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

# Task Proposal
## Forecasting for Wind Energy

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# 1 Scope

This proposal is to establish a new Task under the *IEA Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems* (IEA Wind) focused on **improving the value of wind energy forecasts to the wind industry**. There are three distinct areas of challenge in forecasting wind power. The first is in the continuing effort to improve the representation of physical processes in forecast models through both improved initialization and improved parameterizations. The second area is the representation of uncertainty, the lack of uniform benchmark criteria and the lack of benchmarks or comparison datasets. A third area is representation, communication, and use of these uncertainties to industry in forms that readily support decision-making in plant operations and electricity markets. This Task will facilitate coordination of efforts in all three of these areas and will work to define best practices for model evaluation and uncertainty communication.

This proposed Task supports central objectives of IEA Wind. The Strategic Plan recently released by the IEA Wind ExCo [1] includes four strategic objectives, two of which are directly supported by the proposed Task: "To reduce the cost of wind energy use, for both land-based and offshore wind" and "Increase the exchange of best practices." Further, two of the five priority areas to address these objectives in the Strategic Plan are "Wind Characteristics" and "Wind Integration", both of which this Task will facilitate. The IEA Wind statement of research needs for the time frame 2012–2030, also recently released [2], highlights short term forecasting, for both wind and power, as a mid-term priority. It highlights atmospheric complex flow modeling and experimentation, which supports the improvement of short-term forecasting, as a long-term (through 2030) priority. As the proposed phase II of Task 31 *Wakebench* will also work on improving the model chain for wind characterization, the division of work between the two Tasks will be with a focus on resource assessment, i.e. forecasting long-term averages, in Wakebench, and on forecasting for the next hours or weeks in this Task. As many of the datasets used in one Task can be useful in the other, we reached an agreement in principle with Wakebench on trying to share data wherever possible and necessary.

The Task we are proposing is an outgrowth of the IEA R&D Wind Task 11—Topical Expert Meeting (TEM) "Forecasting Techniques" held in April 2013 at the Federation of the Scientific and Technical Associations (FAST Center), Milan, Italy [3] and previous three Joint Action Symposiums since 2004 [4]. Following the meeting it was determined that there was substantial interest developing an IEA Task on wind power forecasting. In addition, part of the EWEA Wind Power Forecasting Workshop in December 2013 in Rotterdam [5] was dedicated on discussing the research needs for improving predictions of wind power. At that occasion participants from the U.S., France, Finland, Denmark, the U.K., and Germany launched a core group aiming at elaborating a Task proposal [5].

There are three work streams envisioned for this new IEA Task that will together address the areas of challenge noted above. The improvement of the representation of underlying physics is recognized by the IEA as being a long-term challenge, and the first work stream will focus on accelerating progress by enhancing communication and coordination among international groups working in this area. Because this is a long-term challenge, it is likely that a second three-year Task will be proposed to extend the work of this Task. The second work stream will focus on coordinating, and standardizing where possible, the various approaches to establishing and expressing errors and uncertainties for wind and power forecasts for both physical and statistical models. It will also include the provision of benchmarks for testing forecast performance on various geographic and climatic areas. The third work package will engage both research and the wind related industry to develop recommendations for representations of probabilistic forecast information that are most useful for the operational environment. It will further shed light on how to use probabilistic forecasts in wind energy.

The expected outcomes of this Task are increased efficiency of international research efforts to improve wind and power forecasting together with publications documenting best practices for assessing forecast model performance, the quantification and representation of uncertainties, and the communication and use of probabilistic information to industry.

# 2 Introduction

Forecasting the chaotic behavior of the atmosphere remains a primary challenge of the atmospheric sciences. Because atmospheric motions occur on scales ranging from 1 mm to $10^4$ km (10 orders of magnitude), it is not feasible to explicitly forecast the evolution of the atmosphere at all scales at once. Consequently, prognostic numerical models generally resolve a range of scales encompassing the phenomena of interest, and the smaller scales are parameterized. For mesoscale atmospheric models, which are not only used for general weather forecasts but also to provide short-term wind forecasts, parameterizations are used to represent processes occurring on horizontal scales less than the 1–10 km grid spacing explicitly resolved by the models. These parameterizations reflect assumptions about which physical processes are dominant on the unresolved scales and generally have constants that may be adjusted according to observations. It is thus possible to ”tune” physical models of the atmosphere to optimally reproduce a phenomenon of particular interest (such as movement of weather fronts and associated precipitation) while less optimally reproducing other phenomena (such at winds at 100 m above the surface). In addition, mesoscale models often offer multiple parameterizations for a particular process, each reflecting a different concept of which unresolved processes are dominant, which allows the modeler to choose which specific set of parameterizations to use. Finally, to create a forecast, a model must be initialized with observations, and the combination of initialization error and the highly non-linear governing equations of the models leads to additional error in the forecasts.

General challenges to modeling for wind resource characterization, including wind forecasting, have been described in numerous venues, including an international workshop sponsored by the U.S. Department of Energy (USDOE) on Research Needs for Wind Resource Characterization held in the U.S. in 2008 [6]. A subsequent USDOE workshop on Complex Flow focused more specifically on conditions of particular complexity for wind energy, such as complex terrain, low-level jets, and others [7]. This workshop identified several key knowledge gaps with respect to mesoscale modeling for complex flows. These include in particular for forecasting:

- Lack of full understanding of flow physics, including effects of stability and heterogeneous or topographically severe land surfaces, and intermittent mixing processes
- Insufficient data for validation or verification

There are several recent and planned field studies that are intended to fill some of the data gaps and thus assist in improving the physics of wind forecast models. In the U.S., the Wind Forecast Improvement Project (WFIP) [8] used enhanced observation networks to evaluate the impact of improved initializations on wind and power forecasts over a full annual cycle. A second WFIP started in early 2015 using enhanced networks of instrumentation to validate and improve the underlying physics of wind forecast models in complex terrain. The New European Wind Atlas

(NEWA) project was launched in March 2015 to develop a mesoscale to microscale model-chain validated with large field experiments in various terrain and wind climate conditions. As validation datasets become available from these experiments they will be used for international benchmarking in both IEA Task 31 and this forecasting Task. While these and other contemporary large studies provide a wealth of data with which to evaluate and improve models, the approach for doing this tends to be ad hoc with respect to each field study. These studies represent major national investments, and there is both an opportunity and a need to better structure and facilitate collaboration among international research groups in order to promote common approaches and metrics for evaluating and improving the performance of wind forecast models.

One of the conclusions of the "Forecasting Techniques" TEM [3] was that, while forecasting is a critical component of large-scale integration of wind energy into the grid, it does not have full value unless accompanied by information describing the uncertainties in the forecast. There are a variety of techniques for creating forecasts with associated uncertainties. These include generating ensembles of forecast model runs, uncertainty quantification using analog ensembles, purely statistical approaches, and various combinations of statistical and deterministic approaches. Determining the uncertainty associated with wind power forecasting is rather more involved than for wind forecasts, since wind power forecast models typically require not only the input from numerical weather prediction (NWP) models, but also local meteorological observations and supervisory control and data acquisition (SCADA) data. The TEM report noted that probabilistic information greatly increases the value of a forecast for risk management, generator scheduling, and dispatch and electrical markets.

The Complex Flow Workshop Report [7] characterized uncertainty quantification for mesoscale modeling as currently "*immature*." The Forecasting Techniques TEM [3] noted that in conjunction with the probabilistic wind power forecasts, "*the identification of standardized methodologies to evaluate forecast performance is needed.*" Evaluation of the uncertainties associated with forecasts ultimately requires data, and there is a significant opportunity for synergy with the efforts to improve fundamental physics in atmospheric models and the associated large-scale field studies. The standardization of evaluation of forecast performance will be an effective input into the design of these studies.

For both wind and power forecasts, there is general agreement that knowing the uncertainties is important. At the same time, there is no general understanding of what to do with the information or in what form it would be most useful. There is currently a spectrum of forecast uncertainty information that can be provided, ranging from simple means and standard deviations through additional statistical moments such as skewness or kurtosis, through quantile information and up to full distributions and scenarios. What is lacking are accepted guidelines and tools that allow quantitative application of that information by the user.

# 3 Objectives and Expected Results

This Task will focus on facilitating communication and collaborations among international research groups engaged in the improvement of the accuracy of forecast models and their utility to the wind industry. This Task has the following specific objectives, which may be adjusted following input from national representatives:

- To establish an active, open forum for sharing knowledge gained from field experiments and associated advances in understanding of fundamental atmospheric physics to create more accurate forecast models and associated uncertainties.
- To establish standards and frameworks for the evaluation of forecast model performance
- To identify paths to increased utility of forecast information to the wind industry
- To identify most promising areas for new research to improve the quality of forecasts

It is anticipated that outcomes from this Task could include

- Increased international collaboration and transfer of knowledge regarding improvement of forecast models for the wind industry
- A generally accepted framework for the evaluation of forecast models
- Guidelines for the evaluation of uncertainties in forecast models
- Development of a general framework for the quantitative use of forecast uncertainties by the wind industry
- Development of tools to facilitate industry use of forecasts and uncertainties
- Webinars and other outreach to inform the industry of advances in forecasting

# 4 Approach and Methodologies

The activities for this IEA Task are divided among three topical work packages (WPs). Additionally, Management of the Task is in its own work package. The four WPs are synergistic and will be executed simultaneously. All four WPs run throughout the whole Task period (M1-M36).

**WP 0: Management, coordination and dissemination** (Lead: Gregor Giebel/DTU)

A Task web site will be developed that will provide current information regarding this Task, provide a calendar of meetings and other significant activities, host downloadable documents produced under this Task, and provide links and contact information for key datasets.

Tasks:

- Task 0.1: Setting up and maintaining Task web site.
- Task 0.2: Contractual reporting
- Task 0.3: Final report

Deliverables:

- D 0.1: Website
- D 0.2 – 0.4: Annual reports
- D 0.5: Organization of biannual meetings

**WP 1: Global Coordination in Forecast Model Improvement** (Lead: Helmut Frank/DWD, Will Shaw/PNNL and Joel Cline/US.DoE)

In collaboration with Task 31 Wakebench, this WP will bring together global leaders in NWP models as applied to the wind industry to exchange information and recommendations regarding most promising areas to improve both the physics of these models and data assimilation

methods, and the influence of various data types, such as data from drones, masts, lidars and turbines in data-sparse areas, e.g. offshore for wind energy forecasting. The emphasis will be on improvements of the wind-related forecast performance of these models especially in typical rotor heights, say, 50 to 200 m above ground, i.e., in the planetary boundary layer (PBL) beyond the surface layer. In this height range the effects of changing stability, complex terrain, the influence of the surface and phenomena such as low-level jets still are only poorly modeled. Forecasting time horizons of 0-3 hours, 3-12 hours, day ahead, 2 weeks ahead, and seasonal are the relevant time scales for the power system, and will be the focus of separate investigations. This can include artificial intelligence techniques or Rapid Update Cycles.
This WP primarily facilitates communication and efficient application of resources in the global wind forecast community via a set of specific Tasks. An annual summary will be developed describing current and developing field measurement campaigns that collect data suitable for testing data assimilation techniques and model physics. Both the existence of various data sets and their conditions of access will be documented. This will also serve as one path to alert investigators to opportunities for participation in these studies. Participants will also plan Task meetings in conjunction with international conferences as well as organize special sessions at these conferences to share technical information and progress. This Task might lead to increased data sharing, hopefully also with industry-owned data, especially power data for verification or data assimilation.

Tasks:

- Task 1.1: Compile list of available data sets, especially from tall towers.
- Task 1.2: Creation of annual reports documenting and announcing field measurement programs and availability of data.
- Task 1.3: Verify and Validate the improvements through a common data set to test model results upon and discuss at IEA Task meetings
- Task 1.4: Organization of regular meetings and special sessions at international conferences on wind energy.

Deliverables:

- D 1.1: Annual summary of major field studies supportive of wind forecast improvement; list of available data
- D 1.2: Organization of meetings and special sessions at international conferences on wind energy
- D 1.3: Report on future issues for research in wind power prediction

**WP 2: Benchmarking, Predictability and Model Uncertainty** (Lead: Bri-Mathias Hodge/NREL + Pierre Pinson/DTU)

This second work package will review the state-of-the-art for error and uncertainty quantification for wind and wind power forecasting models, with a special emphasis on the underlying NWP forecasts. This activity will further engage both NWP and field measurement researchers to develop guidelines, best practices, and perhaps standards, for evaluating forecast uncertainties. For model evaluation, we would work together with Task 31 in their Model Evaluation Protocol (MEP) implemented in the WindBench platform [10]. This would include trying to use some of their collected datasets while also opening a call for additional datasets for benchmarking. Following recent activities in the organization of forecast competitions and benchmarking exercises [9], an aim here will be to build a set of benchmark cases (to be released publicly) for researchers, students and practitioners to have easy and direct possibility to benchmark their

approach vs. the existing. This will also encourage replication studies. For this to be successful, datasets should be complemented by a clear description of the experimental setup for all these cases (e.g., data description, period to use for genuine forecast verification, etc.).
Besides, of particular interest is the collection of probabilistic forecast datasets to be able to establish best practices for probabilistic forecast evaluation. There exist a number of mathematically sound proposals for the evaluation of such forecasts, but this does not appear to be accepted and considered broadly by forecasters and forecaster users. The evaluation of forecast uncertainties will also engage the international community of wind power forecasters to relate protocols for evaluating NWP uncertainties to those derived for full wind power forecast models. This can include a decomposition approach to understand how known uncertainties propagate through the modelling efforts into the power forecast, and their ultimate effects. Validation targets should include ramp events, storms, and weather windows for installation, operation and maintenance, mainly offshore.

Tasks:

- Task 2.1: Design of benchmark exercises: best practice
- Task 2.2: Standard evaluation protocol for both deterministic and probabilistic forecasts: review of existing, best practice, and critical assessment of new proposals
- Task 2.3: Uncovering uncertainty origins and development through the whole modelling chain. Parallels with the Windbench platform.
- Task 2.4: Set-up and dissemination of benchmark test cases and data sets

Deliverables:

- D 2.1: IEA Recommended Practices on Wind Power Forecast Evaluation, for both deterministic and probabilistic forecasts
- D 2.2 Forecast data and evaluation protocol implemented and used in WindBench (Task 31)
- D 2.3: Collection and release of forecast cases for benchmarking and replication studies

**WP 3: Usage of Probabilistic Forecasts and Scenarios** (Lead: George Kariniotakis/ParisTech + industry/end user)

The third WP will survey the current state of use of forecast uncertainties by the power systems sector, which will be documented in a report. It will then engage both actors of the wind industry and the research communities to identify how current and emerging capabilities to determine uncertainties can be used to address the variety of decision-support needs of the industry. Where useful, simple indicators of forecast quality will be developed. This WP will also provide outreach to users of forecasts via webinars or other means to enhance their knowledge and ability to use all available information for operations.

Tasks:

- Task 3.1: State of the art of use of forecasts uncertainties in the business practices (operation/management, planning of power systems, markets operation/participation) of actors in the power systems sector (TSOs, DSOs, ESCOs, traders etc).
- Task 3.2: State of the art and knowledge sharing from demonstration/pilot projects that deal with the use of forecasts in decision making.
- Task 3.3: Assessment of the role of short-term forecasting in decision making related to long term (multi annual) processes. In several projects, e.g. for projection of the power system evolution by 2030/2050 with high shares of renewables, it is necessary to

generate multi annual time series that simulate wind power forecast errors with hourly resolution. State of the art, benchmarking, recommended methodology.

- Task 3.4: Review of existing/proposal of best practices on how to measure/quantify the value from the use of probabilistic forecasts
- Task 3.5: Communication of wind and wind power forecasts to end-users. Review, recommendations/best practice. Is it necessary to standardise wind power forecasting products?
- Task 3.6: Set up data sets for benchmarking on the value from the use of forecasts, i.e., for trading.

Deliverables:

- D 3.1: Report on use cases for probabilistic forecasts and scenarios, including the optimal uncertainty measure and evaluation protocol
- D 3.2: Position paper regarding the use of probabilistic forecasts (based on tasks 3.1 and 3.2, addressed to higher level management)
- D 3.3: Webinars to inform users about outcomes of tasks 3.3 – 3.6

# 5 Time Schedule with Key Dates

If the ExCo accepts this proposal, the Forecasting Task will continue for a period of three years beginning in 2015. A kick-off meeting could be organised after the EWEA Technology Workshop on Wind Power Forecasting in Autumn in Brussels.

The Task may be further extended for such additional periods as may be determined by two or more Participants, acting in the Executive Committee. Extension shall thereafter only apply to those Participants who agree to the extension.

# 6 Reports, Deliverables, and Dissemination of Results

Within each Work Package a number of deliverables will be elaborated to summarize the most important results. These reports/deliverables will be composed by the Operating Agents in collaboration with the work package leaders based on inputs and reviews from the participants. The planned deliverables are listed in Table 1.

Table 1: Deliverables

| No. | Deliverable | Planned |
|---|---|---|
| D 0.1 | Website | M3 |
| D 0.2 | First annual progress report | M12 |
| D 0.3 | Second annual progress report | M24 |
| D 0.4 | Final report | M36 |
| D 0.5 | Biannual meetings | M6, M12, M18, M24, M30, M36 |
| D 1.1 | Annual summary of major field studies supportive of wind forecast improvement; list of available data | M12, M24, M36 |
| D 1.2 | Organization of meetings and special sessions at international conferences on wind energy | M6 – M36 |

| | | |
|---|---|---|
| D 1.3 | Report on Future Issues for Research in Wind Power Prediction | M30 |
| D 2.1 | IEA Recommended Practices on Wind Power Forecast Evaluation, for both deterministic and probabilistic forecasts | M36 |
| D 2.2 | Forecast data and evaluation protocol implemented and used in WindBench platform (Task 31) | M36 |
| D 2.3 | Collection and release of forecast cases for benchmarking and replication studies | M6 |
| D 3.1 | Report on use cases for probabilistic forecasts and scenarios, including the optimal uncertainty measure and evaluation protocol | M24 |
| D 3.2 | Position paper regarding the use of probabilistic forecasts | M36 |
| D 3.3 | Webinars to inform users about outcomes of tasks 3.3 – 3.6 | M24-M36 |

# 7 Methods of Review and Evaluation of the Work Progress

The following key milestones are defined for the follow-up of the progress of the project.

Table 2: Milestones

| Milestone | WP | Milestone | Planned |
|---|---|---|---|
| M 0.1 | 0 | Kick-off Meeting | M1 |
| M 0.2 | 0 | Web site operational | M3 |
| M 0.3 | 0 | First annual progress report | M12 |
| M 0.4 | 0 | Second annual progress report | M24 |
| M 0.5 | 0 | Final report | M36 |
| M 0.6 | 0 | Progress meeting #1 | M6 |
| M 0.7 | 0 | Progress meeting #2 | M12 |
| M 0.8 | 0 | Progress meeting #3 | M18 |
| M 0.9 | 0 | Progress meeting #4 | M24 |
| M 0.10 | 0 | Progress meeting #5 | M30 |
| M0.11 | 0 | Progress meeting #6 | M36 |
| M 1.1 | 1 | Annual summary of field studies #1 | M12 |
| M 1.2 | 1 | Annual summary of field studies #2 | M24 |
| M 1.3 | 1 | Annual summary of field studies #3 | M36 |
| M 2.1 | 2 | Report on IEA Recommended Practices on Wind Power Forecast Evaluation | M36 |
| M 2.2 | 2 | Benchmark exercise defined; dissemination of benchmark test cases and data sets | M6 |
| M 2.3 | 2 | Forecast data and evaluation protocol | M36 |
| M 3.1 | 3 | Report on use cases for probabilistic forecasts | M24 |
| M 3.2 | 3 | Position paper regarding the use of probabilistic forecasts | M36 |
| M 3.3 | 3 | Setup and dissemination of webinars #1 | M24 |
| M 3.4 | 3 | Setup and dissemination of webinars #2 | M36 |
| M 0.12 | 0 | Final meeting | M36 |

# 8 Obligations and Responsibilities

It is noted that the main responsibilities of the Operating Agent are given at WP0 of section 4.
All of the project partners are responsible for:

- The progress of the work in correspondence with the work program in agreement with the time schedule;
- Besides the annual progress meetings, the reporting of progress to the Operating Agent on a 3-monthly basis, mostly through teleconference meetings;
- The contributions to the project deliverables and progress reports.

# 9 Funding

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 country shall bear the costs of workshops and meetings convened in conjunction with this Task.
- 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 their annual share of the costs in accordance with a time schedule to be determined by the Participants.

The Task will be centrally managed by the Technical University of Denmark (DTU, WP0) and have three Scientific and Technical Operating Agents or WP leaders:

- DWD, to coordinate the NWP improvements in WP1,
- National Renewable Energy Laboratory of the U.S. (NREL), to coordinate the benchmark and uncertainty aspects in WP2, and
- MINES ParisTech/ARMINES (FR), to coordinate uncertainty usage aspects in WP3.

The WP leaders can share the function of WP lead with a co-lead.

The Task Operating Agent is proposed to be:
Gregor Giebel
DTU Wind Energy
Frederiksborgvej 399
4000 Roskilde
Denmark
Phone: +45 4677 5095 / Email: grgi@dtu.dk

# 10 Budget Plan

The total costs of the Operating Agents for coordination, management, reporting, and database maintenance and operation is **54 k€/yr** during a three year period, and may not exceed this level except by unanimous agreement of the Participants. The budget is shared between the Operating Agent and the WP Leads. The transfer from the Operating Agent to the WP Leads is one lump sum per year.

*Table 2. Operating Agent costs*

| | | Euro/unit | Euro/year |
|---|---|---|---|
| Meetings, coordination work | 2 PM | 16.000 | 32.000 |
| Reporting | 0,5 PM | 16.000 | 8.000 |
| Travel costs | 2 meetings + ExCo (OA only) | 2000 | 10.000 |
| Other costs | Meetings, telcos, publications, website | | 4.000 |
| **TOTAL** | | | **54.000** |

Assuming 9 countries sign up, this would mean an annual participation fee of 6000€/year. At 12 signatories, this would drop to 4.500€/year.

# 11 Management of Task

We envisage biannual meetings in connection with the two major workshops in the field, the US Utility Variable generation Interest Group (UVIG) Forecasting Workshops (typically in February or March) and the EWEA Technology Workshop on Wind Power Forecasting, every other year in autumn in Europe. In between, an online meeting would keep track of the progress. Also for the actual meeting, an online meeting facility should be enabled. In the years where there is no EWEA Forecasting Workshop, an alternative meeting point could be the Wind Integration Workshop also usually held in October or the EWEA Annual Event.

The main form of communication in the group will be via email, and via personal contacts during various conferences including the biannual meetings.

The US government has already funded setting up and participation in the Task, so the US participants do not require separate funding from the Operating Agent budget.

# 12 Organisation

The Task will be centrally managed by DTU as a single point of contact with the IEA Wind ExCo. However, Joel Cline of the US Department of Energy will be internally acting as Co-Lead of the Task. The WPs will be scientifically managed by the WP leads.

Gregor Giebel - Danish Technical University (DTU) – Operating Agent
Joel Cline – Department of Energy Co-Operating Agent
Helmut Frank – DWD, WP1 Lead
Will Shaw – Pacific Northwest National Laboratory, WP1 Co-Lead
Bri-Mathias Hodge – National Renewable Energy Laboratory, WP2 Lead
Pierre Pinson – DTU, WP2 Co-Lead
George Kariniotakis – MINES ParisTech/ARMINES (Centre PERSEE), WP3 Lead

Already known members of the working group are (national financing permitting):
Caroline Draxl – National Renewable Energy Laboratory
Lueder Von Bremen – ForWind-Centre for Wind Energy Research
Hannele Holttinen – VTT
Clive Wilson – UK Met Office
Idar Barstad – met.no

# 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 programmes, 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 endeavour 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 licences. 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 Countries and Organisations with declared interest or to be approached for Participating in Task __**

| Country | Institution(s) |
|---|---|
| Australia | CSIRO |
| Canada | IREQ / Hydro Quebec |
| Denmark | Technical University of Denmark, ENFOR, ConWX, WEPROG, Vattenfall, DONG Energy |
| Finland | VTT |
| France | MINES ParisTech / ARMINES, RTE, EDF |
| Germany | ForWind-Centre for Wind Energy Research, Deutscher Wetterdienst, Fraunhofer IWES |
| Norway | Norwegian Meteorological Institute, Kjeller Vindtekknik |
| Portugal | INEGI, University of Porto |
| Spain | Vortex, REE, CENER, Ciemat |
| United Kingdom | United Kingdom Meteorological Office, DNV GL |
| USA | Department of Energy, NCAR, DoE National Laboratories such as NREL |

# 15 References

[1] IEA Wind 2013. “End-of-Term Report 2009–2013 and Strategic Plan 2014–2019,”57 pp.

[2] IEA Wind 2013. “Long-Term Research and Development Needs for Wind Energy for the Time Frame 2012 to 2030,” 34 pp.

[3] IEA Wind 2013. “Forecasting Techniques”, Report: IEA R&D Wind Task 11—Topical Expert Meeting.

[4] First joint action symposium on wind forecasting techniques. Norrköping: International Energy Agency (IEA), 2002; Second joint action symposium on wind forecasting techniques. Lyngby: International Energy Agency (IEA), 2004; IEA/POW'WOW Workshop on Optimal Use of Information in Short-Term Forecasting, September 11/12, 2008 in Madrid

[5] EWEA Technology Workshop: Wind Power Forecasting - From R&D to commercial offering – a 360° view of present and future. Rotterdam (NL), 3/4 December 2013. http://www.ewea.org/events/workshops/past-workshops/wind-power-forecasting/

[6] Schreck, S, J. Lundquist, and W. Shaw, 2008: U.S. Department of Energy Workshop Report—Research needs for wind resource characterization. NREL Rep. TP-500-43521, 116 pp.

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