IEA Wind Technology Collaboration Programme

Phase 1 Management Report

Task 41: Enabling Wind to Contribute to a Distributed Energy Future

January 2019 - December 2022

May 2023

PHASE 1 MANAGEMENT REPORT
Task 41: Enabling Wind to Contribute to a Distributed Energy Future
Covering from January 2019 to December 2022.

Prepared for the:
International Energy Agency - Wind Implementing Agreement

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1 Review of the cooperative activities

IEA Wind Task 41 is an international group of researchers from eleven member countries and associations dedicated to advancing wind technology as a cost-effective and reliable distributed energy resource. Our objectives are to coordinate international distributed wind energy research, facilitate collaboration on priority research topics, and increase the visibility of wind technology as a distributed energy resource.

Technology to be considered within this Task will cover a broad range but will include wind turbines deployed in a distributed application, connected at a distribution voltage (nominally up to 70 kV) in a behind the meter, in front of the meter, or in an off-grid application. In the context of this proposal, DW is inclusive of all scales of wind turbine technologies and is agnostic to business model, although in some instances, such as technology standards, more specific industry segregation is included.

Task 41 built a bridge from work previously focused on small wind turbines to a broader definition of distributed wind turbines and from unfinished turbulence research handed off from Task 27. Under Task 41 leadership, both previous Task 27 members and new membership have increased to handle the expanding scope. The Task 41 Work Plan, which was approved on March 28, 2019, is divided into five research work packages (WPs) to advance wind technology as a cost-effective and reliable distributed energy resource including:

1. **Progressing distributed wind technology design standards for small and mid-sized wind turbines to allow for accelerated innovation and improved consumer confidence (Standards)**: Research to support future development of design and testing standards for small and mid-sized wind turbines
2. **Data Information catalog for DW research (Data Catalog)**: Create an information sharing platform for distributed wind research and data
3. **Expand learning and support of the integration of DW into evolving electricity systems (Integration)**: Enable efficient and reliable integration of wind technology into evolving electricity systems
4. **Outreach and expand collaboration of ongoing R&D activities that could address specific challenges associated with DW technologies (Outreach and Collaboration)**: Facilitate and coordinate distributed wind research with other IEA tasks and international organizations
5. **Innovation and Downscaling of Large-Scale Wind Technology (Innovation)**: Conduct focused DW research and apply advances of large-scale wind technology to smaller-scale wind technology.

Through these efforts an active approach to expanding international collaboration was developed and included:

- updating domestic and international distributed wind turbine standards,
- developing a research and data catalogue for distributed wind,
- publishing a state-of-the-industry report on the integration of distributed wind systems, and
- identifying downscaling opportunities for distributed wind.

1.1 *Standards*

The IEC 61400-2 is an important standard for small wind turbines and is either used in whole or in part to meet many country's standards. Much effort has been expended to ensure that as many countries and their experts have input into the research being conducted to improve this standard. Task 41, like Task 27 has been laser focused on conducting the needed research to evolve this technical standard.

In order to gather feedback about IEC 61400-2, three International Standards Assessment Forums were planned to give industry and other stakeholders an opportunity to provide input on the different aspects of the standard and research needed to elucidate potential changes for the standard.

1.1.1 *International Standards Research and Assessment Forum*

Task 41 members completed a recommendations report on potential standards changes applicable to distributed wind turbines.[8, 10] It is anticipated that these recommendations will be considered by standards experts working on the fourth revision of IEC 61400-2. This report was based on discussions and feedback gathered at two International Standards Assessment Forums.

International Standards Assessment Forums

- Europe
  - In-person
  - 26-28 June 2019
  - Thirteen standard experts in attendance from Austria, Denmark, Ireland, Republic of Korea, Spain, Taiwan, and U.S.
  - Held in Dundalk, Ireland
  - Hosted by Sustainable Energy Authority of Ireland
- North America
  - Virtual
  - 28 August, 1 September, 3 September 2020
  - Twenty standards experts from Argentina, Canada, China, Ireland, Italy, Spain, U.K. and U.S.
  - Hosted by National Renewable Energy Laboratory

An Asian based forum was planned but was repeatedly delayed by covid pandemic travel restrictions. Considerations were made to hold a meeting virtually but based on the very limited virtual engagement by Asian task members and the need to engage widely with technology leaders from across Asia, it was not felt that a virtual session would be effective. Eventually the formal kickoff of the revision to IEC 61400-2 overtook task efforts

1.1.2 Simplified Loads Model Improvements

The Simplified Loads Methodology (SLM) was developed as part of a simple, yet conservative approach to understanding small wind turbine loads. This method was included in the 2013 IEC 61400-2 standard and since that time modeling and empirical results have helped to guide a revision of several key equations, developed in part through task collaboration. The most significant is Load Case A the only fatigue load case in the SLM. It is expected that these simplified load models will be incorporated into the revision of IEC 61400-2.

1.2 Data Catalog

Deliverable 12, "Distributed Wind Data Catalog Development Guide and Instruction Manual," was completed in June 2021. The data provides instructions for the IEA Wind Task 41 distributed wind data catalog. While IEA Wind Task 41 created a minimal viable product for Work Package 2, the deliverable also describes additional features that could be added to the data catalog or included in the development of future data catalogs.

Data are the main component of a problem-solving cycle, whether it is scientific, social, technological, or innovative in nature. Researchers around the world are conducting research and creating data sets relevant to distributed wind; however, researchers often do not know about others' research and data sets. The Task 41 goal of creating and documenting a catalog of distributed wind metadata (information about data) for task members was achieved in 2021. A metadata catalog shows researchers what is available but, at the same time, mitigates potential data sensitivity and intellectual property concerns. In the specific case of Task 41's data catalog, when a task participant needs specific data, they can consult the catalog, identify data sets, and then approach the data owner about conditions for use.

1.3 Integration

Distributed wind integration takes on two models, one is developing hybrid power systems of min-grids and the other is using wind power plants to support distribution system operators. There is some linkage to wind turbine size since smaller wind turbines are typically but not only used as part of hybrid power systems. And wind power plants are typically but not always using larger wind turbines.

As more wind capacity is added to distribution systems, isolated grids, grid-connected microgrids, and hybrid power plants and systems, the need for distributed wind turbines to provide additional grid services and support grid stability becomes more important. Task 41 members completed research reports about this need in 2021. The research includes determining what advanced controls are needed to enable distributed wind to provide grid services and what other design requirements may be needed specifically for high renewable-contribution isolated power systems.

Task collaboration supported several specific outcomes, such as project work under the U.S. Department of Energy, Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (MIRACL) project. Specific to Task 41 an informal assessment of distributed energy grid codes for member nations was developed as was a state of the industry report for isolated hybrid power systems (3) which will be updated in the second phase of this project.

1.4 Outreach and Collaboration

We understood that it was beholden to the distributed wind research community to engage more specifically in outreach and collaboration. Through this effort, participants developed a detailed outreach plan for distributed wind, developed active engagment with other wind TEP tasks, supported cross TEP collaboration and supported industry events when appropriate.

The detailed outreach plan took a holistic view of potential collaboration across industry associations, IEA and international NGO's. Although not a roadmap to collaboration, it provided a methodology to assess potential collaboration efforts that may be applicable to distributed wind.

To understand potential cross Wind TCP collaboration, participants reviewed the research plans of likely IEA Wind TCP Tasks to determine potential collaboration efforts or identify specific overlap with understood DW concerns. We then identified Task 41 members who were engaged with these tasks, either providing intentional understanding of ongoing cross task work efforts, providing opportunities for direct collaboration on task products, or working distributed wind focused efforts into future work plans explicitly. Task 41 members actively engaged in efforts with the following tasks:

- Task 25 - Design and Operation of Energy Systems with Large Amounts of Variable Generation: General cross member engagement.
- Task 28 - Social Acceptance of Wind Energy Projects: General cross member engagement leading to a new human Dimensions of Distributed Wind work package in phase two of Task 41.
- Task 48 – Airborne Wind: Participated in the formulation Technical Experts Meeting (TEM) for this new effort and continue to provide active support in several work packages generally relating to distributed application development.
- Task 50 - Hybrid Power Plants: Participated in the formulating TEM and providing active engagement through Work Package 3 (Integration) with several identified collaboration opportunities. As both efforts continue, other points of collaboration will be implemented over the course of both projects.
- Task 54 - Cold Climate Wind Power: Collaboration on a paper specific to ice through recommendations for distributed scale turbines, leading to expanded collaboration in Phase 2 of the project.

Based on work completed in phase 1, the following additional efforts are planned for phase 2

- Task 45 - Recycling wind turbine blades. Engagement coordinated through Work Package 5.
- Task 52 - Large-Scale Deployment of Wind Lidar: Task level engagement which could include the development of assessment decision trees relating to the appropriate use and scope of lidar deployment for distributed wind applications.

After two cancellations because of the covid pandemic, Task 41 members joined members from Task 52 (Large-Scale Deployment of Wind Lidar) and Task 54 (Cold Climate Wind Power) at the University of Applied Sciences FM Technikum Wien in Vienna, Austria for three days in October 2022 for a joint meeting. The task members held both separate working group meetings in parallel and collaborative meetings together to explore how the tasks could further engage with each other. During the joint meeting, the task members heard presentations from as part of the University Research Collaborative sponsored by Task 41. The Austrian Wind Energy Association (IG Windkraft) also organized a co-timed industry event at which task members were invited to present their research.

Lastly, task members supported industry specific outreach and engagement in multiple countries, including Spain, Austria, Denmark and the U.S. Most recently, task members worked with the Austrian Wind Energy Association to organize a co-timed industry event in association with the task meetings.

1.5 Innovation

An effort was made initially to identify specific areas of potential turbine downscaling, but it became clear that the most common considerations, such as increasing turbine swept area to provide lower turbine specific power have already taken root in the distributed wind industry. Potential scaling studies into additional down-scaling considerations, such as the use of pitch regulation on smaller turbines to reduce rotor loading, were identified, but partner organizations were unable to identify funding to implement this research. To support these research questions without the identification of funding, task members developed the Distributed Wind University Research Collaborative in an effort to coordinate academic research on key topics related to distributed wind. Although originally focused on downscaling research topics, the global distributed wind industry was engaged to identify additional research questions that could be addressed by expanded university research collaboration. The University Research Collaborative now consists of approximately 160 professors and students from around the world. Current work efforts focused on aeroelastic modeling and hybrid power plants and systems. The last topic is a natural overlap with Work Package 3, although the University Research Collaborative was started under Work Package 5. The University Research Collaborative was kicked off in November 2020 by offering this new project as a method to share innovative research coming out of academia.

In an attempt to find a time that would best match global university research scheduals, the first Student symposium was held virtually in July 2021. Students from Australia, Spain, Columbia, and U.S. shared results from two masters thesis and four phD thesis. This timing turned out to be problematic because of typical northern Europeans vacation schedulas.

The second student symposium was held in October of 2022 during the Task 41 in-person meetings in Vienna, Austria including both in-person and virtual presentations. Four student researchers at universities in Austria, Australia, the Netherlands, and Denmark presented their research findings. Groundwork has also been laid for a symposium to take place in conjunction with the 2023 fall meeting and the North American Wind Energy Acadamy / WindTech conference in the United States.

As part of efforts to understand future research needs, Task members worked to support a peer reviewed jurnal artical to identify the research challanges for small wind turbines, lead by the European Acadamy of Wind Energy, small wind committee. This document was then expanded to incoporate the grand challanges of distributed wind, which is in draft form and has been carried into Phase 2 of this effort.

2 Accomplishments/unique contributions/technology advances

Task 41 sucessfully completed almost all of the desiered deliverables and milestones, sucessfully completing many of its goals, although continued efforts are ongoing. Several specific accomplishments completed in the first four years of this effort include publishing recommendations to update international standards applicable to distributed wind turbines, created a metadata catalog for its members, researched advanced controls for distributed wind, and facilitated collaboration with outside university researchers.

One highlight is Task 41's colaborative research to identify the advanced controls needed to enable distributed wind turbines to provide grid services and to determine what other design requirements may be needed specifically for high renewable-contribution isolated power systems. With advanced controls, distributed wind can provide additional benefits beyond electricity, such as enhancing grid reliability and resilience.

Another highlight is the development of a new equation under the simplified loads models for fatigue that only includes the dominant gyroscopic loads for passive, free yaw machines. This new equation and corrections to the simplified loads models will be presented as part of the revision to the IEC 61400-2 standards for small wind turbines as they write the fourth revision of the standard.

3 Degree to which objectives were achieved

Although not necessarily implemented as they were originally conserved, all project deliverables outside of a form on updating standards planned for Asia and a final grand challenges report were completed before the end of the Tasks first term. The grand challenges report for distributed wind is expected to be completed early in the second task term, partially based on the Grand Challenges Technical Experts Meeting being held in the winter of 2023.

Some of the initial work packages required modifications based on the reformulation of the Task 41 team brought on by the global pandemic. This was particularly true of attempting to expand TCP collaborations since meetings were limited to virtual constraints. While contact was made with several other TCP tasks, engagement to the depth that true collegial relationship development was impaired.

4 Effectiveness of national participation

National participation has increased and is likely to continue to increase given the number of countries who have been observing Task 41 virtual meeting. Observers include Singapore, India, Poland, and Australia; note the dominance of pacific rim countries.

General task sharing was hampered by the covid pandemic even though efforts were made to make task meetings available to all interested parties, such as holding virtual meetings with different time zones, often targeted for Europe, Asia and North America, so that specific regions would not have to bear the brunt of time zone differences.

The pandemic did allow task members did expand collaboration with researchers outside of the IEA Wind TCP network, largely virtually. As an example of this collaboration the second standards meeting which was held virtually but was timed to maximize participation across the Americus included participation from Europe, Latin and South America, and Asia, in addition to strong representation from Canada and the United States. Such broad participation would not have been likely from an in-person meeting. Alternatively, it became more difficult to engage with Asian participants, likely due to language difficulties which are more pronounced in a virtual setting. The pandemic forced the cancelation of meetings to engage with Asian industry in small wind turbine standards, but moving the meeting to a virtual form, as was done in the US, was not implemented based on the lack of engagment.

Another example of how expanded international engagement was improved with the expanded acceptance of virtual forums is the Distributed Wind University Research Collaborative, which allows academics from outside the IEA Wind TCP community to collaborate with IEA Task members, while supporting important research.

National task members continued to engage with domestic and international partners though the pandemic, particularly through virtual industry forums. Although not as effective as in-person meetings, virtual meetings did allow wider international participation.

5 Participation by "industry"

We have had industry observers from Poland and Germany who have participated in Task 41 meetings, particularly during the International Standards Assessment Forums.

Industry members, primarily turbine manufacturers, attended the Distributed Wind Energy Association's Business Conference held in February 2023. At this conference, the *Current status and grand challenges for small wind turbine technology* paper was used to frame the presentations in the "Technology & Project Development Advances in Distributed Wind" session. For example, the "Novel Approaches for Wind Resource Validation" presentation addressed "Grand challenge 2 – improve prediction and reliability of long-term turbine performance despite limited resource measurements."

During a virtual workshop for distributed wind installers in the United States, PNNL shared the "A Framework for Characterizing the Risk of Ice Fall and Ice Throw from Small Wind Turbines" report written in collaboration with Task 54 member, Charles Godreau. Installers shared feedback on their experiences with small wind icing and downloaded a copy of the report for later reading.

Industry engagements was also implemented as part of the IEA Wind TCP Industry Forum in Balbo Spain, the U.S. based Distributed Wind Energy Association meetings in 2020, 2021 and 2022, the Danish Nordic Folkecenter small wind workshop in 2021 and 2022, and the Austrian Wind Energy Association in 2022.

6 Conclusions/Recommendations (technical)

Conclusions for work done by Task 41 experts are captured in the list of *Information and Dissemination Activities* below. But some conclusions given in those papers are of such significance, they deserve to be restated here. This is not a complete list of all conclusions and recommendations flowing from Task 41 efforts.

The first set of conclusions comes from reference [1] below where four recommendations are offered.

1. SLM fatigue loads assessment for free yaw turbines be replaced by a new simplified fatigue load that accounts for gyroscopic loads only.
2. The gyroscopic term in Equation (9, IEC28) be applied with the same safety factor of 1.35 as allowed in aeroelastic simulations.
3. The safety factor for use in DLC H for the turbine tower be reduced to 1.6.
4. The last term in Equation (9, IEC28) be replaced by the last term in Equation (21), to account for blade thrust.

From reference [3, 12] in relation to AC minigrid/microgrid power systems:
Development of a new strategy to have AC Mini-grids, which allow for easy expansion over time and require components of the system have active control. Expansion of the system capacity on the AC side is more scalable and flexible than connecting more capacity on the DC side of a common DC/AC grid forming inverter. However, the system control becomes more complicated when more active components are

connected to the AC grid and thus all these components must be designed to contribute to the proper operation of the power system.

If the system control is based only on the local voltage and the frequency, it is very simple to add new active components, and the active components can even be distributed throughout the grid. This control concept also makes it simple to interconnect more mini-grids and / or connect a mini-grid to a larger power system, where the mini-grid(s) become valuable parts of the larger power system. The active components actual responses to the voltage and frequency may need to be adjusted as the grid develops to ensure stability.

In relation to international standards for distributed wind turbines, recommendations from reference [10] include:

1. Adopt a new classification for microturbines, with a rotor area less than 5 m^2 or power not exceeding several (crudely, 1–3) kW.
2. Add a classification for so-called 'medium scale' turbines: these currently fall outside the 61400-2 standard's limit of 200 m^2 rotor area but more closely resemble smaller turbines as opposed to the (much larger) multi-MW turbines currently covered within 61400-1.
3. Examine the size of turbine where Simplified Load Methodology is appropriate.
4. The IEC 61400-2 standard needs to be extended to accommodate multiple power curves depending on conditions, starting with HAWTs in each of the proposed (updated) design classes.

From reference [4] relating to the development of an ice through risk framework:
A data-driven framework is developed to characterize potential risk from ice throw or fall from a small wind turbine allows decision makers to determine appropriate mitigation techniques and siting practices.

From reference [7, 9] optimization of wind power plants:
This paper proposes a deterministic optimization methodology to minimize the losses in distribution networks with WPPs, by exploiting WPPs' capability to control reactive power in coordination with the on-load tap changers from the MV/HV transformer, avoiding the need for network reinforcements.

From reference [2, 6] in relation to the modeling of distribution networks:
This paper proposes and presents the methodology used for the development of a multi-voltage active distribution network model, named DTU7k-BusActiveDistributionNetwork (DTUADN). The DTU-ADN spans across 3 voltage levels, 60 kV-10 kV- 0.4 kV, and hosts an abundant amount of distributed renewable energy sources, primarily wind and solar power, connected across all the voltage levels.

7 Information and Dissemination Activities

Publications/dissemination outside of IEA Wind TCP:
Task members from the **United States** finished and published **national research** related to Work Package 3 in January 2023: https://www.nrel.gov/wind/miracl-report/index.html.

[1] David Wood (September 2022)."Improvements to the Simplified Loads Methodology in IEC 61400-2." NREL/SR-5000-83708 https://www.nrel.gov/docs/fy22osti/83708.pdf

[2] A. U. Baviskar, K. Das, M. J. Koivisto and A. D. Hansen (2022). Multi-Voltage Level Active Distribution Network with Large Share of Weather-Dependent Generation. Download from https://orbit.dtu.dk/en/publications/multi-voltage-level-active-distribution-network-with-large-share-.

[3] **Cronin, T**. June 2022. EUDP IEA Task 41, Deliverable 3.4, State of the industry report for isolated mini-grid power systems. Technical University of Denmark.

https://usercontent.one/wp/iea-wind.org/wp-content/uploads/2022/08/D3.4-IEA-Task-41-report-State-of-the-industry-report-for-isolated-microgrid-p.pdf.

[4] **D. Preziuso**, **A. Orrell**, C. Godreau. September 2022. "A Framework for Characterizing the Risk of Ice Fall and Ice Throw from Small Wind Turbines." PNNL-33214. https://www.pnnl.gov/sites/default/files/media/file/Small%20Wind%20Icing%20Framework%20-%20PNNL-33214.pdf.

[5] Bianchini, A., Bangga, G., **Baring-Gould, I**., Croce, A., **Cruz, J. I**., Damiani, R., Erfort, G., Simao Ferreira, C., Infield, D., Nayeri, C. N., Pechlivanoglou, G., **Runacres, M**., Schepers, G., **Summerville, B., Wood, D**., and **Orrell, A**.: Current status and grand challenges for small wind turbine technology, Wind Energ. Sci., 7, 2003–2037, https://doi.org/10.5194/wes-7-2003-2022, 2022. (Not created under the auspices of Task 41 but the document did involve multiple Task 41 experts, highlighted in bold.)

[6] A. U. Baviskar, K. Das, M. J. Koivisto and A. D. Hansen, "Multi-Voltage Level Active Distribution Network with Large Share of Weather-Dependent Generation," in IEEE Transactions on Power Systems, doi: 10.1109/TPWRS.2022.3154613. March 2022.

[7] Baviskar, Aeishwarya; Das, Kaushik; Hansen, Anca Daniela; Menegatos, Panos: Loss Minimization in Distribution Network using Wind Power Plant Reactive Power Support. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.14554845.v1. July 2021.

[8] M. Kelly. "Towards updating the standards for small wind turbines, via IEA Wind Task 41." A presentation at the 6th International Conference on Small & Medium Wind Energy. September 2021.

[9] A. Baviskar, A. D. Hansen, K. Das and P. J. Douglass, "Open-Source Active Distribution Grid Model with a large share of RES- features, and studies," 2021 9th IEEE International Conference on Power Systems (ICPS), 2021, pp. 1-6, doi: 10.1109/ICPS52420.2021.9670223. December 2021.

[10] Mark Kelly, Ian Baring-Gould, and Trudy Forsyth (2021). Recommendations on potential standards changes for distributed wind: driving research via IEA Task 41. Download from https://iea-wind.org/wp-content/uploads/2021/12/IEA-Task-41-Report-with-recommendations-on-potential-standards-changes-for-DW.pdf.

[11] Reilly, Jim, Ram Poudel, Venkat Krishnan, Robert Preus, Ian Baring-Gould, Ben Anderson, Brian Naughton, Felipe Wilches-Bernal, and Rachid Darbali (2021). Distributed Wind Controls: A Research Roadmap for Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (MIRACL). Download from https://www.nrel.gov/docs/fy21osti/76748.pdf.

[12] Tom Cronin and Per Nørgård (2021). Design guide for high renewable-contribution isolated power systems. Download from https://iea-wind.org/wp-content/uploads/2021/12/IEA-Task-41-Design-guide-for-high-renewable-contribution-isolated-power-systems-systems.pdf.

[13] Evans S, Dana S, Clausen P, Wood D. "A simple method for modelling fatigue spectra of small wind turbine blades." *Wind Energy*. 2020; 1–9. https://doi.org/10.1002/we.2588

8 Unresolved technical issues

Although most distributed wind technology in nearing cost parity with distributed solar technologies, especially at deployment scales above approximately 15 kW, multiple technical and non-technical issues remain that when addressed can either expand development potential or continue to lower costs [5]. Further cost reductions are especially needed for smaller wind turbines designs which are still not cost competitive with distributed solar PV.

Work proposed within Phase 2 of Task 41 is focused on addressing several the identified challenges while continued engagement through efforts such as the Distributed Wind University Research Collaborative will continue efforts across the global research community. Building on the Grand Challenge Framework, distributed wind specific challenges have been identified. Although specific to distributed scale wind technology, these challenges are consistent with the wider wind science grand challenges.

For distributed wind, the remaining grand challenges include:

1. Lower the specific power for distributed wind turbines yet maintain the requirement for high reliability and resiliency.
2. Improve prediction and reliability of long-term turbine performance despite limited resource measurements.
3. Improve the economic viability of distributed wind energy, focusing across design and deployment technologies.
4. Increase opportunities to integrate wind with other renewables and link with other technologies to support applications, the future electricity grid, and hybrid power plants and systems.
5. Expand engagement, social acceptance, and deployment for global distributed wind markets to support turbine designs that address local needs and requirements.
6. Address global circular economy concerns by making distributed wind systems fully recyclable at a minimal cost premium.

In addition to these technical areas, improved information, understanding, and standards in relation to the impacts and siting of distributed wind is needed. This is especially true given the very wide variety of siting requirements, conditions, needs and desires of local communities.

9 Lessons learned /management recommendations for other Tasks

The following recommendations are presented based on the first four years of this effort. To the extent possible, these findings will be applied to the second phase of this effort.

Recommendation: Build DW networks wherever and however you can.
With limited in-person meetings and a reliance on virtual meetings attempts were made to address reasonable time zones for all participants. The typical meeting would include three days of 2-hour meetings, one in the Central European business time zone, one in the Asia/Pacific time zone, and one in the North American time zone. Virtual meeting structure, while affordable and easy, create a barrier for those non- native English-speaking experts. This is particularly true for Asians and has resulted in less Asian participation and more European/North American participation.

Virtual meetings, combined with the convening power of the IEA Wind TCP allows for experts from non-member nations to easily take part in both research and dialog. Although IEA Wind TCP membership is still important for full Task engagment, there are new ways to engage with wider wind research community to the benefit of all.

Although more virtual engagement has allowed expanded participation, engaging with experts outside of the wind area still requires time consuming engagment. Collaboration is still limited by the availability of task members, which remains limited.

The expanded costs of effective communications, needed for network building and effective outreach, must be accounted for in Task and Operating Agent budgets.

Recommendation: Hold back-to-back meetings with other Wind TCP Tasks.
The best engagement in building new TCP task relationships was with Task 54. Both meetings were held in Vienna, one preceding the other. This allowed for limited overlap by all experts and expanded overlap with task leadership.

Recommendation: Move to increased participation in pacific-rim countries.
There has been recent observation of Task 41 from Singapore, and India. And there are hopes to engage Japan and Australia yet again.

10 List of participating experts

Country	Participant	Organization
Austria	Alexander Hirschl	University of Applied Sciences FM Technikum Wien
Belgium	Mark Runacres	Vrije Universiteit Brussel
Canada	Mauricio Higuita Cano	Nergica
	Dominic Bolduc	Nergica
	Imen Romdhane	Nergica
	David Wood	University of Calgary
China	Keqilao Meng	Inner Mongolia University of Technology
	Jia Yan	Inner Mongolia University of Technology
Denmark	Anca Hansen	Technical University of Denmark
	Tom Cronin	Technical University of Denmark
	Kaushik Das	Technical University of Denmark
	Mark Kelly	Technical University of Denmark
	David Rudolph	Technical University of Denmark
	Tonny Brink	Nordic Folkecenter for Renewable Energy
Greece	Nikolaos Stefanatos	Center for Renewable Energy Sources and Saving
	Eftihia Tzen	Center for Renewable Energy Sources and Saving
Ireland	Raymond Byrne	Dundalk Institute of Technology
	Paul MacArtain	Dundalk Institute of Technology
Italy	Francesco Castellani	University of Perugia
	Linda Barellli	University of Perugia
	Luisa Pagnini	University of Genoa
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Spain	Ignacio Cruz	CIEMAT
	Luis Cano	CIEMAT
	Beatriz Ramos	CIEMAT
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	Danielle Preziuso	Pacific Northwest National Laboratory
	Sarah Barrows	Pacific Northwest National Laboratory
	Ian Baring-Gould	National Renewable Energy Laboratory

	Brent Summerville	National Renewable Energy Laboratory
	Ruth Baranowski	National Renewable Energy Laboratory
	Trudy Forsyth	Wind Advisors Team

11 Other appropriate information

Task 41 had a period of performance of four years (January 2019 – December 2022), not nearly long enough to have robust technical results for all areas of work package efforts. Subsequent work will carry on under the approved Extension Proposal with a period of performance of four years (January 2023 – December 2026).

Task 41 will continue with a 4-year task extension that was initiated in January 2023. Task members will address topics for which international collaboration can have a significant impact. The four primary research themes of the new work plan are standards and technical specifications, integration, social science, and information dissemination. The expected results are technical reports, journal articles, and other products that highlight key research findings; research results that can inform the fourth revision of the IEC 61400-2 standard; established participation in conferences focused on small and medium wind turbines; and expanded collaboration and engagement in the wider distributed energy research fields.