbine and plant approaches will require continued turbine OEM involvement. Lidar-assisted control has therefore been the subject of much Task 32 work including several workshops⁵ and publications.⁶

	OTHER	TASK 32	OUTCOMES
2018			
50-1 50-2	16C 50-1 50-2 caution		
2019	OTHER REPAIRING UTILITIES TO MIGRATE ID INTEGRATION CONFIDENCE	DATA TOOLS (FAIR) OPEN INNOVATION? COMMERCIAL DRIVERS? Physical Model buildout ENERGIC EXPERIMENTAL MODEL UNCERTAINTY	REDUCE COSTS INCREASE PRODUCTIVITY EXTEND LIFE
2020	RECAST 50-3 50-4?	GLOBAL REPORT REPAIRING	
2021	STANDARDS CONVERGENCE SUBSIDY FREE ENVIRONMENT END OF THE ERUITY LATER	NEW TECH? (AWEs?) GODS REPLACE FREE MONEY ENERGY	REPAIRING COSTS
2030... IPCC SR15			

Data, tools, and models

This group noted that the phase out of incentives for wind energy and general technical development would require lidar data to become one of many parts of the renewable energy data ecosystem. Chaining and coupling models for specific applications will therefore be important. The use of FAIR data principles (findable, accessible, interoperable, and re-usable) will help this data and model ecosystem to grow, while maintaining the opportunity for innovation.⁷

Similarly, it will be important to understand the cause and propagation of uncertainty through these models (although uncertainty is to some extent another model).

⁵ See Workshop 8, "Certification of Lidar-Assisted Control Applications", <https://www.ieawindtask32.org/workshop-8/>.

⁶ See e.g. Simley et al., "Optimizing Lidars for Wind Turbine Control Applications—Results from the IEA Wind Task 32 Workshop" at <https://www.mdpi.com/2072-4292/10/6/863>.

⁷ For more information about FAIR data principles, data ecosystems, and how it might impact wind lidar, see the minutes from Workshop 12 at <https://www.ieawindtask32.org/workshop-12/>.

The ideas presented in each of these roadmaps will help inform IEA Wind Task 32 activities in 2019 and beyond.

Close

11:50	Close <ul style="list-style-type: none">• Summary of ideas and plans for 2019 and beyond
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Andy Clifton provided a short summary of the ideas discussed in the three workshop sessions and noted that the Task 32 Advisory Board would be developing a list of possible workshops and other events to address these and other issues in 2019 and beyond.

Workshop ideas will be publicized through the task websites (www.ieawindtask32.org, <https://community.ieawind.org>), professional social media, and through the mailing list.

End of Meeting

12:00	End of meeting
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The hosts, participants, and Operating Agent were all thanked for their contribution and enthusiastic participation. The meeting closed at midday.

Summary of Suggested Task 32 Events and Other Actions

What	Status	When	Organizer	Application area
Workshop 11 on Windfield reconstruction in the induction zone	Definite	Early 2019	Nicolai Nygaard	Power Performance Testing
Workshop: "What if we'd had lidar first?"	Suggestion			All
Workshop: "Wind lidar in cold climates"	Suggestion		Nergica	All
Re-evaluating IEC 61400-12-1 and the need for a short met mast	Suggestion			Power Performance Testing
Users' guide to IEC 61400-12-1	Suggestion			Power Performance Testing
Workshop: "Power performance testing for complex terrain"	Suggestion			Power Performance Testing
Workshop: "Site calibration using ground-based lidar"	Suggestion			Power Performance Testing

Participant List

1	Alexandra Arntsen	NRG Systems
2	Andrew Clifton (Operating Agent)	University of Stuttgart
3	Andy Scholbrock	NREL
4	Cédric Arbez	Nergica
5	Darlene Gillis	Sentrex Wind Services Inc.
6	Dongheon Shin	Jeju University
7	Dong-Hun Ryu	Korea Testing Laboratory
8	Dongwan Kim	Jeju Energy Corporation
9	Eric Simley	National Renewable Energy Laboratory
10	Evan Mulrooney	Techéol
11	Guillaume Sabiron	IFP Energies Nouvelles
12	Hyunseok Oh	Korean Register
13	Kyungnam Ko KO	Jeju University
14	Luke Simmons	DNV GL
15	Lynn Nakaska	WSP
16	Matthew Smith	Business Development
17	Matthew Wadham-Gagnon	Nergica
18	Minsang Kang	Jeju Energy Corporation
19	Mun-jong Kang	Korean Register
20	Nicolai Gayle Nygaard	Ørsted Wind Power
21	Nicolas Jolin	Nergica
22	Paul Mazoyer	Leosphere
23	Paul Woodhouse	Sentrex Wind Services
24	Peter Clive	Wood - Clean Energy
25	Philippe Coulombe-Pontbriand	RES-Group
26	Shumpei Kameyama	Mitsubishi Electric Corporation