

Games and other news from IEA Wind Task 36

Forecasting for Wind Energy

Gregor Giebel, DTU Wind Energy

W. Shaw, H. Frank, C. Möhrlein, C. Draxl, J. Zack, P. Pinson, G. Kariniotakis, R. Bessa

Wind Integration Workshop, Berlin 2021



Topics

- Overview of IEA Wind,
- ...and Task 36 Forecasting
- Gamification of probabilistic forecasts
- The next phase



International Energy Agency History

The IEA was founded in 1974 to help countries co-ordinate a collective response to major disruptions in the supply of oil.



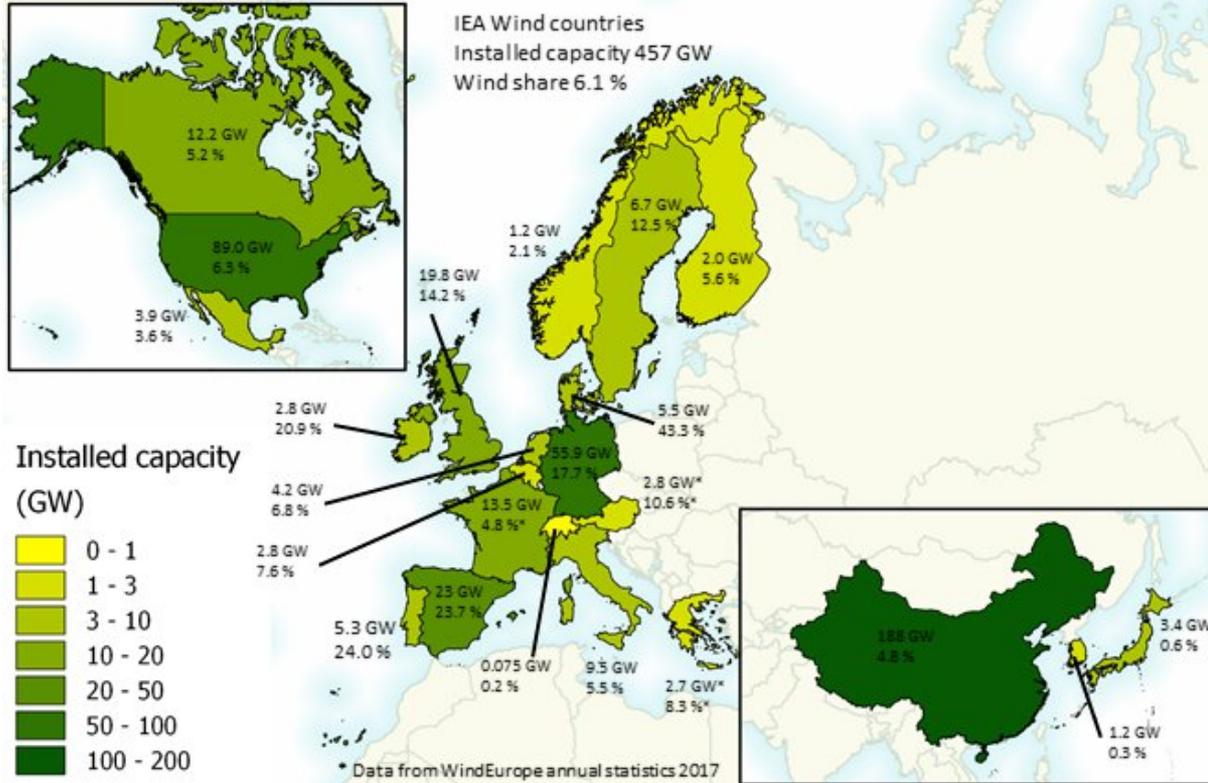
Image source: dpa

- *Specific Technology Collaboration Programs (in renewable energy):*
- Bioenergy TCP
- Concentrated Solar Power (SolarPACES TCP)
- Geothermal TCP
- Hydrogen TCP
- Hydropower TCP
- Ocean Energy Systems (OES TCP)
- Photovoltaic Power Systems (PVPS TCP)
- Solar Heating and Cooling (SHC TCP)
- Wind Energy Systems (Wind TCP)

See iea.org!

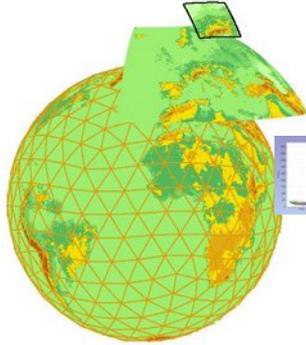


iea wind

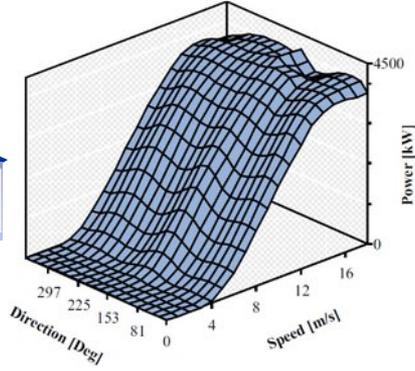


- Task 36 members:
- AT, CN, DE, DK, ES, FI, FR, IE, IT, UK, US

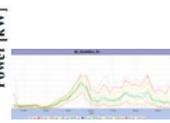




Numerical Weather Prediction



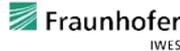
Prediction model



End user



Australian Government
Bureau of Meteorology



**TECHNICAL
REPORT**

Renewable energy power forecasting technology

IEC TR 63043 ED1: Renewable Energy Power Forecasting Technology

For a good, comprehensive and recent (Nov 2020) text on the state of the art in forecasting, please see this Technical Report from IEC Sub-Committee 8A Grid Integration of Renewable Energy Generation, Working Group 2 Renewable energy power prediction.

<https://webstore.iec.ch/publication/26529>



Information Portal

The Task 36 Information Portal aims to be a useful resource for people in forecasting, especially providing links to publically available data for model development.

<https://iea-wind.org/task-36/t36-information-portal/>

The Task members identified several issues which might be useful in an information portal for wind power forecasting. Those are:

- [A list of meteorology masts](#) with online data over 100m height, useful for verification of wind speed predictions
- [A list of meteorological experiments](#) going on currently or recently, either to participate or to verify a flow model against
- [A list of publicly available wind power forecasting benchmarks](#), to test your model against
- [A list of current or finished research projects](#) in the field of wind power forecasting
- [A list of future research issues](#)
- [A list of open weather data](#)

For all of those, we would be happy to accept input, so head over to the site and see where you can help, or what you can use!

Please find the full text of the task description [here](#).

The task is led by [Gregor Giebel](#) from DTU Wind Energy.

NWP Benchmark cases

Started:
June
2021

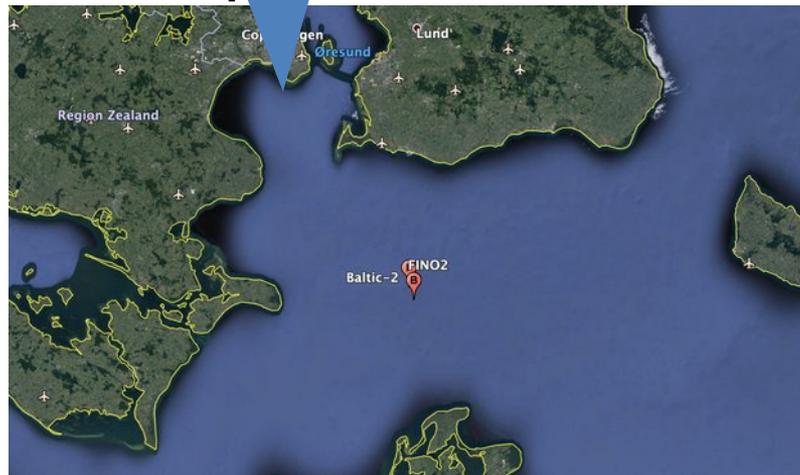
U.S. case



- 1 day in September 2016
- mountain waves observed
- observations and model meteorological data available, at 10/5 min resolution
- well documented in the literature, a wealth of information available about the region
- wind farms in the area (but data under an NDA)

Slide from Caroline Draxl, NREL – please contact IEA.Forecasting.Benchmark@groups.nrel.gov for participation

European case



- 1 week in October 2020
- power output available every 15 min, with 100% turbine availability
- corrected nacelle wind measurements averaged over the farm every 15 min
- FINO2 is about 4 km NW of Baltic-2

Forecast games to motivate probabilistic forecasting

- Probabilistic renewable power forecasts existed since ~2005
- Some superficial interest from end users, but little adoption
- Now: trying to "gameify" the interest, and make the difference between deterministic forecasts and probabilistic clearer
- Collaboration with Nadine Fleischhut, researcher in decision making under uncertainty and communication of uncertainty at Max Planck Institute for Human Development

WP3 Forecast Games and Experiments:

Game 1: Offshore wind power decision making in extreme events

Conducted by Dr. Corinna Möhrten, WEPROG in collaboration with Dr. Nadine Fleischhut, MPI for Human Development, Berlin

3 Postulates formed the basis for the experiment design:

- (1) Success in the trading is highly dependent on the costs of the balancing power needed due to forecast errors
- (2) 5% of the cases, where there are large forecast errors are responsible for 95% of the costs in a month or year
- (3) Reducing these costs is more important than improving the general forecasts by $\sim 1\%$

The Experiment:

Decide in 12 cases whether to trade 50% or 100% of the generating power of an offshore wind park according to an available forecast given the possibility of a high-speed shutdown, where the wind park stops generating due to excessive wind conditions.

Definition of a "high-speed shutdown" (HSSD) or "cut-off wind" event :

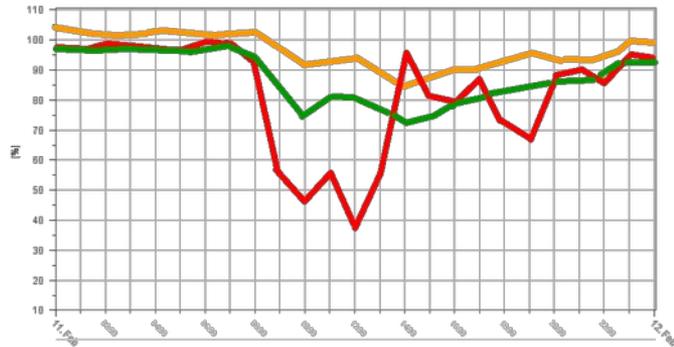
A high-speed shutdown event occurs typically in the wind range above 21-27m/s, mostly known as the cut-off wind threshold of 25 m/s. Note that wind turbines use both wind gusts and the mean wind to determine, whether or not they turn into high-speed shutdown (HSSD).

Forecast Game 1:

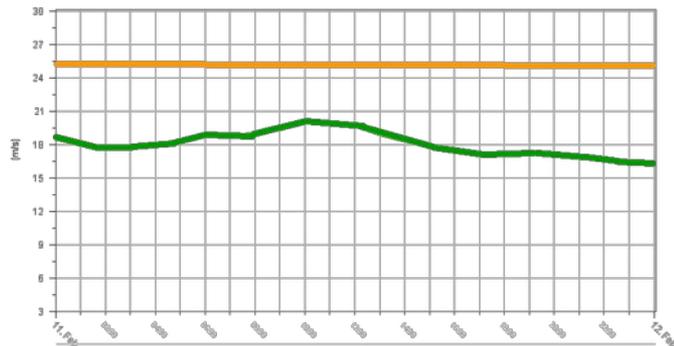
Offshore wind power decision making in extreme events

Type of forecasts used in the experiment:

In the experiment are deterministic and probabilistic forecasts for the **day-ahead horizon**. All forecasts are generated with input from NWP (numerical weather prediction) forecasts from the 00UTC cycle the day before.

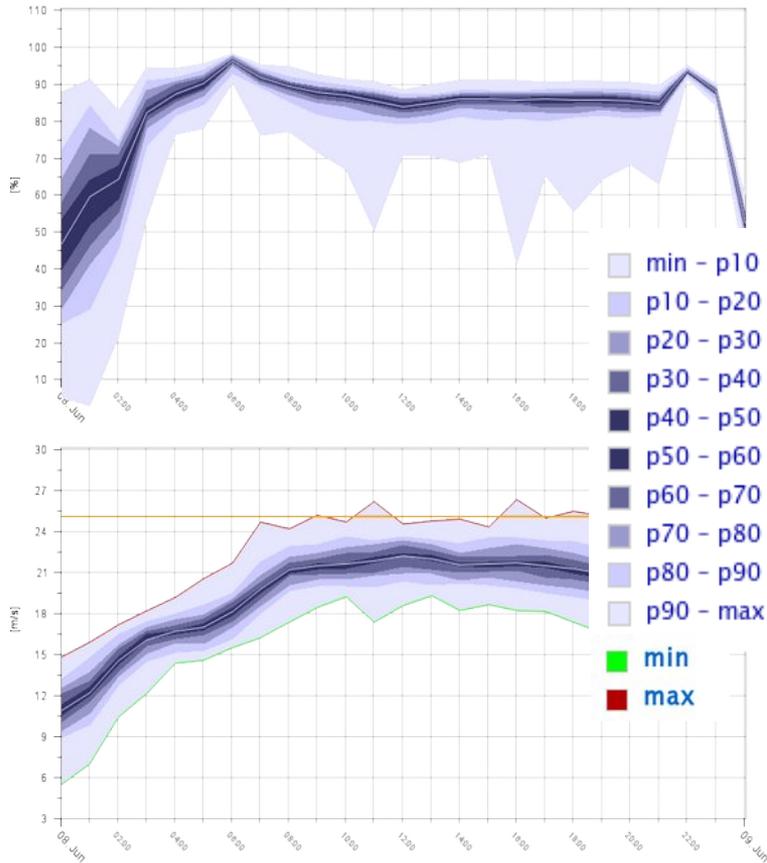


3 independent deterministic wind power forecasts in the unit [% of installed capacity] based on 3 different NWP (numerical weather prediction) models



1 wind speed forecast in the unit [m/s], which is a mean forecast from 75 ensemble members and smoother than a typical deterministic forecast. **Additionally, you see a reference line for the 25m/s threshold reference value** for high-speed shutdown or also sometimes called cut-off wind speed threshold.

Forecast Game 1: Offshore wind power decision making in extreme events



9 wind power percentiles (P10..P90) and a mean (white line) in the unit [% of installed capacity] generated from 75 NWP forecasts of a multi-scheme ensemble prediction system.

9 wind speed percentiles P10..P90 and a mean (white line) in the unit [% of installed capacity] generated from 75 NWP forecasts of a multi-scheme ensemble prediction system.

Note: The percentiles here are physically based uncertainty bands and provide an overview of the uncertainty of the forecast.

Definition: A percentile indicates the value below which a given percentage of forecasts from the 75 available forecasts falls. E.g., the 20th percentile is the value below which 20% of the forecasts are found.

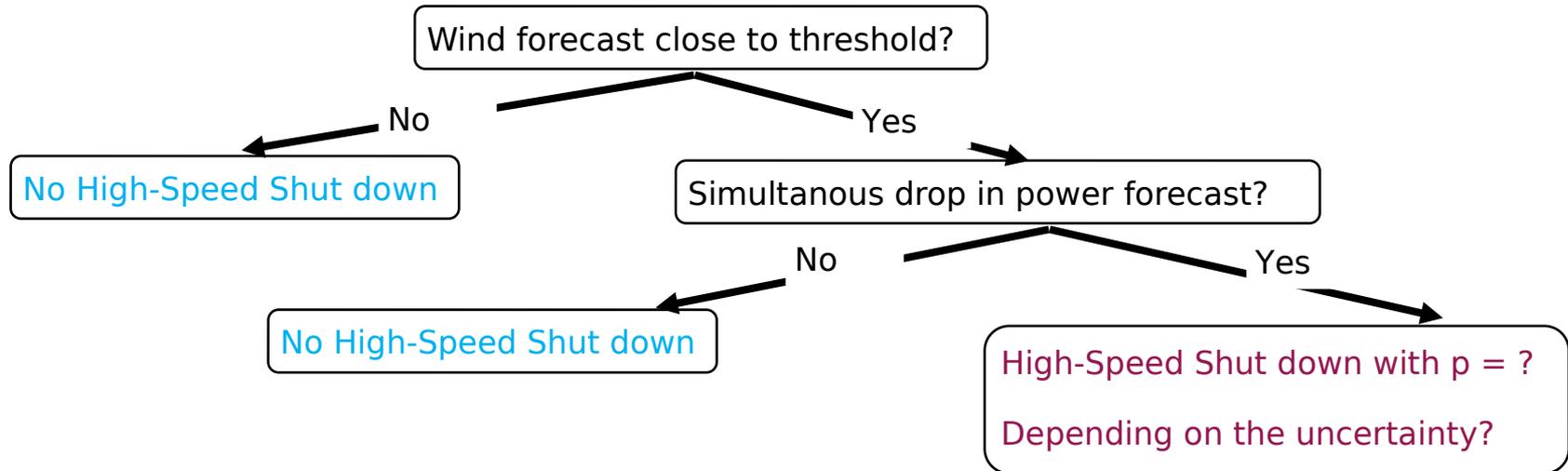
Heuristic Decision strategies



task 36

Which cues (“predictors”) do people use and why?

Simple heuristic decision tree?



“Probabilistic Forecasting Games & Experiments” initiative:



task 36

Decision-making in extreme events

1. Experiment (2020)

Game: Decisions were made with deterministic forecast and could be reverted after seeing the probabilistic forecast

- whether or not a high-speed cut-off takes place within the forecast time in 12 cases
- whether to trade 50% or 100% of the generating power of an offshore wind park

Decision Tools:

- 3 independent deterministic forecasts showing the wind power & wind speed
- probabilistic forecast showing wind power and wind speed inclusive uncertainty bands

2. Experiment (2021)

Game: decisions are made first with deterministic and then with probabilistic forecasts

- 2 x times 20 cases (20 deterministic and 20 probabilistic cases)
- the participants make decisions based on either deterministic or probabilistic forecasts
- request on participant's confidence level regarding their decision
- real-time environment, e.g. participants may be surprised by forecasts that fail to warn or over-predict

Decision Tools:

Same as in 2020

Forecast Game 1: Offshore wind power decision making in extreme events

The cost profile

To reflect the costs of large and small errors we have defined a simplified cost function for the period, where high-speed shutdown (HSSD) can take place.

Definitions:

- the wind farm is 100MW and the spot market price is 50 Eur/Mwh.
- balance costs are equivalent to spot market prices
- The cost function will only consider your choice for the hours, where the actual generation is full load or no generation

Trading	HSSD*	No HSSD*
100%	-5.000	5.000
50%	0	2.500

* High-Speed Shutdown == cut-off winds

Note that trading **100% is a risky choice** that can both increase your income and loss. The more conservative **50% trading strategy eliminates the risk of a loss**, because **balance costs are equal to spot market prices** and **you can curtail the wind farm to avoid balance costs**.

Forecast Game: Offshore wind power decision making in extreme events

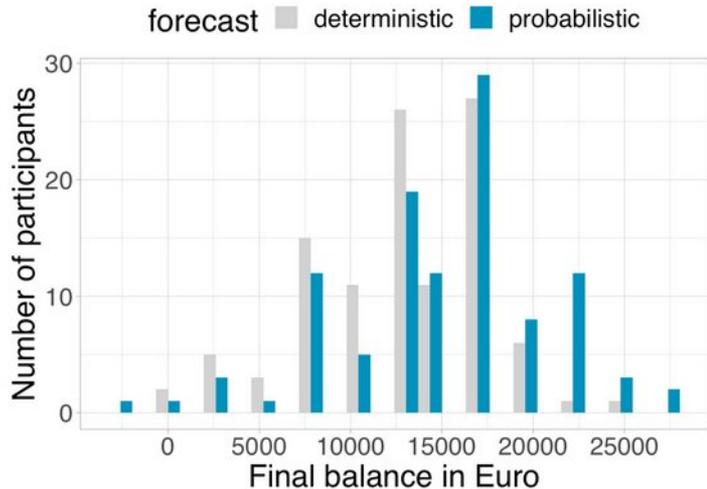
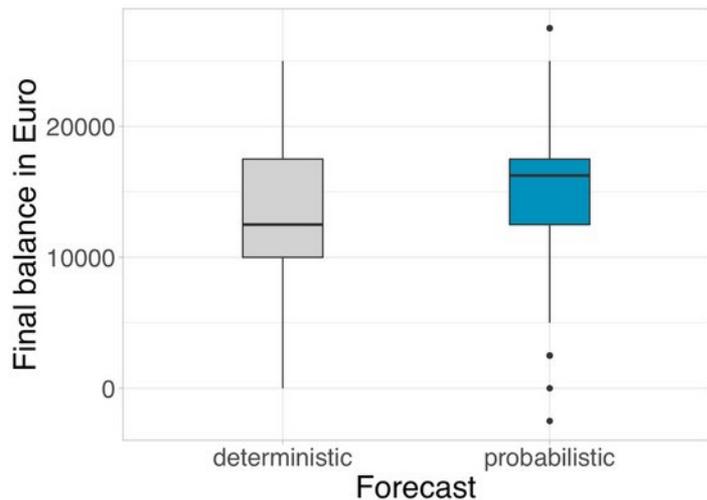
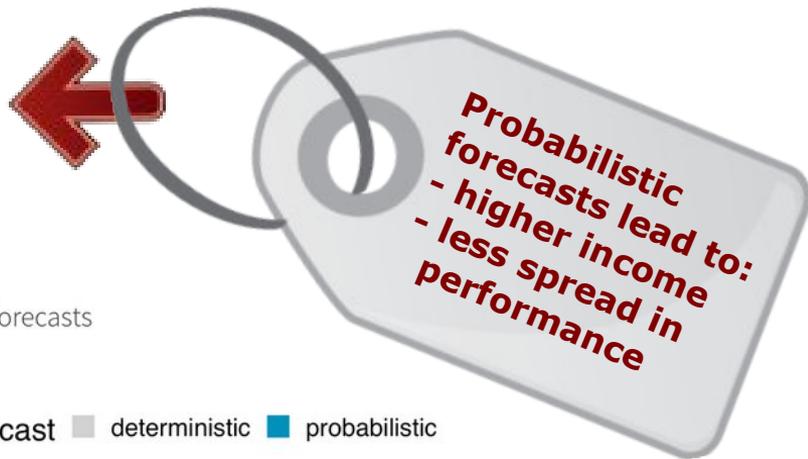
ANALYSIS – final balance -

108 participants:

Best score deterministic: 25.000 EUR

Best score probabilistic: 27.500 EUR

Histogram of participants' final balance based on deterministic vs. probabilistic forecasts



2nd Experiment Design (2021)

Value of probabilistic power forecasts

task 36

Wind Power Trading: What is the value of probabilistic forecasts for decision making?

How well can you use probabilistic or deterministic forecasts for simple trading decisions?

Find out by participating in a short decision experiment (ca. 20-30 minutes).



The study is a cooperation of the [IEA Task 36 WP3](#) and project [WEXICOM](#) at the Max Planck Institute for Human Development.

Start

2nd Experiment Design (2021)

Value of probabilistic power forecasts

task 36

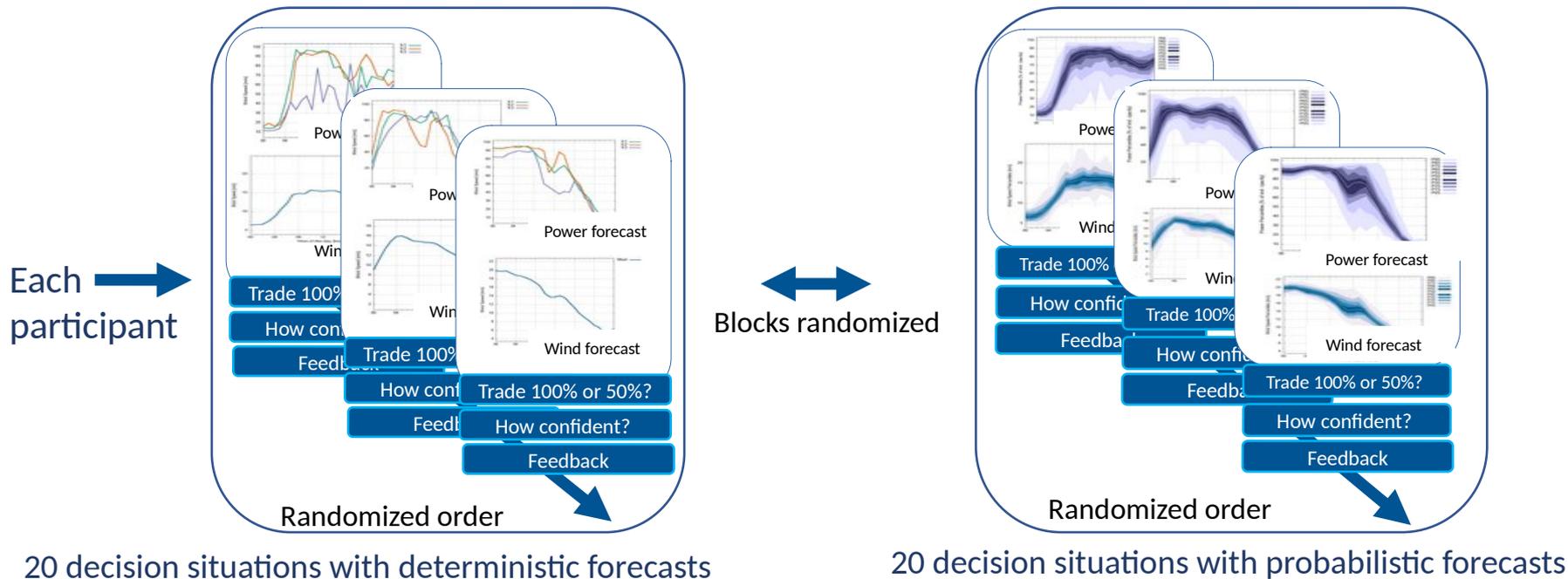
How do professionals decide based on probabilistic wind & power forecasts?

Design & Analysis: Dr. Nadine Fleischhut*, Dr. Corinna Möhrlen**

Host of Experiment: *Max-Planck Institute for Human Development, Hans-Ertel Center for Weather Research, Germany

Ensemble Forecasts: **MSEPS 75 Member EPS of WEPROG

Trade 100% or only 50% wind energy - given the risk of high-speed shutdown?



20 decision situations with deterministic forecasts

20 decision situations with probabilistic forecasts

2nd Experiment Design (2021)

Value of probabilistic power forecasts

task 36

Your task as participant:

- Decide in 20 cases whether to trade 50% or 100% of the generated power of a wind park in a **high wind speed area in complex terrain**
- In **each case there is the possibility of a high-speed shutdown**, meaning the wind park stops generating due to excessive wind conditions
- Make your decisions based on available forecasts

Definition of a “high-speed shutdown” (HSSD) or “cut-off wind” event:

A high-speed shutdown event at this wind park occurs typically in the hourly averaged wind range of 18-30m/s. Note that wind turbines use both wind gusts at time horizons of seconds and the mean wind speed over minutes and hours to determine whether or not to turn into high-speed shutdown (HSSD).

Setup Summary of the experiment:

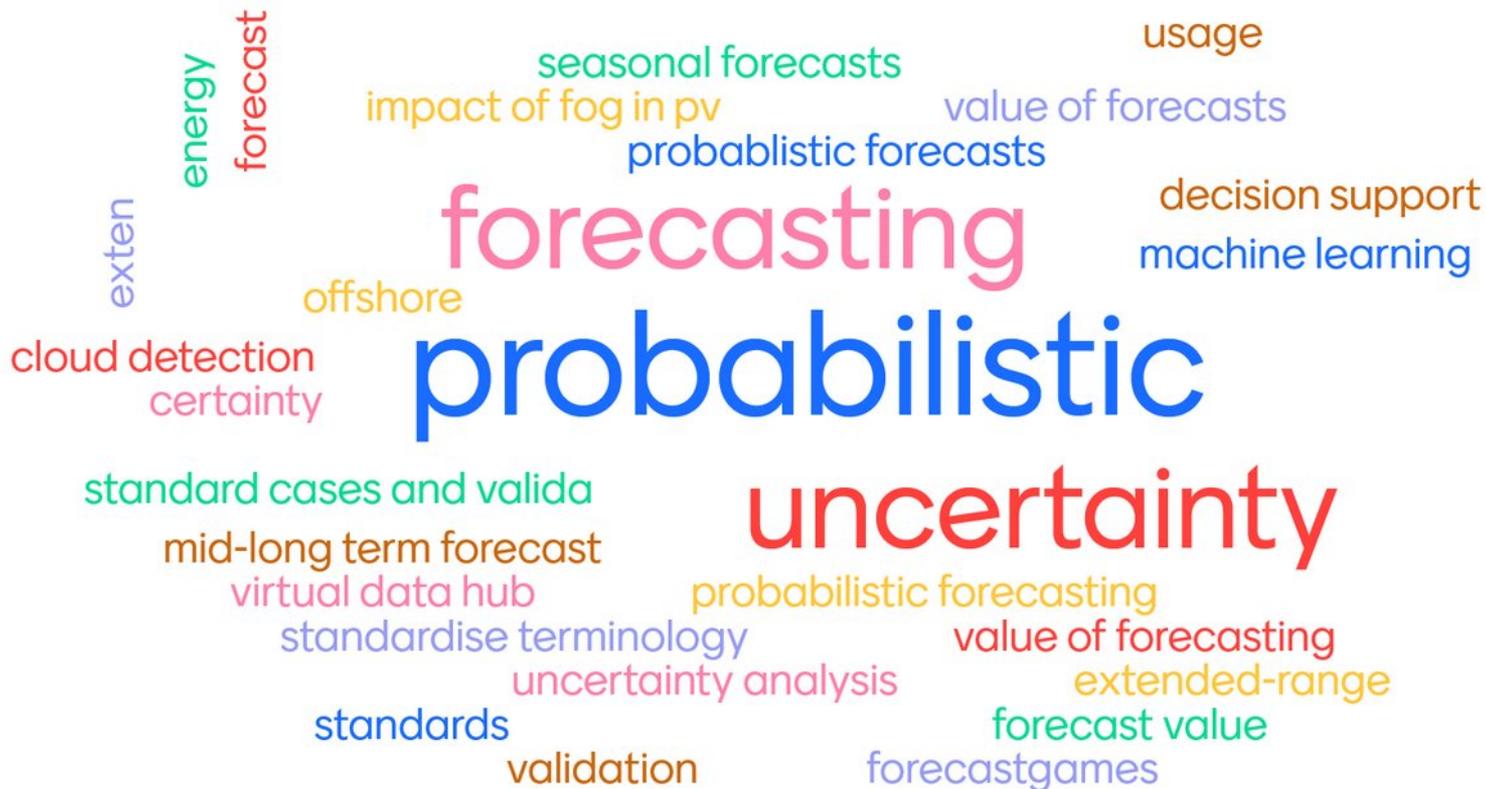
- 1) Every participant makes all decisions based on deterministic as well as on probabilistic ensemble forecasts. For each forecast type, the situations are presented in blocks randomized among each other.
- 2) For every participant, the order of blocks is randomly chosen at the beginning.
- 3) For each decision the participants have to indicate how confident they were with the decision in a scale from 50% to 100%.
- 4) After each set of decisions, the participants are asked to describe the strategy and cues they have used in their decision-making.
- 5) A unique ID allows participants to play multiple times with different nick names in order to try out different decision strategies.

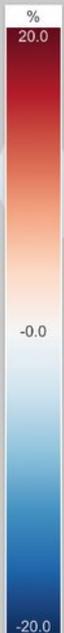
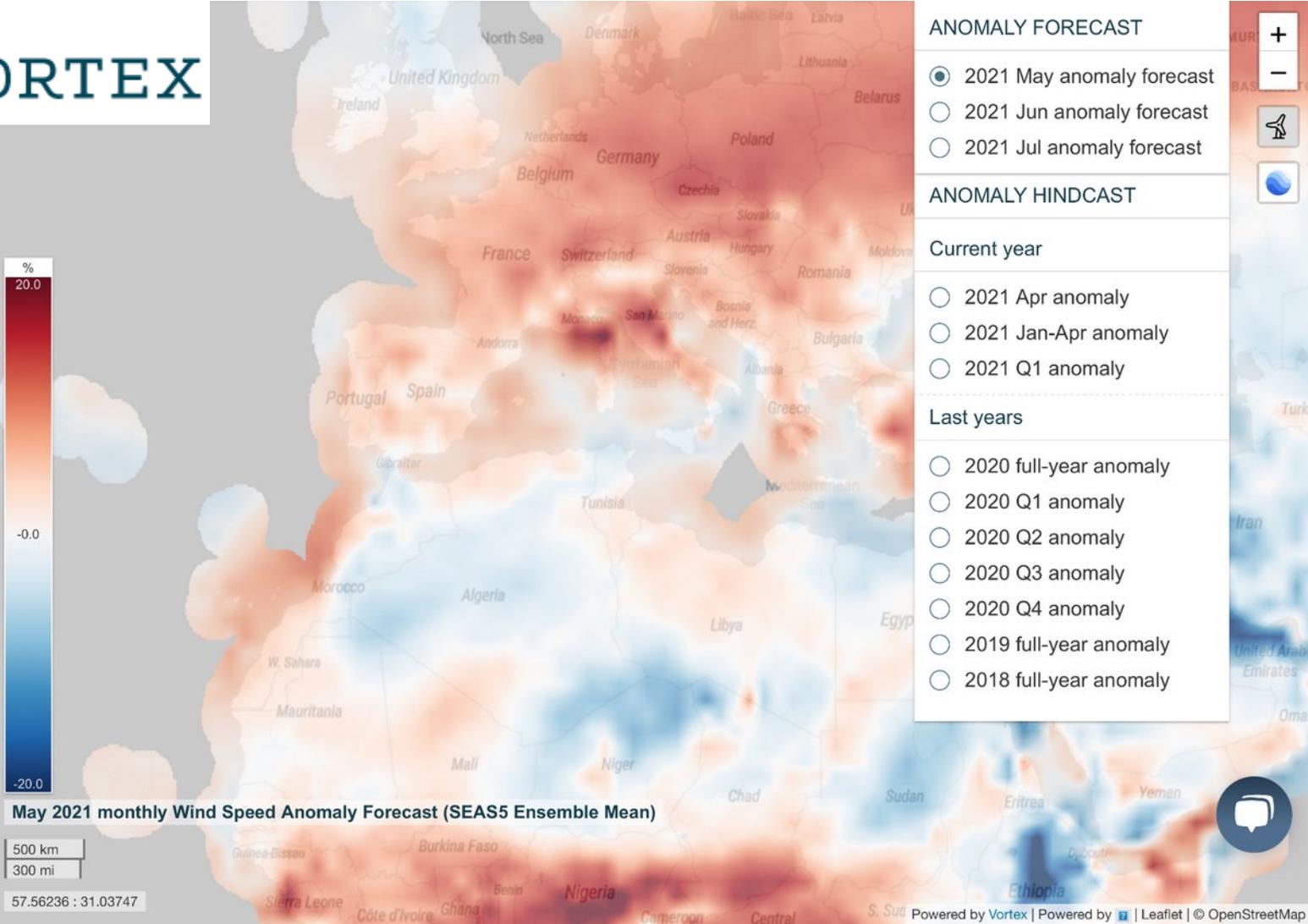
Next: Forecasting for the Weather Driven Energy System

Preparations for the next phase of forecasting collaboration are ongoing. A recent Task meeting yielded this word cloud.

Strong collaboration with other TCPs.

To start 2022.





May 2021 monthly Wind Speed Anomaly Forecast (SEAS5 Ensemble Mean)

500 km
300 mi

57.56236 : 31.03747

ANOMALY FORECAST

- 2021 May anomaly forecast
- 2021 Jun anomaly forecast
- 2021 Jul anomaly forecast

ANOMALY HINDCAST

Current year

- 2021 Apr anomaly
- 2021 Jan-Apr anomaly
- 2021 Q1 anomaly

Last years

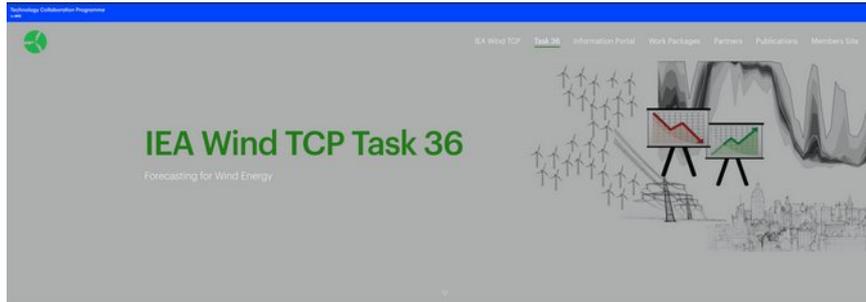
- 2020 full-year anomaly
- 2020 Q1 anomaly
- 2020 Q2 anomaly
- 2020 Q3 anomaly
- 2020 Q4 anomaly
- 2019 full-year anomaly
- 2018 full-year anomaly



Task 36 Web Presence

Website

www.iea-wind.org/task-36



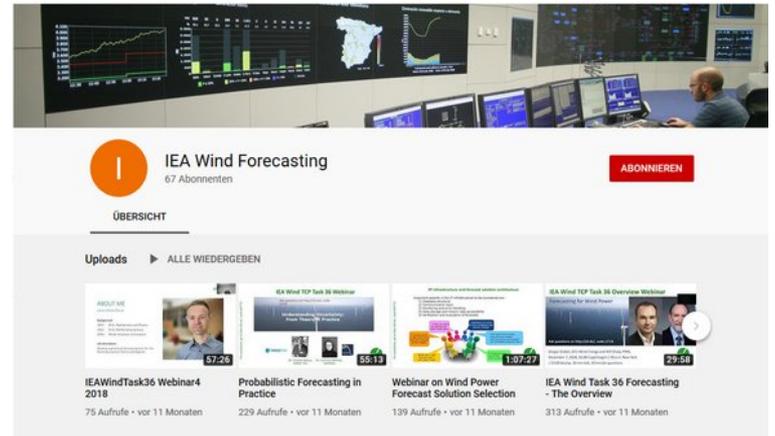
About Task 36

Improving the value of wind energy forecasts to the wind industry

EDIT PAGE

 YouTube Channel

<https://www.youtube.com/channel/UCsP1rLoutSXP0ECZKicczXg>



Handouts

- 2-page handouts: quick overview of major results
- 3 currently available; can be obtained from:

<http://www.ieawindforecasting.dk/publications/posters-og-handouts>

IEA Wind Task 36
Forecasting for Wind Power

FORECASTING FOR YOU

Setup

Wind power forecasts have been used operationally for over 25 years. Despite this fact, there are still several possibilities to improve the forecasts, both from the weather prediction side and from the usage of the forecasts.

The IEA Wind Task is divided in three work packages. Firstly, a collaboration on the improvement of the scientific basis for the **wind predictions** themselves. This includes numerical weather prediction model physics, but also, widely distributed information on accessible datasets. Secondly, we deal with the **conversion to power** and losses affecting the forecast vendors. Thirdly, we will be engaging real users aiming at dissemination of the best practice in the usage of wind power predictions.

The Task is currently in its second phase, 2020-2023.

Results of phase I (2016-2018)

We developed an **information portal**, with links to data, projects and knowledge useful for wind power forecasting. This could be a list of all assets useful for online validation of WPP models, a list of field campaigns with open data for model verification, or a selection of benchmarks for forecasts with established data sources and existing reference frameworks.

A major result was the IEA Wind Recommended Practice (RP) on **Forecast Solution Selection**, detailing out the necessary steps to get the best adapted forecasts for the individual use case. The RP starts with the initial deliberations which might or might not end up with the decision to also a forecast trial. The second document details how to conduct such a trial in order to yield accurate and usable results for both the end user and the participating vendor. The last part shows how to evaluate the trial to get 13 representative, 21 representative and 33 reliable results.

For **probabilistic forecasts**, we published two papers with an overview (for a broader reader) and one with a long list of specific use cases (more technically oriented). We also classified methods for uncertainty forecasting, and tried to establish a common vocabulary. We also mapped the current use of probabilistic forecasts through a questionnaire.

iea wind

www.ieawindforecasting.dk

Task 36
Overview

Impact

The Task sends out news a few times a year, is present on conferences and meetings, and has its own YouTube channel. There, alongside video transmissions of the public sessions, we also had a **webinars** of full an hour talks plus audience questions on the major results of phase I. The fourth one was an additional one for forecast use in Denmark.

The Task members also try to get an **enhance collaboration** between weather prediction providers and vendors, and between vendors and end users. One activity for the current phase of the Task (2020-2023) is a look into **standardization** of data, to make data exchange more fluent across the industry. Another activity is to estimate the **value of better forecasting**.

We also collaborate with other Wind Tasks, e.g. in the common workshop on minute scale forecasting we had together with Task 32 later. In the future, we will also collaborate with IEA PV Task 15 Solar resources, which also deals with forecasting and has some of the same issues.

Collaboration

Currently, some 750 people from 12 countries are collaborating on forecasts. There are meetings every half year, often in combination with relevant conferences. We also have special sessions at conferences for outreach, and usually an overview poster. If you are interested to collaborate, or just to be informed about new results, please contact George Gøbel.

Solution

The chosen forecast 3 month of the IEA Wind Task 36 has been solving out a number of the lower end of integration and applicable hours and forecast steps to a variety of scenarios and published recommendations and use cases of a number of customer papers, observations and a number of workshop and webinars are available through the main website.

Additionally, a peer reviewed journal publication was published in January 2020 to the Open Access Journal for Energy Forecasting. This was a 300 page book containing 16 refereed articles. This was a 300 page book containing 16 refereed articles. This was a 300 page book containing 16 refereed articles.

iea wind

www.ieawindforecasting.dk

IEA Wind Task 36
Forecasting for Wind Power

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Challenge

The selection of vendors to rely on for weather dependent power forecasts is a complex task. It involves a number of factors that are not always obvious to the end user. This document provides a structured approach to the selection process, covering the key aspects of the selection process, from the initial selection of vendors to the final selection of a solution.

Forecast Solution Selection

The process of selecting a forecast solution involves a number of steps. It starts with the identification of the user's requirements, followed by the selection of potential vendors. The next step is to evaluate the vendors' performance, which involves comparing their forecasts against historical data. Finally, the user selects the best solution based on the evaluation results.

Challenge

Understanding the benefits and the pitfalls when employing probabilistic forecasts requires recognition that a stochastic forecast, practical and indispensable for power generation and use systems.

Challenge

Understanding the benefits and the pitfalls when employing probabilistic forecasts requires recognition that a stochastic forecast, practical and indispensable for power generation and use systems.

iea wind

www.ieawindforecasting.dk

IEA Wind Task 36
Forecasting for Wind Power

Understanding Uncertainty: the difficult transition from a deterministic to a probabilistic world

Challenge

Understanding the benefits and the pitfalls when employing probabilistic forecasts requires recognition that a stochastic forecast, practical and indispensable for power generation and use systems.

Solution

The chosen forecast 3 month of the IEA Wind Task 36 has been solving out a number of the lower end of integration and applicable hours and forecast steps to a variety of scenarios and published recommendations and use cases of a number of customer papers, observations and a number of workshop and webinars are available through the main website.

iea wind

www.ieawindforecasting.dk

Forecast Solution
Selection

Forecast Solution Selection

The process of selecting a forecast solution involves a number of steps. It starts with the identification of the user's requirements, followed by the selection of potential vendors. The next step is to evaluate the vendors' performance, which involves comparing their forecasts against historical data. Finally, the user selects the best solution based on the evaluation results.

Benchmarks and Trials

The process of selecting a forecast solution involves a number of steps. It starts with the identification of the user's requirements, followed by the selection of potential vendors. The next step is to evaluate the vendors' performance, which involves comparing their forecasts against historical data. Finally, the user selects the best solution based on the evaluation results.

Where to get the guidelines

The guidelines for selecting a forecast solution are available in the IEA Wind Task 36 handbook. They provide a structured approach to the selection process, covering the key aspects of the selection process, from the initial selection of vendors to the final selection of a solution.

iea wind

www.ieawindforecasting.dk

Uncertainty and
Probabilistic
Forecasting

Understanding Uncertainty: the difficult transition from a deterministic to a probabilistic world

Challenge

Understanding the benefits and the pitfalls when employing probabilistic forecasts requires recognition that a stochastic forecast, practical and indispensable for power generation and use systems.

Solution

The chosen forecast 3 month of the IEA Wind Task 36 has been solving out a number of the lower end of integration and applicable hours and forecast steps to a variety of scenarios and published recommendations and use cases of a number of customer papers, observations and a number of workshop and webinars are available through the main website.

iea wind

www.ieawindforecasting.dk

www.IEAWindForecasting.dk

For more detailed information, see also the Annex of last year's presentation at EGU :
<https://meetingorganizer.copernicus.org/EGU2020/EGU2020-14253.html>



Gregor Giebel

Frederiksborgvej 399, 4000 Roskilde, DK

grgi@dtu.dk

Will Shaw, PNNL,

Richland (WA), USA

will.shaw@pnnl.gov



<https://arc-vlab.mpib-berlin.mpg.de/wind-power/experiment/>

The IEA Wind TCP agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.