The International Energy Agency
Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems

iea wind

International Energy Agency (IEA)
Implementing Agreement for Co-operation in the Research and Development of Wind Energy Systems (IEA Wind)

Work Plan

Task 41

Enabling Wind to Contribute to a Distributed Energy Future

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1. Scope

The purpose of the proposed IEA Wind Task is to coordinate international research on Distributed Wind (DW)[1] turbine technology, technology development or assessment to allow DW to integrate into future markets, and processes or procedures to support the cost effective development of DW technologies. 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 70 kV) or below 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. This is expected to be a four year effort.

2. Introduction

Equipment, installation and operation costs for large utility scale and offshore wind technologies have decreased while energy production per turbine has increased [1]. The costs of solar PV have likewise decreased substantially over the last 10 years [2]. The costs of distributed wind systems however have not seen any such decrease and in some instances have actually increased in costs, at least in the U.S., though little time indexed data exists [3].

This difference poses a question for the distributed wind market sector. Understanding that many of the advances that have lowered the cost for utility scale turbines should be generally valid if applied to distributed technologies leads us to some of the following questions. Which of these technology innovations are the most appropriate for distributed technologies? Why has the distributed wind industry not applied these innovations? What additional research may be needed to understand their applicability will be important to the further development of this industry?

The Distributed wind market also has expansive potential as has been demonstrated by active markets in Italy and until recently the U.K. when the life cycle cost of DW technologies is competitive to consumer rates for electrical energy. Additionally, countries with limited transmission infrastructure will quickly reach integration limits for large central station power, including renewable energy, indicating an expanding need for more distributed solutions. China for example is experiencing severe curtailment of wind power (as well as solar power) due to the limitation of power transmission while countries across Africa and south-east Asia have limited transmission networks to support the deployment of large scale wind applications, leading to smaller scale deployments of more distributed technologies.

Market potential projections in the U.S. show that the distributed wind market could exceed 20 GW over the next 15 years, with the majority of installed capacity coming from large wind turbine technology installed in distributed applications [4]. Additionally, IEA research identifies that approximately 34% of unserved populations across the globe will be supplied by mini-grid solutions which could include distributed wind, an estimated $113 billion-dollar market through 2030 [5]. However, the technology innovation needs, deployment methodology, and social

[1] As background, DW systems are installed by individuals, businesses, and communities who want or need to self-generate power. DW systems are primarily used to offset retail power costs or electrify remote locations and assets not connected to a centralized grid. Additionally, DW systems are used to lock in long-term power cost certainty, provide grid independence, and support power system resiliency. The DW industry can be divided into three customer classes: (1) residential customers, including small businesses and farms, typically utilizing a single small (up to 100 kilowatts [kW] in size) wind turbine; (2) commercial and industrial customers, including large businesses, public facilities, and communities, typically utilizing one or more medium-scale (between 100 kW and 1 megawatt [MW]) or utility-scale (greater than 1 MW) wind turbines, and (3) small-scale municipal, community or utility projects that use utility-scale turbines (greater than 1 MW) but only in small numbers installed on regular distribution networks. While residential installations are typically off-grid or "behind the meter," offsetting electricity use for a single entity on the site the turbine is deployed, commercial and industrial installations can be either behind or "in front of the meter," installed on the local distribution network to serve local loads for multiple customers, while utility projects are almost always "in front of the meter." There was also a discussion of business models, including the definition of "community wind" with the general World Wind Energy Association definition requiring that a project must have two of the following three criteria i) local ownership, ii) benefit goes to the community, iii) local decision making [6].

acceptance strategies are far from optimized for this emerging sector. For this market area to thrive, especially given the increasing competitiveness of solar PV, innovation from across this market segment will be required.

In March of 2018, IEA Task 11 Base Technology Information Exchange co-hosted a Technical Experts Meeting "Strategic Dialog for Community and Distributed Wind: Developing a common understanding of future technology and market innovations for the expansion of the global distributed wind market", the DW TEM, that brought together DW experts from around the world to obtain a better understanding of the markets and challenges facing the DW industry. The TEM was also co-located with a regular meeting of IEA Task 28, Social Acceptance of Wind Energy Projects to allow strategic engagement around issues facing the deployment of DW technologies. Through a structured workshop setting followed by moderated breakout sessions, experts provided input and insights associated with technology and deployment innovations that will be needed to yield aggressive global growth for DW technologies. The workshop provided a discussion of current research trends, deployment challenges, and integration requirements, resulting in a better understanding of market needs over the mid to long term. Results of this meeting were then shared and expanded at a meeting of Task 27, Small Wind Turbines in High Turbulence Sites.

This proposal is for a new IEA Wind Research Development and Deployment collaboration to accelerate the development and deployment of DW technology. The collaboration will carry out its work in a series of focused work packages (WP) but unlike other IEA Wind efforts, will implement a strong cross IEA Task collaboration effort. It was felt that to be successful any new DW-focused IEA effort needs to expand engagement across IEA Wind and other IEA efforts more widely, including:

- IEA tasks that are considering activities that overlap with identified DW concerns and where the DW efforts can receive valuable input. Task 28 would fall in this category.
- IEA tasks that overlap with identified DW concerns but that currently have limited DW technology inclusion; engagement in these tasks may allow for inclusion and expanded focus on DW challenges. Many of the IEA wind tasks fall into this category.
- IEA tasks outside of wind that are addressing technologies or markets in which DW could or should engage. IEA work on PV, storage, and other Distributed Energy Resources (DER) would fall into this category.
- DW research areas in which no IEA work is being undertaken, the focus of this specific effort.

3. Objectives and Expected Results

As was highlighted by the DW TEM and previous research, the primary issues facing the DW market are broad and range from lack of information, consumer confidence, high costs, and a lack of consensus on appropriate deployment requirements. [4] This requires a broad approach be taken as trying to address only one of the key challenges, such as supporting innovation around system designs, may make a lower cost product, but will not address the other problems facing the industry. Additionally, many different institutions are working to address specific pieces of the problems, but there are no organizations that are able to bring together the expansive work that is being undertaken across a broad spectrum of research. It should also be noted that the work being undertaken in the larger area of distributed generation, resilient energy systems and islanded or microgrids systems, greatly dwarfs all the work being undertaken specifically for DW. Most of these efforts are technology agnostic, although the dominance of the very robust PV industry means that other viable technologies, such as wind, are largely left out of consideration which may or may not limit the ability of DW and other technologies to successfully engage in this market space. It should also be noted that the DW TEM and other discussions leading to this proposal should be seen as the starting

point of discussions and that through further collaboration and discussions further research work or development issues will be identified. Likely this specific effort will not be able to take on additional research efforts, but it may be able to play a role in communicating those challenges to organizations or efforts doing similar work.

Based on the extends list of challenges identified thus far, five areas of technical collaboration were identified as the most pressing but where expanded international collaboration would be poised to have expanded impact. These areas include:

- Research to support an update of existing wind standards, expanding consumer confidence while allowing needed technology innovation.
- Technical data sharing in both process and practice, providing researchers and the wider industry access to global information that can be used to address wider challenges facing DW.
- Research and the development of tools to improve resource assessment and more specifically performance prediction from DW technologies.
- Expanded research and collaboration around the integration of DW technologies, focusing on new and advancing markets such as off-grid, microgrids, and advanced distribution networks.
- Expansion of information sharing, communication, and outreach about DW energy technologies generally, but with a specific focus on research efforts that address DW issues in concept but are not considering DW technologies because of a lack of understanding or knowledge.

Four of these items are specifically included in the following work packages. Discussion were held around the development of tools for resource assessment but it was determined that although continued coordination and communication of national efforts would be important, there were not currently specific collaborative work that should be undertaken. Communication of national work will continue to be undertaken through this collaboration.

4. Approach and Methodologies

In addition to a management work package (WP0), the proposed scope of this task focused on four technical areas where specific engagement in needed, namely supporting collaboration and research leading to the update of standards specific to small and mid-sized wind turbines (WP1), the need to develop and make available a way to share data about DW research and information as no central, global way currently exists (WP2), expand learning and support in the integration of DW into the expanding distributed generation markets, with a focus on the mini-grid/off-grid markets and distributed generation markets (WP3), a concerted effort to expand the collaboration of extensive research that is ongoing around the world in areas that can or could address specific challenges associated with DW but are not because of a lack of knowledge or understanding (WP4) and finally an effort to collaborate on innovative research to lower the cost of wind turbine technology (WP5). A table of the WP and some sub-tier efforts is provided in Table 1. It is proposed that each WP will be operated as independent work efforts, with an identified topical lead and defined research paths leading to specific results. WP4 will focus more on cross cutting collaboration and will act as a conduit of information between existing work areas, other research efforts known to task members and the key work efforts being undertaken within IEA Wind and other IEA efforts. In a process modelled from PV research collaborations, the task will meet semi-annually to allow face to face meetings of the different WP as appropriate, but also allow continued cross collaboration between the WP. To the extent possible these meetings will take place in collaboration with other related efforts, supporting the wider efforts at the heart of WP4.

The Operating Agent (OA) will initially lead WP0 and WP4, with identified leaders or co-leaders in the other four work areas to facilitate engagement. Quarterly calls or meetings will take place between the OA and leaders of all of the WP to insure ongoing collaboration across the combined Task.

Table1: Work Packages

No	WP	Sub-WP	Lead Organization	Milestones
WP0	Management and coordination	Technical & administrative management	NREL/PNNL	M1-2
WP1	Progressing distributed wind technology design standards for small and mid-sized wind turbines to allow for accelerated innovation and improved consumer confidence.	Wind turbine standards Assessment	NREL	M3
		Compendium of standards recommendations		M4
WP2	Data Information catalog for DW research	Data catalog specification	PNNL	M5
		Data catalog development		M6
WP3	Expand learning and support of the integration of DW into evolving electricity systems	Microgrids and distributed grids	NREL	M7-8
WP4	Outreach and expand collaboration of ongoing R&D activities that could address specific challenges associated with DW technologies	IEA collaboration and outreach	NREL/PNNL	M9
		General outreach and communication		N/A
WP5	DW innovation and downscaling of utility scale technology	Research collaboration on innovation to reduce DW technology LCOE	CIEMAT	M10

WP0: Management and Coordination

The Task will be managed within this work package. The OA will ensure that the technical objectives and deliverables are achieved and will facilitate ongoing technical communication among the WP Leaders and the IEA Wind ExCo.

One of the first jobs of this WP will be to establish the Task web site with both public and private access for the Task. This website will facilitate discussion and collaboration between the Task partners as well as provide public information, e.g. papers. The WP will help define standard data and reporting formats for the Task. The OA will use appropriate project management procedures. Dissemination and regular liaison with the IEA Wind ExCo will be an integral part of this WP. The OA will also coordinate meetings, expected in the fall and spring, to be hosted by specific partners and interim virtual meetings of at least the WP leads.

To help facilitate expanded dialog, task meetings may also include topic specific expert

meetings in relation to distributed wind, where non-participating experts are invited to present and discuss specific topics of relevance to the distributed wind research community. The OA will discuss the associated topics with the Task 11 OA to determine if such meetings should be held as formal Task 11 Technical Expert Meetings, but are expected to be much smaller and thus would not include enough participants to warrant a formal Task 11 effort.

The OA will also coordinate twice yearly meetings in collaboration with the designated meeting host.

This work package will be led by the Operating Agent.

Deliverables

- D1 Development of general TEA Task 41 and distributed wind PowerPoint presentation for use by members. (Spring 2019)
- D2 First annual progress report. (Fall 2019)
- D3. Second annual progress report. (Fall 2020)
- D4. Third annual progress report. (Fall 2021)
- D5. Final Report. (Fall 2022)

Milestones:

- M1. Project kick-off meeting. (Winter 2019)
- M2. Launch Task 41 web site. (Spring 2019)

WP1: Progressing distributed wind technology design standards for small and mid-sized wind turbines to allow for accelerated innovation and improved consumer confidence.

The small and mid-sized wind industry has identified the design and testing standards for DW as a barrier to innovation and a source of increased cost. Sometimes, especially for turbines that have a rotor swept area greater than 200 m^2, which are too large to be tested to the International Electrotechnical Commission (IEC) 61400-2 standard, companies are not seeing the value of certifying their turbine models. For smaller turbines, there is growing evidence that the standard load equations may not be valid and work completed through Task 27 shows that current standards are not appropriate for highly turbulent conditions which are more common for DW technologies that are installed at lower heights in areas with higher surface roughness. Additionally, the one size fits all conditions of the small wind standards may not be as appropriate for the wide range of potential uses for small wind technologies, where systems with much shorter operational lives may be appropriate. This effort would not expect to engage in modifying current standards for turbines over 1 MW in size.

This effort will take two steps, the first is to convene and coordinate industry stakeholders to understand what issues have been identified with the current international and domestic standards focused at small and mid-sized wind turbines while the second will be to coordinate the development of technical justification for any proposed modifications to the existing standard. The first effort will take place in 2019 through the convening of several international forums leading to a recommendation of which elements of the current standards should be re-considered. The second step will include more detailed research by national and international organizations on the specific potential standards modifications which can be proposed through the formal IEC process in 2021.

In the end, this task will also develop recommendations for a conformity assessment of distributed wind systems and based on discusses with participant countries, support the initiation of a revision of the IEC 61400-2 or other standard by IEC Technical Committee (TC) 88. To get broad buy-in for proposed changes, this activity will need to be an international effort bringing in stakeholders from around the world.

This work package will be led by the National Renewable Research Laboratory, USA.

Deliverables:

D6. Stakeholder forum to engage wind industry around the effectiveness or modifications of current standards for small and mid-sized turbines in the U.S. (Winter 2019)
D7. Stakeholder forum to engage wind industry around the effectiveness or modifications of current standards for small and mid-sized turbines in the Europe. (Summer 2019)
D8. Stakeholder forum to engage wind industry around the effectiveness or modifications of current standards for small and mid-sized turbines in the Asia. (Fall 2019)
D9. Report on recommendations for potential standards changes that will be used to drive additional national and international research. (Winter 2020)

Milestones:

Milestones will depend the final participants and their chosen focus. The following milestones are notional based the anticipated activities.

M3. Report on recommendations for potential standards changes that will be used to drive additional national and international research. (Winter of 2020)
M4. Compendium of standards improvement recommendations. (Summer 2022)

Participants:

Vrije Universiteit Brussel, Belgium (expected)
China General Certification and Inner Mongolia University of Technology, China
Denmark Technical University & Nordic Folkecenter for Renewable Energy, Denmark
Dundalk Institute of Technology, Ireland
New Energy and Industrial Technology Development, Japan (expected)
Department of Energy CIEMAT, Spain
National Renewable Energy Laboratory, USA

Seeking funding commitment prior to directly engaging:
Fachhochschule Technikum Wien, Austria
Lodz University of Technology, Poland (pending IEA Wind TCP engagement)

WP2: Data Information catalog for DW research

WP2 will focus primarily on developing an information sharing catalog for research data on DW technologies. Wide scale technology and deployment innovation requires information and the sharing of information across research and development organizations, both in terms of data but also documents and research studies. This WP will look to better understand the potential data contributors and users, what shared resources are needed, what data is available on key topics, recommended practices around data collection, reporting and storage. The current focus of this effort will be to collect and make available meta data (information about data) not the data itself, sidestepping issues around data sensitivity and intellectual property. The goal will be to catalog informational resources so that there is an understanding of available data, and how that data should be archived. It is envisioned that if a researcher needs specific data, they can consult the catalog, identify data sets and then approach the data owner about conditions of use. The use of that data will be determined on a case by case basis between the interested party and the data owner, taking IEA wind, Task 41, and the WG out of the need to address specific use cases or intellection property provisions.

As this project develops it may be that it can become a repository of publicly available data or a data storage location of last resort as needed. Beyond data, this site could also catalog data processing tools, decision support tools, and other research efforts that are not currently in the public space. The Tethys database on environmental impacts (https://tethys.pnnl.gov/)

developed under IEA Wind Task 34 could serve as a model. Of specific early interest will be the investigation of potential portal informational and usability requirements. This website will also serve as a public dissemination tool for the Task and help to engage the wider wind community. Following the assessments of needs, the WP members will work with other WP and individual national projects to specify and initiate the development of a portal framework. Based on this early assessment and wider discussions, if appropriate, a portal will be developed over the course of this task.

This work package will be led by the Pacific Northwest National Laboratory, USA.

Deliverables:

D10. Specification of a data sharing catalog; including a review of needs, what meta data should be collected, and potential options for hosting the catalog. (Fall 2019)

D11. Development of data sharing, storage and if needed security protocols for meta data to be stored on the platform. Specification of a potential data sharing portal that expands on the catalog. (Fall 2020)

D12. Development of a data instruction guide for the DW data catalog. (Spring 2021)

Milestones:

The following milestones are planned based on the defined activities.

M5. Specification of data sharing catalog. (Dec of 2019)

M6. Completion of initial implementation of DW data catalog. (Dec of 2020)

Participants:

China General Certification, China
Denmark Technical University, Denmark
Dundalk Institute of Technology, Ireland
Department of Energy CIEMAT, Spain
Pacific Northwest National Laboratory, USA

Seeking funding commitment prior to directly engaging:
Fachhochschule Technikum Wien, Austria

WP3: Expand learning and support of the integration of DW into evolving electricity systems

Although in most locations large-scale wind has reached grid parity, DW technologies have typically not due to their smaller size, higher deployment cost, and lack of economies of scale. For this reason, expanding insight into markets with increased costs (isolated microgrids) or additional non-monetary benefits (resiliency, reliability, grid support, and diversification) will allow the expanded consideration of DW technologies. While some examples exist of integrating DW at higher outputs with other DERs in microgrids, controls protocols, data requirements and integration have not been standardized, increasing the cost of each system. The custom system engineering and testing is a barrier to the expansion and contribution of DW in this market sector. Similar issues exist with the expanded deployment of DERs into the distribution network, with increasing expectations and requirements around the controllability and security of DER technology, which the DW industry has largely, up to this point, not needed to address. Core challenges for the use of DW technologies in small-scale, islanded, microgrid, remote and emergency power, and high-DER-contribution distribution network market areas include:

- Lack of interoperability, controls standardization, data needs and grid-forming capability of current technology for operation in advanced distributed energy grids
- Limited active focus in cyber security and controls communication technology by the DW industry

- Value of DW to distribution grid in terms of energy production, resiliency, rotating inertia and diversity is not well characterized
- Extensive development work in DER-focused domestic and international standards, which the DW community is largely absent from.

This project will support collaboration around the research, development, demonstration, and testing of DW technologies with a focus on how DW technology is to be used in the new and developing distributed generation markets, including more active control systems, improved security, technology to support expanded system flexible leading to increased resiliency and the provision of enhanced grid support services, including potentially black start capability. As the use of power electronics expands, reducing the amount of moving inertia, even if wind technologies use power electronics, the inertia of the turbine rotor may provide additional services that cannot be provided by solid state storage and advanced PV inverters. These innovations will help to ensure that DW can be combined easily and flexibly with other generation technologies and with minimal operator skills and training.. These capabilities will support the validation of models and controls in the microgrid and distributed generation environment, reducing the barriers to DW participation across these markets. Of specific interest is engagement on international standards development in the micro-grid and DER technical area, for which DW is largely absent.

This work package will be led by the National Renewable Energy Laboratory, USA.

Deliverables
Specific deliverables produced through this effort include.

D13. Summation of relevant international and defined national electrical standards, operational practices that would be applicable to DW looking from the grid or microgrid perspective with a specific consideration of turbine size and complexity. (Fall 2019)

D14. Based on initial work completed in the U.S., review how DW is modelled in distributed grid and microgrid systems, the availability of design tools and models and an assessment of the modeling methods used for wind energy. (Fall 2019)

D15. Assessment of different levels of DW system control, including a classification for DW control strategies for high contribution distributed grids, including different capabilities of grid support and likely data needs for future wind systems. (Summer 2020)

D16. Design or best practice guide for the design of high renewable contribution isolated power systems. (Fall 2020)

D17. State of the industry report for isolated microgrid power systems. (Fall 2021)

Milestones:

M7. A review document of control and communication for advanced wind system integration. (Summer 2020)

M8. State of the industry report on isolated microgrid power systems. (Fall 2021)

Participants:
Inner Mongolia University of Technology, China
Denmark Technical University & Nordic Folkecenter for Renewable Energy, Denmark
Dundalk Institute of Technology, Ireland
Korea Institute of Energy Research, Korea
Department of Energy CIEMAT, Spain
Natural Resources Canada, Canada
National Renewable Energy Laboratory, USA

Seeking funding commitment prior to directly engaging:

Goldwind, China
Lodz University of Technology, Poland (pending IEA Wind TCP engagement)

WP4: Outreach and expand collaboration of ongoing R&D activities that could address specific challenges associated with DW technologies

To think of DW as a singular technology or a singular research area is similar to saying that offshore wind is just a matter of installing wind turbines in the water. Every consideration that one would have in the research of utility scale wind turbines or their deployment has a DW corollary. As the concepts of distributed generation expand there are additional technical areas and technical collaborations which may impact specific elements of DW technology or its deployment, such as more active control or cyber security for distributed generation. Advances or decisions in many of these areas could identify potential improvements or specify requirements that may be hard for the DW industry to support or actively engage due to the small size of that industry. Even within the IEA Wind TCP, several tasks are doing work that could directly support the expanded use of DW technology but these are not actively considering DW technologies. This is a similar issue outside of the IEA Wind TCP where additional work being undertaken within the area of energy access would provide obvious parallels for DW deployments. However, for example, the 2017 Energy Outlook [5] calls out distributed solar PV as a primary solution to address energy access concerns while the use of DW is not mentioned.

It is understood by the DW community that the utility scale wind market dominates research efforts and there is not the expectation that all IEA Wind Tasks should address DW efforts as part of their mandates. For this reason, it is beholden to the DW research community to engage more specifically in other work to enable these connections to be made, resulting in this WP. Through this effort, WP participants will review the research plans of each IEA Wind Task, identify a small number that seem most appropriate, and will seek to engage more actively in the ones that have the most specific overlap with understood DW concerns. The WP team members will then work to engage more broadly with these selected WP efforts. Of current IEA Wind TCP efforts the following tasks are likely doing work that could directly support the expanded use of DW technology:

- Task 19: Cold Climate. Potentially important. DTU is also a participant with Task 19 and can help coordinate. Many cold climate deployments are made up of large scale distributed wind technologies. Research conducted on ice throw and other cold climate considerations may have direct corollaries to wider DW deployments.)
- Task 25: Integration of Large Amounts of Wind. Collaboration will be very important. DTU participants of Task 41 are also represented on Task 25. Task 25 is focused on large grid systems, but DW technologies are very relevant in high contribution systems.
- Task 26: Cost of Wind. Potentially important. NREL has held initial discussions with task OA to investigate further investigate potential collaboration. Due to the general use of large scale distributed generation in some member countries, primarily in Europe, data already be available. Some potential for expanded data collection for smaller wind turbine technologies is possible.
- Task 28: Social Acceptance. Collaboration will be very important. Several organizations including DTU and NREL already have organizational representation within this task, further engagement will be considered especially since Task 28 is in the process of considering a task extension.
- Task 34: WREN. Potentially important. NREL will further investigate potential collaboration. Limited data is available on the impacts of distributed, and specifically small wind on avian and bat species.
- Task 36: Forecasting. Potentially important. DTU will further investigate potential collaboration. Forecasting could have a large impact on the operation of high renewable contribution microgrids, especially those with limited storage, however

resource data is typically not available, which makes standard forecasting algorithms less useful.

- Task 39: Quiet Wind. Potentially important. NREL will further investigate potential collaboration. Sound poses one of the key challenges to DW deployment, so technology solutions could greatly support expanded DW development. A key question will be if the technology being developed is going to be applicable for a wide range of wind technologies or will only be useful in common large turbine designs.

Following more detailed assessment of potential collaboration approaches, WP members will engage either directly or through surrogates, with the most appropriate work efforts. This could include expanding direct engagement with these tasks or co-hosting regular meetings.

WP members will also assess expanded collaborative efforts outside of the IEA Wind TPC that have specific DW technical overlap, such as IEA Energy Access efforts, and will actively engage with those efforts. Results from these collaborations will be brought back to each Task meetings for expanded discussions. Efforts will be implemented based on available opportunities with members identifying potential engagement opportunities and then engaging all members to see if there are viable engagement opportunities. In this manor a broad set of stakeholders can be engaged with limited funding. In the event that specific high priority engagement are identified, the OA may play a key outreach role. More general outreach efforts will also be undertaken with a targeted focus in areas where DER are generally accepted but limited wind based development has been undertaken. The OA will initiate efforts to develop sample DW and Task PowerPoint presentations that can be used as participants engage with stakeholders as part of standard conference attendance.

It is understood that this effort could become expansive very quickly given complexity of the wider DER industry and the likely need for expanded dialog around DW technologies. It is expected that only three to four specific engagement efforts will be possible each year, so the WP participants will need to spend some time identifying exactly how and where to engage to allow this effort to remain reasonable.

This work package will be led by the Operating Agent.

Deliverables:
Specific deliverables will include.

D18. Development of a specific IEA Wind TCP task engagement plan to be reviewed by Task. This will include DW focused research efforts that could be incorporated into future task proposals, allowing the specific consideration of DW topics within other IEA Wind TPC efforts. (Fall 2019)

D19. Identification of specific, high priority non-IEA Wind TCP stakeholders that could be a source for additional targeted engagement. (Summer 2020)

Milestones:
Efforts will mainly depend on specific focus opportunities though general engagement and specific targets of engagement will be included in Task reporting.

M9. Implementation of IEA Wind TCP task outreach and engagement plan. (Fall 2019)

Participants:
At least one organization from each partner nation has agreed to participate in this effort although specific activities or commitments were not specified.

WP5: DW innovation and downscaling of utility scale technology
In order to allow small and medium scale wind turbine technology to flourish, expanded

industry wide collaboration and research is going to be needed to lower LCOE through cost reductions and performance enhancements. This WP will focus on expanding the collaboration of international research organizations around specific areas of potential innovation based on discussion of WP members. Of specific interest is likely to be around the downscaling of utility scale wind turbine technology, understanding how some of the advances obtained in cost reductions for utility scale technology can be more readily applied to midscale and potential small scale wind technology. Initial actions will include using studies that have been developed around large wind turbine cost savings opportunities and assessing the potential to leverage this technology for mid and small scale wind technologies. An additional consideration could also be given to different development or business models that may be applicable for the distributed wind market.

This work package will be led by CIEMAT, Spain.

Deliverables:
Specific deliverables will include

D20. Report on the potential opportunities for cost reductions in mid and small scale wind technology based on current LCOE lowering technology innovations being applied to large and offshore turbine technologies. (Fall 2020)

Milestones:

M10. Report on downscaling opportunities for mid and small scale wind turbines. (Fall 2020)

Participants:
National Renewable Energy Laboratory/USA
Department of Energy CIEMAT, Spain

Seeking funding commitment prior to directly engaging:
Lodz University of Technology, Poland (pending IEA Wind TCP engagement).

5. Timeline and Key-Dates

The following provides an overview of the project timeline and key dates

- This project is envisioned as a four year project duration with an option to renew for an additional 4 years, depending on the interest of the participants and ExCo approval.
- A Task kickoff meeting was held in the winter of 2019.
- Annual reports to IEA Wind TCP ExCo.
- Planned winter and late summer meetings of the Task are planned, with specific in person WP meetings taking place, generally annually as part of main task meetings.

The proposed time schedule is presented in Table 2 (below).

Table 2 Task Schedule

WP	Sub-WP	Year 1	Year 2	Year 3	Year 4
WP0: Management and Coordination	▪ Annual Progress and Final Reports ▪ Task Meetings ▪ ExCo Meetings	X X X	X X X	X X X	X X X
WP1: Progressing distributed wind technology design standards for small and mid-sized wind turbines to allow for accelerated innovation and improved consumer confidence	▪ Assessment of current standards ▪ Standards improvement recommendations ▪ Standards Collaboration	==X====X====X====	==========X==========X	==========X	
WP2: Data Information Catalog for DW Research	▪ Specification of data sharing catalog ▪ implementation of DW data catalog ▪ Data instruction guide for DW data catalog	====== X====	==========X==========X	==========X	
WP3: Expand learning and support of the integration of DW into evolving electricity systems	▪ Off-Grid/microgrid system ▪ Distributed grid system	==========x====	==========X==========X		
WP4: Outreach and expand collaboration of ongoing R&D activities that could address specific challenges associated with DW technologies	▪ IEA Engagement assessment ▪ Implementation of IEA Wind TCP and other engagement efforts	===X==== ==========x==========X==========X==========			
WP 5: DW innovation and downscaling of utility scale technology	▪ Research collaboration on innovation to reduce DW technology LCOE	==========X==========			
X or x Represent ExCo, Task or WP in person meetings					

6. Reports, Deliverables and Dissemination of results

Annual progress reports will provide a status of the overall project and each WP and will be developed by the OA. Within each WP a number of deliverables have been elaborated and will be finalized at the end of the task kick-off meeting in order to summarize the most important results. WP leads will be responsible for the development and release of each specific product based on the inputs and reviews from the participants. The planned deliverables are shown in Table 3. Publishing some papers and/or conference presentations will be considered from the main deliverables of each WP and will be coordinated with the OA and other general task participants.

Table 3 Reports and Deliverables

No.	Del.	Deliverable Title	Contributor(s)	Month Due
WP0	D1 D2 D3 D4 D5	▪ Task 41 presentation material ▪ First annual progress report ▪ Second annual progress report ▪ Third annual progress report ▪ Final report	OA +All	6 12 24 36 48
WP1	D6 D7 D8 D9	▪ U.S. standards stakeholder engagement forum ▪ European standards stakeholder engagement forum ▪ Asia standards stakeholder engagement forum ▪ Recommendations for potential standards changes	Belgium, China, Denmark, Ireland, Japan, Spain and the US	3 9 12 15
WP2	D10 D11 D12	▪ Specification of data sharing catalog ▪ Initial implementation of DW data catalog ▪ Data instruction guide for DW data catalog	China, Denmark, Ireland, Spain and the US	12 24 30
WP3	D13 D14 D15 D16 D17	▪ Review of defined national and international standards that would be applicable to DW looking from the grid or microgrid perspective ▪ Review of DW grid and microgrid design tools and modeling approaches ▪ DW system controls classification report ▪ Best practice guide for the design of high renewable contribution isolated power systems ▪ State of the industry report for isolated microgrid power systems	China, Denmark, Ireland, Korea, Spain, Canada and the US	12 12 18 24 36
WP4	D18 D19	▪ IEA Wind TCP task engagement plan ▪ Identification of high-priority non-IEA wind stakeholders	OA + All	19 18
WP 5	D20	▪ Report on potential DW cost reduction opportunities based on identified large turbine innovations	Spain and the US	24

7. Methods of Review and Evaluation of Work Progress

Each work package is designed to be able to demonstrate clear progress towards specific task deliverables. Each WP will be summarized in the progress report developed by the OA each year and provided to the ExCo. Since each of the WP have defined research goals, in most cases the deliverables described will provide the context for task progress in place of more general meetings or progress reports. Specific timelines for deliverables and milestones is provided in Table 3, which will be the best measure of task progress. The following key meetings will measure the progress of the project:

- Task Kick-off meeting (Winter 2019): Secure participant commitments and finalize work plans for each WG
- Annual Progress Meeting 1 (Fall 2019): Review standards recommendations, data sharing portal specification, DW integration and control requirements, IEA engagement plan.
- Annual Progress Meeting 2 (Fall 2020): Updated on standards research, review of data portal, discussion of results of performance assessment research, and outreach efforts.

- Annual Progress Meeting 3 (Fall 2021): Review of standards modification recommendations, review of data portal guide prior to publications, discussion of near to mid-term research challenges, review next steps of outreach efforts, initiate discussion of potential task extension.
- Annual Progress Meeting 4 (Fall 2022): Discuss standards modification progress, evaluate effectiveness of data portal, discussion of results of performance prediction methodologies and tools, review next steps of outreach efforts, and final drafting of task extension proposal, if applicable.

Additional working meetings both in-person and via the web will be held throughout the project as needed to support collaboration, coordination, and information exchange. It is expected that each WP will include an annual in person meeting timed with the general

8. Obligations and Responsibilities

This Task requires collaboration among all Participants as well as contributing technical work that is conducted independently. The general obligations of the OA and the Participants are described below. Although considered minimal since most specific results will be the result of identified national research efforts, the data and products developed through this Task will be available equally to all participants. Data and products of this Task will not be available externally until completion of the Task or by agreement of the Participants. New entrants will be encouraged throughout the Task and will be obligated to contribute to the cost-share for the year in which the Task is joined. Participants who wish to withdraw from this Task after it begins will be obligated to contribute their share of the cost-share for the year in which they wish to withdraw.

Operating Agent

In addition to the responsibilities enumerated in Article 4 of the IEA Wind Agreement the Operating Agent shall:

- Act as the single point of contact for the Task with the IEA
- Work to coordinate WP efforts through direct dialog with WP leads
- Prepare a detailed Task Work Plan in cooperation with the WP leads and other Participants. The work plan will be reviewed annual and updated as appropriate. The final work plan will be submitted for approval by the Executive Committee with status and updates summarized annually.
- Be responsible for organizing meetings with representatives designated by Participants, including:
  - Semi-annual technical exchange meetings per year to report on each WP effort with specific focused discussions on specific WP efforts as needed
  - Semi-annual web meeting with WP leads
- Maintain a website of documents and summary of activities
- Conduct a review of IEA Wind TCP tasks to identify ones with specific DW overlap
- Conduct a review of general IEA efforts to identify ones with specific DW overlap
- Develop a DW engagement strategy that will include the identification of Participants or WP leads to attend specific meetings hosted by others or the co-hosting on Task meetings with other IEA efforts as appropriate
- Be responsible for the performance of the Task and report annually to the ExCo on the progress and the results of the work performed under the work plan
- Provide to the ExCo, within six months after completion of all work defined in the Work Plan, a final report summarizing the findings of the Task for its approval and transmittal to the Agency.

The responsibilities of the Operating Agent relate to the cooperation in the WP0 and WP5. The Operating Agent shall not be liable for the national efforts of the Participants even if the national efforts are in relation to specific efforts identified within a WP.

Participants

In addition to any obligations listed in the IEA Wind Agreement, the following obligations and responsibilities will be adhered to by the Participants of the Task:

- Each Participant shall bear its own cost for the scientific work, including travel expenses.
- The host country/sponsor shall bear the costs of workshops and meetings of experts.
- In the event that the U.S. DOE is unable to support the costs of the Operating Agency, the total costs of the Operating Agent shall be borne jointly and in equal shares by the Participants.
- Each Participant shall transfer to the Operating Agent its annual share of the costs in accordance with a time schedule to be determined by the Participants, acting under the direction of the Executive Committee.
- Each Participant will identify which WP in which they will participate and is expected to participate in at least one WP.
- Each Participant shall submit presentation materials and reports presented at the Task meetings to the Operating Agent for posting on the Task website, the format of which shall be agreed upon by the Participants.
- Each Participant will participate in editing and review of Task articles, presentations, technical documents, and the final report with expanded focus of documents that are produced by WP they are supporting.

In addition to the activities described in the Work Packages in Section 4, each participating country/sponsor is conducting related work. The planned effort from each participating country/sponsor will be estimated and documented in Table 4 at the Task kick-off meeting. The column "Task Effort" indicates the effort taken specifically for this Task while the column "Related Effort" indicates the effort for related work that will partly support this task. The Task is expected to officially begin on at the start of the project and will conclude four years after.

Table 4. Planned effort (in FTE months) from each Participant for each year.

Country / Lead Organization / PI	Work Package	Task Effort (FTE Months)					Related Effort (FTE Months)					Total Effort (FTE Months)				
		Year 1	Year 2	Year 3	Tear 4	Total	Year 1	Year 2	Year 3	Tear 4	Total	Year 1	Year 2	Year 3	Tear 4	Total
USA/NREL/Baring-Gould	WP0,1,3,4,5	1	1	1	1	4	3	3	3	3	12	4	4	4	4	16
USA/NREL/Tinnesand	WP0,2	0.5	0.5	0.5	0.5	2	1	1	1	1	4	1.5	1.5	1.5	1.5	6
USA/NREL/van Dam	WP1	0.75	0.75	0.75	0.75	3	1.5	3	3	3	10.5	2.25	3.75	3.75	3.75	13.5
USA/PNNL/Orrell	WP 0, 2, 4	2.5	2.5	2.5	2.5	10	2.5	2.5	2.5	2.5	10	5	5	5	5	20
Ireland/DkIT/Byrne	WP1, 3, 4	0.5	0.5	0.5	0.5	2	1	1	1	1	4	1.5	1.5	1.5	1.5	6
China/CGC/Bian Qiying	WP1,2,4					0					0	0	0	0	0	0
China/Goldwind/Li Yan	WP1					0					0	0	0	0	0	0
China/IMUT/Jia Yan	WP1,3,4					0					0	0	0	0	0	0
China/IMUT/Ren Yongfeng	WP1,3,4					0					0	0	0	0	0	0
China/IMUT/Meng Keqilao	WP1,3,4					0					0	0	0	0	0	0
DK/NFRE/Brink	WP1,3,4					0					0	0	0	0	0	0
DK/DTU/Hansen	WP1,3,4					0					0	0	0	0	0	0
DK/DTU/Das	WP1,3,4					0					0	0	0	0	0	0
Korea/KIER/Kim	WP3,4					0					0	0	0	0	0	0
Spain/CIEMAT/Cruz	WP1,2,3,4,5					0					0	0	0	0	0	0
Canada/NRCan/Dockrill	TBD					0					0	0	0	0	0	0
Japan/NEDO/Watanabe	TBD					0					0	0	0	0	0	0
Poland/LUT/Karczewski	TBD					0					0	0	0	0	0	0
Poland/LUT/Domagalski	TBD					0					0	0	0	0	0	0
Belgium/VUB/Runacres	TBD					0					0	0	0	0	0	0
Austria/FTW/Peppoioni	TBD					0					0	0	0	0	0	0

9. Type of Funding and Proposed Operating Agent

This Task will be both "cost shared" and "task-shared" in that the costs of the Operating Agent shall be borne jointly and in equal shares by the Participants. The funding principles are summarized as follows:

- Each Participant shall bear their own costs for carrying out the scientific work, including reporting and travel expenses.
- The host shall bear the costs of workshops and meetings convened in conjunction with this Task.
- Each participating country's intended resource allocations for the projected four years will be determined at the Task kick-off meeting (see Table 4 above).
- Each participant shall transfer to the Operating Agent their annual share of the costs in accordance with a time schedule to be determined by the Participants, acting under the direction of the Executive Committee.

The Operating Task will be performed in a collaboration between the National Renewable Energy Laboratory and Pacific Northwest National Laboratory

10. Proposed Budget Plan

The estimated total costs of the charge OA for coordination, management and reporting will be 63,000 Euros per year and a total of 252,000 Euros over four year project duration, as shown below in Table 5.

Table 5. Projected estimated expense items of the Operating Agent

Expense Item	Description	Estimated Cost (Euros per year)	Estimated Cost (Euros Total)
Management & Technical Support		30,000	120,000
Task Management Travel	3 meetings (plenary + ExCo) with a total of 5 expected person trips per year	20,000	80,000
Task Outreach Travel (WP5)	3 relevant meetings per year	15,000	60,000
Administrative and Miscellaneous	Website, etc.	5,000	20,000
Total		**70,000**	**280,000**

The full costs of the OA are currently being covered by the U.S. Department of Energy. In the event that these costs cannot be covered, the specific costs will be divided equally by the Participants and will be invoiced once a year. There are currently 10 IEA Wind TCP member countries committed to the Task, resulting in an estimated annual invoice of Euro 7,000 per Participant per year.

11. Management of the task

The OA is responsible for overall Task management and reporting. The management structure will be designed to conduct the work packages as described in Section 4 of this document according to the planned work scope and budget. The OA will coordinate with the participants to 1) define the scope and estimated labor for each Participant's contribution for inclusion in the work plan, 2) establish a communication method and procedure for collaboration to conduct the work, 3) monitor progress through semi-annual reporting, and 4) conduct plenary meetings at approximately 6 month intervals at which progress is evaluated by all participants. Each Participant will support the Task according to the list of planned and agreed country/sponsor participant contributions within the defined work scope.

The OA will arrange the in-person meetings twice a year in coordination with the meeting host. As part of each meeting, Participants will be expected to give a presentation on the most recent national/sponsor activities that support the work of Task 41 and other topical items within the work scope. Meeting notes will be distributed to all participants after each of the plenary meetings.

In-order to facilitate the required collaboration, web-based meetings will be conducted as needed throughout the project duration.

Email will be used as the primary method of communication between meetings using a master mailing list that will be used for organizing meetings, distributing information, and as a platform for discussions. The OA will keep the mailing list up to date.

A website will be created for Task 41 and web pages will be maintained and updated throughout the project duration for data archive, transfer, and dissemination of information to the Participants and to the public.

The semi-annual Task status reports that are prepared for the ExCo will also be distributed to the

participants. All of this information will be available on the IEA Wind members-only website.

12. Organization

An operating agent has not been identified for this work although several organizations have specified willingness. Work package leaders identified be assigned in accordance with the approach and methodologies detailed in Section 4 and the Task Work Plan that will be developed following ExCo approval of the Task.

The Task Operating Agent is proposed to be a collaboration between the National Renewable Energy Laboratory and Pacific Northwest National Laboratory

13. Information and Intellectual Property

(a) **Executive Committee's Powers**. The publication, distribution, handling, protection and ownership of information and intellectual property arising from activities conducted under this Annex, and rules and procedures related thereto shall be determined by the Executive Committee, acting by unanimity, in conformity with the Agreement.

(b) **Right to Publish.** Subject only to copyright restrictions, the Annex Participants shall have the right to publish all information provided to or arising from this Task except proprietary information.

(c) **Proprietary Information.** The Operating Agent and the Annex Participants shall take all necessary measures in accordance with this paragraph, the laws of their respective countries and international law to protect proprietary information provided to or arising from the Task. For the purposes of this Annex, proprietary information shall mean information of a confidential nature, such as trade secrets and know-how (for example computer programs, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments) which is appropriately marked, provided such information:

1) Is not generally known or publicly available from other sources;
2) Has not previously been made available by the owner to others without obligation concerning its confidentiality; and
3) Is not already in the possession of the recipient Participant without obligation concerning its confidentiality.

It shall be the responsibility of each Participant supplying proprietary information, and of the Operating Agent for arising proprietary information, to identify the information as such and to ensure that it is appropriately marked.

(d) **Use of Confidential Information.** If a Participant has access to confidential information which would be useful to the Operating Agent in conducting studies, assessments, analyses, or evaluations, such information may be communicated to the Operating Agent but shall not become part of reports or other documentation, nor be communicated to the other Participants except as may be agreed between the Operating Agent and the Participant which supplies such information.

(e) **Acquisition of Information for the Task.** Each Participant shall inform the other Participants and the Operating Agent of the existence of information that can be of value for the Task, but which is not freely available, and the Participant shall endeavor to make the information available to the Task under reasonable conditions.

(f) **Reports on Work Performed under the Task.** Each Participant and the Operating Agent shall provide reports on all work performed under the Task and the results thereof, including studies, assessments, analyses, evaluations and other documentation, but excluding proprietary information, to the other Participants. Reports summarizing the work performed and the results thereof shall be prepared by the Operating Agent and forwarded to the Executive Committee.

(g) **Arising Inventions.** Inventions made or conceived in the course of or under the Task (arising inventions) shall be identified promptly and reported to the Operating Agent. Information

regarding inventions on which patent protection is to be obtained shall not be published or publicly disclosed by the Operating Agent or the Participants until a patent application has been filed in any of the countries of the Participants, provided, however, that this restriction on publication or disclosure shall not extend beyond six months from the date of reporting the invention. It shall be the responsibility of the Operating Agent to appropriately mark Task reports that disclose inventions that have not been appropriately protected by the filing of a patent application.

(h) **Licensing of Arising Patents.** Each Participant shall have the sole right to license its government and nationals of its country designated by it to use patents and patent applications arising from the Task in its country, and the Participants shall notify the other Participants of the terms of such licenses. Royalties obtained by such licensing shall be the property of the Participant.

(i) **Copyright.** The Operating Agent may take appropriate measures necessary to protect copyrightable material generated under the Task. Copyrights obtained shall be held for the benefit of the Annex Participants, provided however, that the Annex Participants may reproduce and distribute such material, but shall not publish it with a view to profit, except as otherwise directed by the Executive Committee, acting by unanimity.

(j) **Inventors and Authors.** Each Annex Participant will, without prejudice to any rights of inventors or authors under its national laws, take necessary steps to provide the co-operation from its inventors and authors required to carry out the provisions of this paragraph. Each Annex Participant will assume the responsibility to pay awards or compensation required to be paid to its employees according to the law of its country.

14. List of Potential Participants

Table 6. List of potential participants

#	Country/Sponsor	Participant Organization	Expert Participant	Commitment
1	USA (OA)	National Renewable Energy Laboratory Pacific Northwest National Laboratory	Ian Baring-Gould and Alice Orrell	Committed
2	Austria	Fachhochschule Technikum Wien	Mauro Peppoloni	Interested – seeking funding
3	Belgium	Vrije Universiteit Brussel	Mark Runacres (Potentially)	Interested
4	China	China Wind Energy Association (CWEA), China General Certification (CGC), Goldwind, and Inner Mongolia University of Technology	Du Guangping Jia Yan，Ren Yongfeng, Meng Keqilao (IMUT) Bian Qiying (CGC), Charlie Dou (CWEA), Li Yan (Goldwind)	Committed
5	Republic of Korea	Korea Institute of Energy Research	Seokwoo Kim	Committed
6	Spain	CIEMAT	Ignacio Cruz	Committed
7	Ireland	Dundalk Institute of Technology	Ray Byrne	Committed
8	Denmark	Denmark Technical University (DTU) & Nordic Folkecenter for Renewable Energy	Anca Daniela Hansen and Kaushik Das (DTU) and Tonny Brink (Folkecenter)	Committed, seeking expanded funding

9	Canada	Natural Resources Canada (NRCan)	Paul Dockrill	Committed
10	Japan	New Energy and Industrial Technology Development (NEDO)	Yoshitomo Watanabe	Interested
11	Poland	Lodz University of Technology	Maciej Karczewski, Piotr Domagalski	Interested (Need to become IEA wind TCP member)

15. References

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