**INTERNATIONAL ENERGY AGENCY**

**Implementing Agreement for Co-operation in the Research, Development and Deployment of Wind Turbine Systems**
**Task 11**

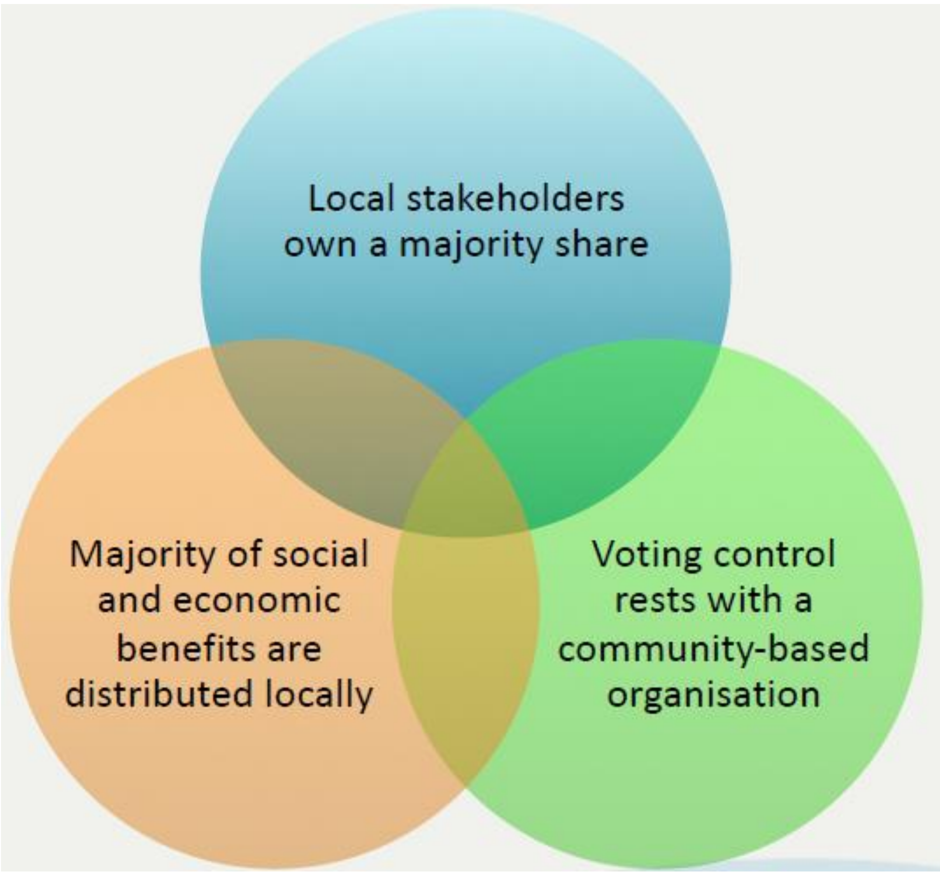
***Topical Expert Meeting #90 on***

# 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

***IEA Wind Task 11- Topical expert meeting***

***March 26-28, 2018***

***DTU, Roskilde, Denmark***



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For more information about the IEA Wind TCP see www.ieawind.org

# International Energy Agency Implement Agreement for Co-operation in the Research, Development and Deployment of Wind Turbine Systems (IEA Wind)

The IEA international collaboration on energy technology and RD&D is organized under the legal structure of Implementing Agreements, in which Governments, or their delegated agents, participate as Contracting Parties and undertake Tasks identified in specific Annexes.

The IEA's Wind Implementing Agreement began in 1977 and is now called the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind). At present, 26 contracting parties from 22 countries, the European Commission, and Wind Europe, participate in IEA Wind. Austria, Belgium, Canada, Denmark, the European Commission, EWEA, France, Finland, Germany, Greece, Ireland, Italy (two contracting parties), Japan, Republic of China, Republic of Korea, Mexico, Netherlands, Norway (two contracting parties), Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States are now members.

The development and maturing of wind energy technology over the past 30 years has been facilitated through vigorous national programs of research, development, demonstration, and financial incentives. In this process, IEA Wind has played a role by providing a flexible framework for cost-effective joint research projects and information exchange.

The mission of the IEA Wind Agreement continues to be to encourage and support the technological development and global deployment of wind energy technology. To do this, the contracting parties exchange information on their continuing and planned activities and participate in IEA Wind Tasks regarding cooperative research, development, and demonstration of wind systems.

Task 11 of the IEA Wind Agreement, Base Technology Information Exchange, has the objective to promote and disseminate knowledge through cooperative activities and information exchange on R&D topics of common interest to the Task members. These cooperative activities have been part of the Wind Implementing Agreement since 1978.

Task 11 is an important instrument of IEA Wind. It can react flexibly on new technical and scientific developments and information needs. It brings the latest knowledge to wind energy players in the member countries and collects information and recommendations for the work of the IEA Wind Agreement. Task 11 is also an important catalyst for starting new tasks within IEA Wind.

# IEA Wind TASK 11: BASE TECHNOLOGY INFORMATION EXCHANGE

The objective of this Task is to promote disseminating knowledge through cooperative activities and information exchange on R&D topics of common interest. Four meetings on different topics are arranged every year, gathering active researchers and experts. These cooperative activities have been part of the Agreement since 1978.

## Two Subtasks

The task includes two subtasks.

The objective of the first subtask is to develop recommended practices (RP). Recent developed RPs were on "Wind Farm Data Collection and Reliability Assessment for O&M Optimization (Task 33)" (RP#17) and "Floating Lidar Systems (Task 32 in coordination with the Offshore Wind Accelerator initiative)" (RP#18).

The objective of the second subtask is to conduct topical expert meetings in research areas identified by the IEA R&D Wind Executive Committee. The Executive Committee designates topics in research areas of current interest, which requires an exchange of information. So far, Topical Expert Meetings are arranged four times a year.

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## Documentation

Since these activities were initiated in 1978, more than 80 volumes of proceedings have been published. In the series of Recommended Practices 18 documents were published and six of these have revised editions.

All documents produced under Task 11 and published by the Operating Agent are available to citizens of member countries participating in this Task.

## Operating Agent

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| COUNTRIES PRESENTLY PARTICIPATING IN THE TASK 11 | |
|---|---|
| **COUNTRY** | **INSTITUTION** |
| Denmark | Danish Technical University (DTU) - Risø National Laboratory |
| Finland | Technical Research Centre of Finland - VTT Energy |
| Germany | Federal Ministry for Economic Affairs and Energy (BMWi) |
| Ireland | Sustainable Energy Ireland - SEI |
| Italy | Ricerca sul sistema energetico, (RSE S.p.A.) |
| Japan | New Energy and Industrial Technology Development Organization (NEDO) |
| Mexico | Instituto de Investigaciones Electricas - IEE |
| Netherlands | Rijksdient voor Ondernemend Nederland (RVO) |
| Norway | The Norwegian Water Resources and Energy Directorate - NVE |
| Republic of China | Chinese Wind Energy Association (CWEA) |
| Spain | Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas CIEMAT |
| Sweden | Energimyndigheten - Swedish Energy Agency |
| Switzerland | Swiss Federal Office of Energy - SFOE |
| United Kingdom | CATAPULT Offshore Renewable Energy |
| United States | The U.S Department of Energy -DOE |

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# 1. INTRODUCTORY NOTE

IEA Wind Task 11 Topical Expert Meeting # 90 on 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

Ian Baring-Gould – National Renewable Energy Laboratory

**BACKGROUND**

The wind industry has realized substantial growth reaching nearly 0.5 TW of installed capacity in 2016 and producing about 4% of global electricity demand in 2015.[1] Equipment, installation and operation costs for large utility scale and offshore have decreased while energy production per turbine has increased. Figure 1 illustrates levelized cost of energy over the past decades and associated learning rates. Future deployment pathways associated with historical learning rates are illustrated relative to a baseline identified by leading wind industry experts.[2] The costs of solar PV have likewise decreased substantially over the last 10 years[3]. 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, Figure 2.[4].

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 the U.K. Additionally, countries with limited transmission infrastructure will quickly reach integration limits for large central station wind power, 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.

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1 http://www.gwec.net/

2 Wiser et al., (2016). https://emp.lbl.gov/publications/forecasting-wind-energy-costs-and

3 Ran Fu, David Feldman, Robert Margolis, Mike Woodhouse, Kristen Ardani. 2017. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. NREL/TP-6A20-68925. https://www.nrel.gov/docs/fy17osti/68925.pdf.

4 Alice Orrell, Nikolas Foster, Scott Morris, Jullet Homer, 2017. 2016 Distributed Wind Market Report https://energy.gov/sites/prod/files/2017/08/f35/2016-Distributed-Wind-Market-Report.pdf

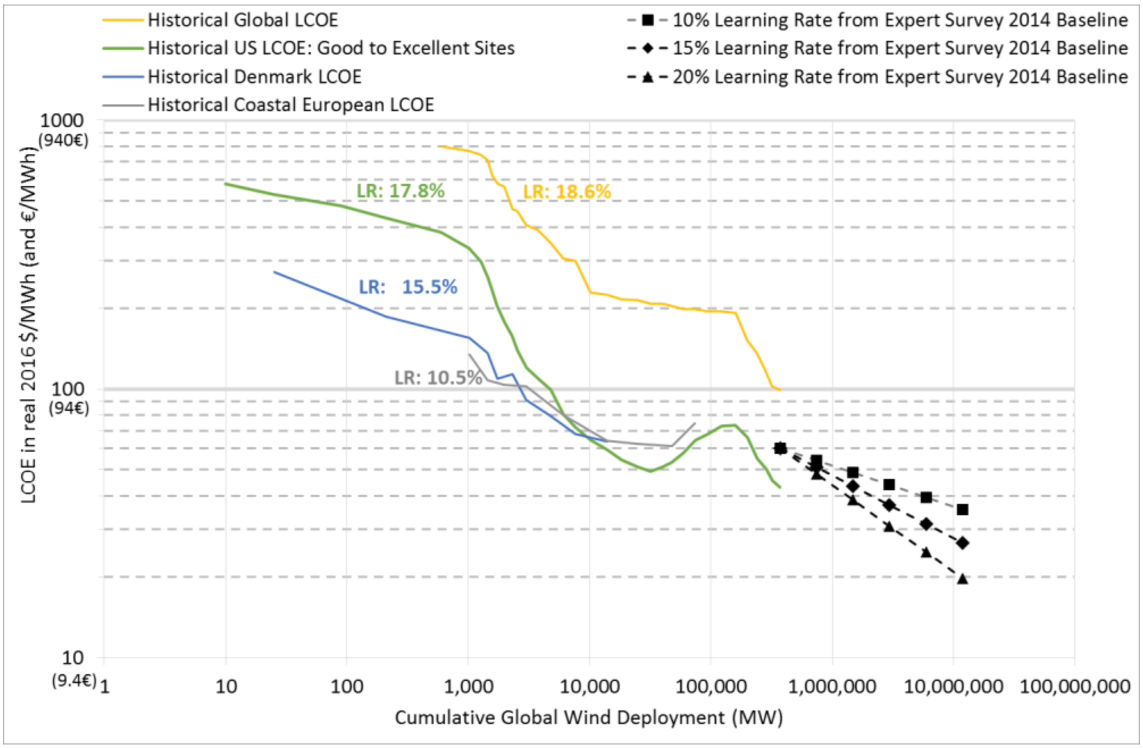


**Figure 1: Historical learning rates and illustration of future deployment levels assuming continued learning. Source: Expert survey on future cost of wind energy (Wiser et al., 2016) updated to 2016 USD; future deployment based on historical learning rates added by authors**

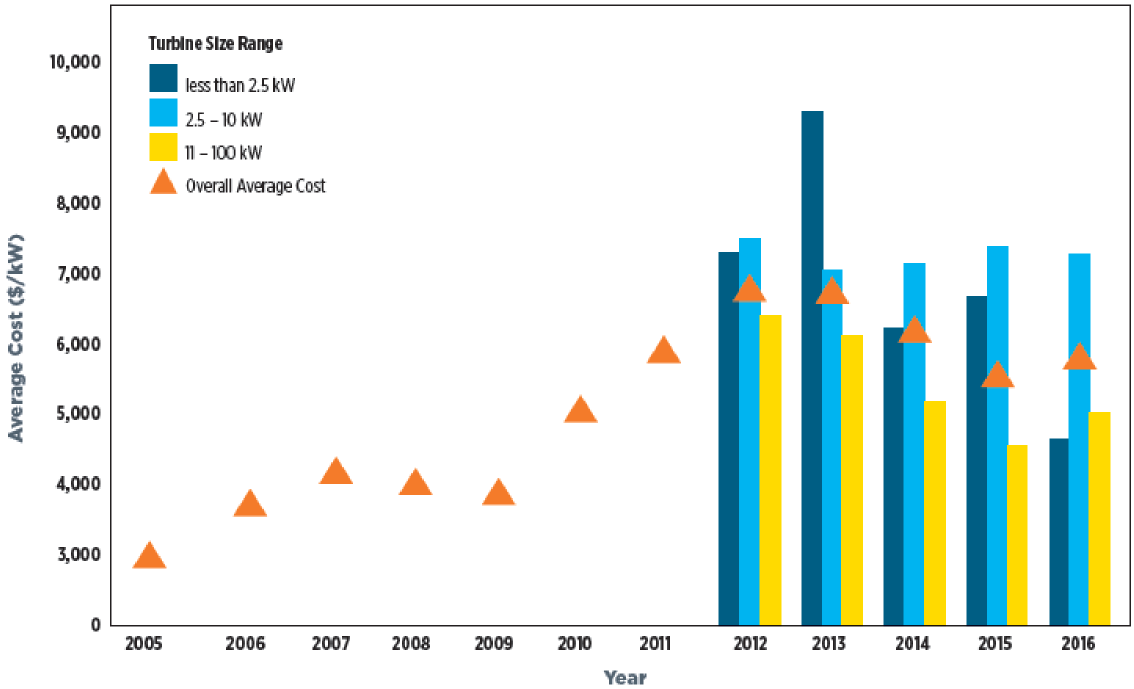


**Figure 2: historical trends of small wind turbines in the US market. Life cycle cost is very dependent of turbine performance which makes it hard to correlate LCOE to project year (figure extracted from Orrell et. al. 2017**

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[5]. Additionally, IEA research identifies that approximately 40% of unserved populations across the globe will be supplied by off-grid solutions which could include distributed wind[6]. Distributed projects, either single or small clusters of turbines deployed to provide local energy needs or as part of an isolated, off grid power system-operate with different cost structures and project development processes than large scale land-based and offshore projects. The technology innovation needs, deployment methodology, and social acceptance strategies are far from optimized for this emerging sector. In order for this market area to thrive, especially given the increasing competitiveness of solar PV, innovation from across this market segment will be required.

## OBJECTIVES

In a structured workshop setting, experts will provide overview short presentations on current market conditions and research projects, but then through moderated breakout sessions will be encouraged to provide input and insights associated with technology and deployment innovations and understandings that will be needed to yield aggressive global growth for distributed wind technologies. The workshop will try to provide a broad discussion of current research trends, deployment challenges, and integration requirements, resulting in a better understanding of market needs over the mid to long-term.

## INTENDED PARTICIPATION

Participants include strategic, system-level thought leaders with wind research, technology, cost, and/or market expertise with a focus on distributed wind energy. Representation from both established and emerging distributed wind market participants will provide a breadth of expertise. All participants will be expected to contribute to break-out sessions targeted at eliciting perspectives related to future distributed wind deployment challenges from a technology, social, environmental, and infrastructure perspectives.

## EXPECTED OUTCOMES

The primary outcome of the meeting will be a global agenda to move distributed wind generation toward wind technology as a primary electricity generation option that is articulated in a published article (see for example the Terawatt-scale photovoltaics: Trajectories and challenges, 2017)[7]. This involves structured ideas and concepts regarding activities that the distributed wind industry R&D community can undertake to influence the wider scale global adoption of distributed wind technology to meet world electricity demand. This information will also be utilized by the IEA Wind Executive Committee to develop a five-year strategic plan and by other participating organizations to inform R&D activities. The secondary outcome will be to bring together distributed wind experts, something that does not happen frequently due to the small size and relative dispersion of this industry segment.

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[5] Eric Lantz, Benjamin Sigrin, Michael Gleason, Robert Preus, Ian Baring-Gould. 2016. Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects. NREL/TP-6A20-67337. https://www.nrel.gov/docs/fy17osti/67337.pdf.

[6] International Energy Agency. 2010. "Energy Poverty: How to Make Modern Energy Access Universal." Available at http://www.iea.org/publications/freepublications/publication/weo-2010---special-report---how-to-make-modern-energy-access-universal.html

[7] Available from Science at: http://science.sciencemag.org/content/356/6334/141

# 2. AGENDA

**IEA Task 11 – Technical Experts Meeting 90**
**Community and Distributed Wind**
**March 26-28, 2018, Roskilde, Denmark**
**Hosted by IEA Wind Task 11, DTU-Risø, and NREL/U.S. DOE**

Note: the following agenda includes the link to the slides presented during the meeting that have been posted on the IEA Wind platform

**Monday – March 26th**

The Monday evening session is devoted to getting to know the different parties taking part in the Technical Experts Meeting and the work being undertaken in the represented countries around Distributed and Community wind.

5:30 PM – Welcome and National Updates (Comwell Hotel – Roskilde)

*Representatives from each participating country will provide a short overview of the status of distributed and community wind development in their country. Specific topics that could be covered would include:*

- *Market for distributed and community wind*
- *Drivers for distributed and community wind development*
- *Technical and market challenges for community wind development*
- *Current research being undertaken*

Presentations:

1. Presentation from Austria: Mauro Peppoloni, UASTW, Austria
2. Presentation from Denmark: DTU Wind Energy, Viking Energy, Ecology Management ApS, Denmark
3. Presentation from Belgium: Mark Runacres, VUB, Belgium
4. Presentation from USA-Canada: Technocentre éolien, Canada
5. Presentation from Spain: Ignacio Cruz, CIEMAT, Spain
6. Presentation from the WWEA: Stefan Gsänger, World Wind Energy Association (WWEA)

7:00 PM – Hosted dinner – Comwell Hotel – Roskilde - combined with the Task 28 participants
8:30 PM - Welcome and short workshop introduction (Ian Baring-Gould, NREL)

**Tuesday – March 27th – Technical Challenges**

The Tuesday meetings are organized around technical focused breakout sessions where attendees will be asked to build on the list of most critical technical challenges to allow distributed wind market to expand, further clarifying and defining these challenges. A second breakout will be devoted to solutions to these challenges with a final narrowing down to who will be the most appropriate actors and resources needed to address these challenges.

8:30 AM - Arrival, check-in
9:00 AM - Opening and Introductions of attendees

- Welcome - DTU Risø – Kaushik Das (DTU Risø)
- IEA Task 11 introduction and welcome – Davy Marcel (Planair SA)
- Introduction of all attendees – All
- Technical introduction - summary of Monday introductory discussion – Ian Baring-Gould (NREL)

9:45 AM - Guiding talk – Market Opportunities for Distributed Wind

*Short presentations on market assessments and opportunities from around the globe, broken out by market sector or geographic regions:*

Distributed and Community Wind. European Market: Ignacio Cruz, CIEMAT, Spain
Small Wind - Community Wind - Distributed Wind - Decentralized Wind: Stefan Gsänger, World Wind Energy Association

10:30 AM - Introduction to Breakouts and Locations – Ian Baring-Gould

10:50 AM - Breakouts on Distributed Wind Technical Challenges (divided into breakout groups)

*In this first session we address the classic metric of LCOE which is still one of most critical metric for evaluating a generation technology. In each breakout, workshop participants will evaluate technology needs for further reduction to LCOE and its main elements: energy production, capital costs, operational expenditures, and performance prediction.*

11:50 AM - Technical Challenge Breakout Reporting

12:15 PM - Lunch and continued discussion

1:15 PM - Guiding talk – Solutions to technical market challenge

*The US wind industry developed a SMART Roadmap roadmap/action plan for distributed wind technology. This presentation will review the findings of this action plan, providing a basis for discussions for solutions to some of the challenges identified in the previous session*

A Consensus-Based, Shared-Vision **S**ustainable **M**anufacturing, **A**dvanced **R**esearch & **T**echnology - Action Plan for Distributed Wind: Trudy Forsyth, Wind Advisors Team, U.S.

1:45 PM - Breakouts on Technology Solutions (divided breakout groups)

*In this second session, we catalog potential solutions to the challenges identified in the previous session in the same groups provided below.*

3:00 PM - Technology Solutions Breakout Reporting

3:25 PM - Break

3:40 PM - Guiding talk – Role of IEA in setting a research agenda

*The IEA wind ExCo provides a useful platform to address communal research needs for the wind industry, this presentation will review the different IEA Wind research tasks, providing some guidance on one avenue that could be better used to expand distributed wind focused development efforts.*

IEA Wind TCP Strategic Communications: Bret Barker, U.S. Department of Energy/Barker Advisory

3:50 PM - Breakouts on roles and resources to address the technical challenges (in three groups)

*The last break-out session of the day will be used to identify roles, resources and timelines to address the challenges identified in the previous sessions, allowing a better understanding of how we can get done what needs to be done*.

5:00 PM - Roles and Resources Reporting

5:30 PM - Wrap-up

6:00 PM - Adjourn for the day, dinner on your own.

**Wednesday – March 28th – Development Challenges (co-sponsored with Task 28)**

Efforts on Wednesday are organized around addressing the non-technical issues, sometimes referred to deployment or soft cost issues, of the expanded use of distributed wind technologies. Through focused breakout sessions where attendees will be asked to build on the list of most critical deployment challenges and solutions to allow distributed wind market to expand. A final breakout session will work to identify the different organizations and resources needed to address these challenges. The breakout groups will be topically focused as defined below.

8:00 AM - Arrival, check-in

8:30 AM - Introductions of new attendees

8:45 AM - Review of Tuesday's findings
9:00 PM - Guiding talk – Factors Driving Deployment and Distributed Wind Project Costs

*Based on U.S. DOE research this presentation will review the key factors that impact the deployment of distributed wind technologies in the US market, specific adoption rate, technology advancement, siting constraints, policy, and financing costs. The presentation will also review data on project costs with a focus non-hardware costs for project development.*

Distributed Wind in the United States: Suzanne Tegen, NREL, U.S.

9:30 AM - Guidance for Breakouts and Locations – Ian Baring-Gould
9:40 AM - Breakouts on Development Challenges and Potential Solutions (in breakout groups)

*In this first session we will build on the discussions of Monday night, focusing on the deployment challenges associated with distributed wind. In each breakout workshop participants will evaluate non-technology needs and identify solutions including topics such as: siting, permitting, technology acceptance, business models and financing models.*

11:00 AM – Break
11:20 AM – Development Challenge and Solutions Breakout Reporting
11:40PM - Role of Distributed Wind in the IEA

*Distributed wind has played an understated role within the IEA Wind research and is not typically considered as part of general discussions. This is exhibited in that large-scale land-based wind and offshore wind have large national efforts although in many cases, equal market potential exists for distributed applications, especially as markets expand in developing nations in the face of climate mitigation and other drivers. This session will explore how distributed and community wind topics can be integrated into IEA activities.*

12:30 PM - Lunch and continued discussion
1:30 PM - Breakouts on roles and resources to address development challenges

*The last break-out session will be used to identify roles, resources and timelines to address the deployment focused challenges identified in the previous sessions, allowing a better understanding of how we can get done what needs to be done.*

2:30 PM – Development Challenge and Solutions Breakout Reporting
2:50 PM - Next Steps and Warp-up

*This session will discuss appropriate next steps from the dialog, including but not limited to:*

- *Development of a summary report on needs for the distributed wind industry*
- *Input into the IEA-Wind 5-year plan on distributed wind*
- *Plan for expanded DW engagement in the IEA Wind ExCo*

3:30 PM - Adjourn

**Breakout Groups:**

Small groups for breakout sessions are envisioned to be done by market segment given that different challenges, and solutions, may be turbine size and market focused. Although three breakout groups had been originally proposed, the following two were implemented based on the interest levels and experience of participants.

1) Larger distributed wind projects, including community, isolated, or industrial
2) Smaller distributed wind projects, behind the meter residential and commercial applications

**Overall schedule:**

| | **Task 28**<br>**Social Acceptance of Wind** | **TEM 90**<br>**Community Wind** |
|---|---|---|
| | Group 1 | Group 2 |
| Monday 26th | Room: H.H.Koch<br>09:00 Start<br>11:00 Coffee break<br>12.30 Lunch<br>15:00 Coffee break<br>17:00 End | 17:00 Social Hour |
| | 19:00 Dinner at the Comwell Hotel | |
| Tuesday 27th | Room: H.H. Koch<br>09:00 Start<br>11:00 Coffee break<br>12:30 Lunch<br>13:30 Visit around Risø<br>17:00 End | Room: Johannes Juul<br>09:00 Start<br>11:00 Coffee break<br>12:30 Lunch<br>17:00 End |
| | Evening: own time / ad hoc arrangements | |
| Wednesday 28th | Room: H.H. Koch<br>08:30 Start<br>11:00 Coffee break<br>12:30 Lunch<br>15.30 Finish | |

## 3. LIST OF PARTICIPANTS

The meeting, when merged with Task 28, was attended by 25 participants from 12 countries and one international organization. Following is the list of participants and their affiliations.

| *Name* | *Initials* | *Organization, Country* |
|---|---|---|
| Mauro Peppoloni | MP | Institute für Erneuerbare Energie, Austria |
| Mark Runacres | MR | Vrije Universiteit Brussel, Belgium |
| Frédéric Côté | FC | TechnoCentre éolien, Canada |
| Karim Belmokhtar | KB | TechnoCentre éolien, Canada |
| Müfit Altin | MA | DTU, Denmark |
| Svend Enevoldsen | SE | Ecology Management ApS, Denmark |
| Kaushik Das | KD | DTU, Denmark |
| Tom Cronin | TC | DTU, Denmark |
| David Philipp Rudolph | DPR | DTU, Denmark |
| Ulrich Høgenhaven | UH | Viking Wind |
| Gundula Huebner | GH | Medical school Hamburg, Germany |
| Jan Hildebrand | JH | Universität des Saarlandes, Germany |
| Stefan Gsanger | SG | World Wind Energy Association, International |
| Garry Keegan | GK | Iarnrod Eireann Irish Rail, Ireland |
| Yayushi Maruyama | YM | Nagoya University, Japan |
| Ignacio Lopez | IL | EWT, Netherlands |
| Mariëlle de Sain | MDS | Pondera Consult, Netherlands |
| Ignacio Cruz | IC | Ciemat, Spain |
| Miguel Hoyos Irisarri | MHI | Norvento Energia Distribuida, Spain |
| Davy Marcel | DM | Planair, Switzerland |
| Patrick Devine-Wright | PDW | University of Exeter, United Kingdom |
| Suzanne Tegen | ST | NREL, USA |
| Bret Barker | BB | U.S. Department of Energy, USA |
| Ian Baring Gould | IBG | NREL, USA |
| Ryan Storke | RS | Storke, USA |
| Trudy Forsyth | TF | Wind Advisors Team, USA |

## 4. SUMMARY of FINDINGS

DTU and the National Renewable Energy Laboratory (NREL), supported by the U.S. Department of Energy, co-hosted IEA Wind TEM #90 at the DTU Risø Campus in Roskilde, Denmark, on March 26-28, 2018. The focus of the meeting was to obtain a better understanding of the markets and challenges facing the distributed wind (DW) industry in the context of greatly decreasing costs for land-based wind, offshore wind, and distributed solar PV technologies. Through a structured workshop setting followed by moderated breakout sessions, experts provided input and insights associated with technology and deployment innovations and understandings 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. The first day of the workshop focused on technology while the second day, which was combined with a co-located meeting of IEA Task 28 (Social Acceptance of Wind Energy Projects), focused on DW deployment and development.

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.[8]

European markets are generally focused around the second and third of these customer classes but are under pressures primarily as the electricity markets move to more cost-focused auction schemes.[9] Some nations have specific policy that supports distributed or community development, although they can be circumvented or are subject to changing political dynamics. Small wind is generally considered a niche market in Europe. In the United States there is just more than 1 gigawatt (GW) of distributed wind capacity installed.[10] A 2017 National Renewable Energy Laboratory (NREL) analysis finds that DW systems are technically feasible for

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[8] Schick, Gsanger, Fobertin (2016),Headwind and tailwind for community power, community Wind Perspectives from North-Rhine Westphalia and the World, Bonn, Germany. Available at: http://www.wwindea.org/download/community_power/Community_Wind_NRW.pdf

[9]Tenk (2018), Community Wind in North Rhine-Westphalia, Perspectives from State, Federal and Global Level, Bonn Germany, Available at: https://www.wwindea.org/wp-content/uploads/2018/02/CP_Study_English_reduced.pdf

[10] Orrell A, N. Foster, S. Morris, & J. Homer. 2017. *2016 Distributed Wind Market Report*. PNNL-25636. Pacific Northwest National Laboratory, Richland, WA. https://www.energy.gov/sites/prod/files/2017/08/f35/2016-Distributed-Wind-Market-Report.pdf

approximately 49.5 million residential, commercial, and industrial "behind the meter" sites nationwide. Considering favorable technology and economic conditions in the future, NREL estimates economically viable potential capacity at 48 GW in 2030 and more than 85 GW in 2050.[11] Globally, Navigant Research forecasts modest but steady industry growth over the next decade for small wind markets, with annual revenue of just over $600 million in 2017, growing to $1.6 billion in 2026.[12] The International Energy Agency also projects that to achieve universal energy access by 2030, more than 40% of total investments must be directed toward isolated mini-grid power systems for which wind energy can be a primary energy provider.[13] All of these studies show viable market growth for the sector but clear challenges to meet future growth potential.

Based on break-out group discussions, the meeting resulted in identifying future needs for the DW energy industry to expand from its current relatively small-scale market. Breakout sessions were conducted for small turbines (nominally less than 100 kW) deployed primarily off-grid or behind the meter at homes, businesses, or community buildings and mid to large turbines (nominally 100 kW to ~2 MW) deployed across a wide range of applications, including directly to the distribution networks. Breakout sessions considered technology and market-based challenges. Most challenges were specific to one of the two turbine size classes, although several held true for both. The following summarizes the challenges identified:

Mid-size to large turbine technology and deployment challenges:

- Limited access to finance: The high uncertainty around lifetime performance predictions driven by the lack of low-cost, high-certainty resource assessments and poor guarantees of long-term operational performance make it difficult to secure low-cost financing for large-scale deployments.
- Human capacity limitations: Limited widespread skilled personnel, organizational capacity, and development tools in the market space result in few organizations working to implement or maintain larger-scale DW projects.
- Integration challenges: Limited or no standardized approaches to interconnection combined with the absence of accepted interconnection analysis tools increase complexity and costs, while a lack of understanding of the potential benefits of modern DW turbines limits the ability to provide auxiliary grid support services.
- Limited viable products: There are only a few turbines available at these market scales and supporting products that are applicable and available to smaller-scale developments (such as SCADA equipment, icing and other operation surveillance, and equipment that will support single-project development) are not available at costs applicable for isolated projects.
- Complicated logistics and transportation issues: Single or small-scale development of large turbine systems remains complicated, especially when being considered in the developing world markets. Packaged solutions and low-cost installation practices need to be developed. Overall, optimization of a DW project requires balancing the dynamic among cost, transportability, and on-site manufacturing.
- High life cycle costs: Although some larger DW projects can rely on state of the art wind technologies, in many cases the smaller DW systems (below a MW in size) generally rely on older technology that has not been optimized for distributed marketplaces. Life cycle

[11] Eric Lantz, Benjamin Sigrin, Michael Gleason, Robert Preus, Ian Baring-Gould. 2016. *Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects*. NREL/TP-6A20-67337. https://www.nrel.gov/docs/fy17osti/67337.pdf.

[12] Wilson, A., and J. Broehl. 2017. *Market Data: Small and Medium Turbines*. Navigant Consulting. Boulder, CO.

[13] International Energy Agency. 2010. "Energy Poverty: How to Make Modern Energy Access Universal." Available at http://www.iea.org/publications/freepublications/publication/weo-2010---special-report---how-to-make-modern-energy-access-universal.html

costs need to be further reduced to make the industry viable.

Small Wind Turbines

- Restrictive standards & certification: Although accepted by the mainstream small wind industry and generally useful, the current certification process is costly, complex, and not widely accepted. It also limits needed innovation and does not effectively keep unreliable small turbines out of the market. A structural assessment of the standards process is needed to address current market constraints.
- High technology costs/non-optimized components and systems: Small wind technology is generally not cost competitive with distributed solar; however, there are a large number of life cycle cost reduction opportunities that need assessment and implementation.
- Limited access to data (of all types): To understand and implement cost reduction and system optimization efforts, more information and operational data are needed on performance, costs, operations, and system maintenance over the life of small wind technology.
- High cost and unknown accuracy of resource assessment approaches: The very high costs and generally unknown accuracy of performance assessment approaches limit project deployment opportunities and more advanced business models, such as leasing and third-party financing.
- Limited interoperability with advanced grid and other technology: The lack of high-quality, accessible, and easy to use decision making tools for off-grid, microgrid,[14] and distribution systems limit the consideration of small wind. Additionally, the lack of controllability and security of most DW systems combined with the lack of understanding around high-contribution wind systems limit development potential.
- Lack of demonstrated and viable business models: The limited deployment of small wind systems combined with the poor understanding of DW by policymakers, specifically when compared to distributed PV, limit the number of supported business models for small wind development.
- Limited consumer confidence: Small wind continues to push against a less-than-stellar track record, a continuous influx of low-quality technology, and a continued belief that there is a lack of viable wind resource, especially when compared to distributed PV, which is seen as a "mature" technology that is universally deployable.

Common to both industries:

- Lack of clear definitions for the DW market: A lack of universally accepted definitions for terms like small wind, community wind, hybrid systems, and even DW make articulating clear messages difficult.
- Limited engagement in international markets: Although large-scale utility wind is commonly considered, DW is generally left out of wider discussions around renewable development in international markets by governments, multi-lateral donors, and development banks. PV is generally the only distributed renewable technology considered in development approaches and government policy.
- Lack of understanding of DW: There is a general lack of understanding of DW across the energy sector in most developed energy markets. Although many companies, communities, and local governments are advocating for a higher reliance on renewable energy technologies, few include DW in their development considerations, relying instead on energy efficiency, transportation, PV, and other larger-scale renewable energy technologies.

[14] In OEDC countries, the term "microgrid" typically refers to a power system that can connect and disconnect from a larger, defined grid system. An off-grid power system in this context is designed to operate independently of a larger grid, similar to what is typically called a minigrid in the energy access community.

- Complicated (high-cost) development process: The complexity and costs associated with the development of even small wind projects make it increasingly hard for small companies to support the development process.

Following the meeting, attendees determined that pursuant to following conversations, a new IEA Task focused on DW should be initiated to better develop a wider IEA Engagement Strategy. This strategy would focus initially on a few primary tasks:

- Standards/certification
- Technical data sharing in both process and practice
- Resource assessment/performance assessment
- Integration, including off-grid, microgrids, and advanced distribution networks
- Information, communication, and outreach about DW energy technologies.

Attendees also expressed that 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.
- IEA tasks that overlap with identified DW concerns but that currently limit DW technology inclusion; engagement in these tasks may allow for inclusion and expanded focus on DW challenges.
- IEA tasks outside of wind (PV, storage, etc.) that are addressing technologies or markets in which DW could or should engage.
- DW research areas in which no IEA work is being undertaken.

The consensus of the Technical Experts Meeting representatives recommended pursuing a wider DW-focused task outside of or incorporating IEA Task 27 with Austria, Belgium, Canada, China, Republic of Korea, Spain, and the USA expressing interest in participation.