Games and other news from IEA Wind Task 36 Forecasting for Wind Energy

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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.

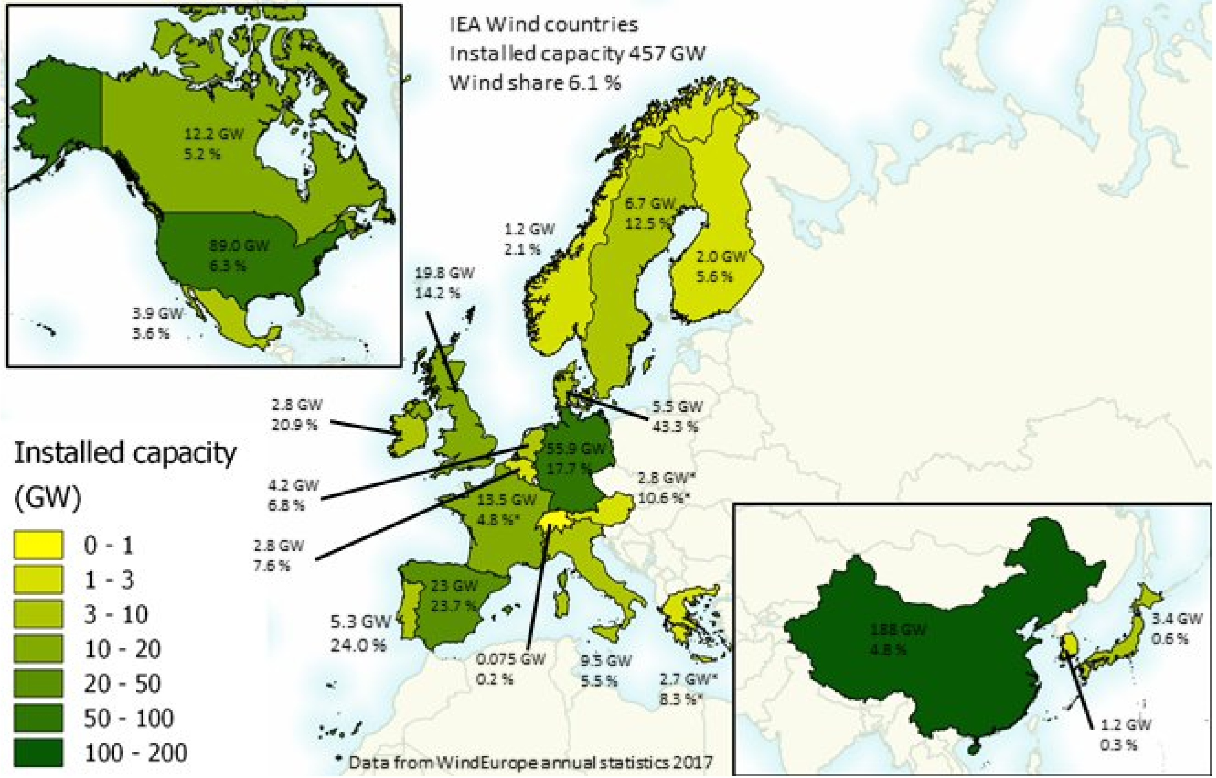
Image source: dpa

- *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)

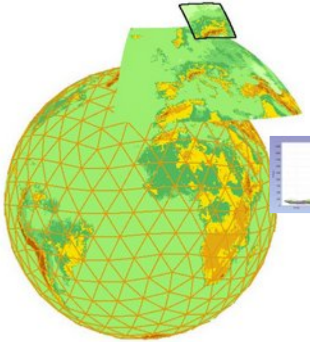
See iea.org!

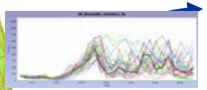
iea Energy Technology Network

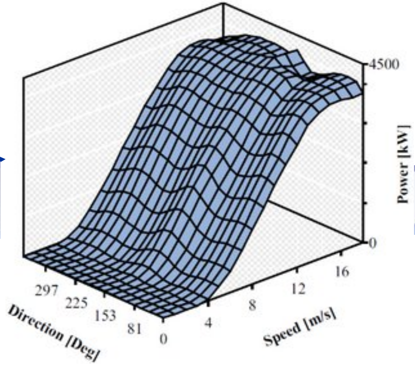
iea wind



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







Numerical Weather Prediction

Prediction model

End user

DWD
NOAA
National Weather Service
DMI
ECMWF
METEO FRANCE
China Meteorological Administration
Met Office
Australian Government Bureau of Meteorology

ENFOR Forecasting and Optimization for the Energy Sector
DNV·GL
energy & meteo systems
WEPROG
ConWX
Fraunhofer IWES
EWC
meteo*swift
NCAR
VAISALA
4cast

50hertz
ISO new england
ENGIE Green
ercot
amprion
nationalgrid
CNR
California ISO
VATTENFALL
TenneT Taking power further
e.on
ENERGINET.DK
Statoil
AEMO

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.

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


IEC TR 63043

Edition 1.0 2020-11

TECHNICAL REPORT

colour inside

Renewable energy power forecasting technology

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.020

ISBN 978-2-8322-9079-8

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/

Technology Collaboration Programme
by iea

IEA Wind TCP | Task 36 | Information Portal | Work Packages | Partners | Publications

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.

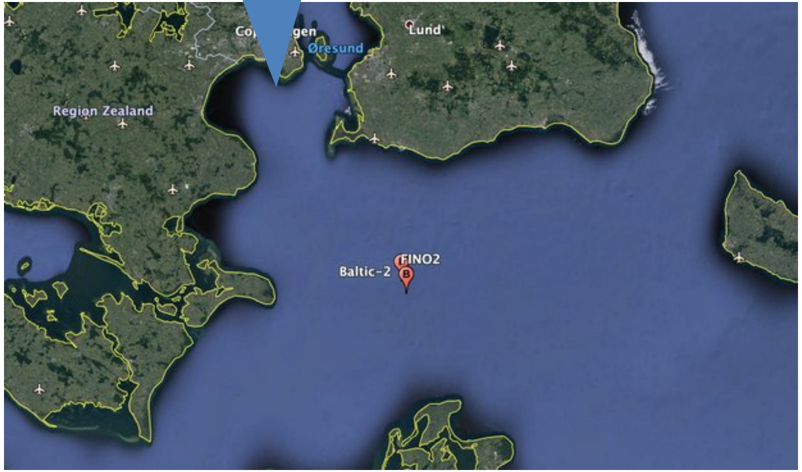
NWP Benchmark cases

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)

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

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

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

iea wind

WP3 Forecast Games and Experiments:
Game 1: Offshore wind power decision making in extreme events

Conducted by Dr. Corinna Möhrlen, 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 ~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.

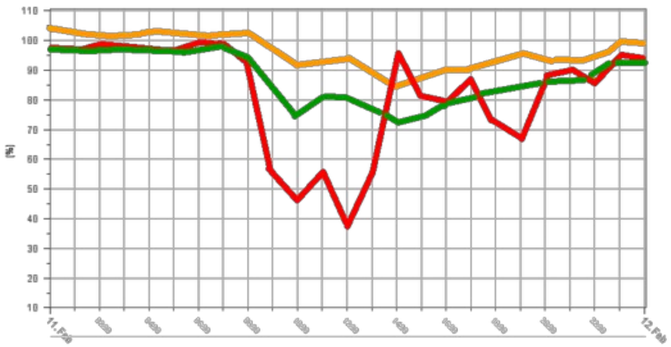
Definition of a "high-speed shutdown" (HSSD) or "cut-off wind" event :

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).

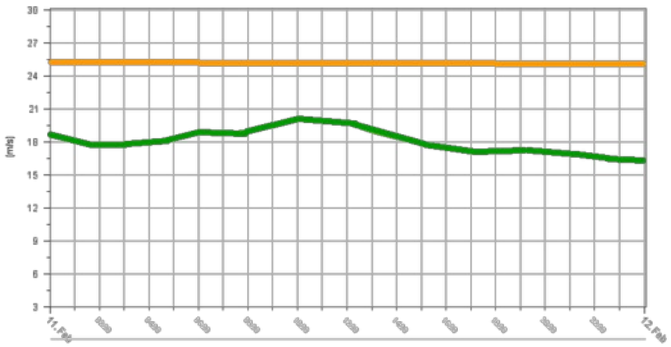
Forecast Game 1:
Offshore wind power decision making in extreme events

Type of forecasts used in the experiment:

In the experiement are determinisitic 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.

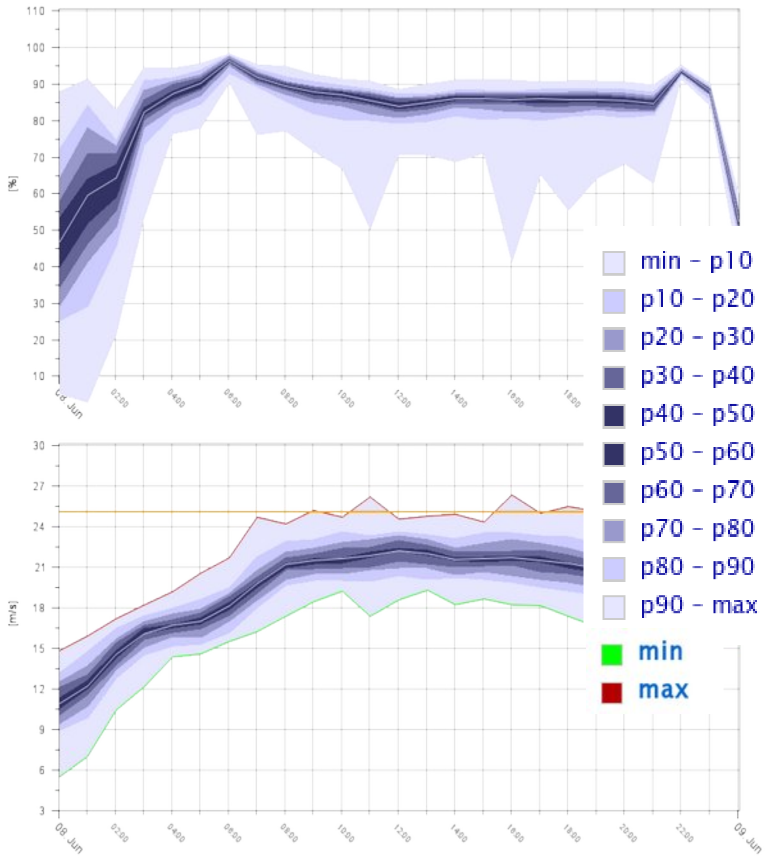


3 independent deterministic wind power forecasts in the unit [% of installed capacity] based on 3 different NWP (numerical weather prediction) models



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.

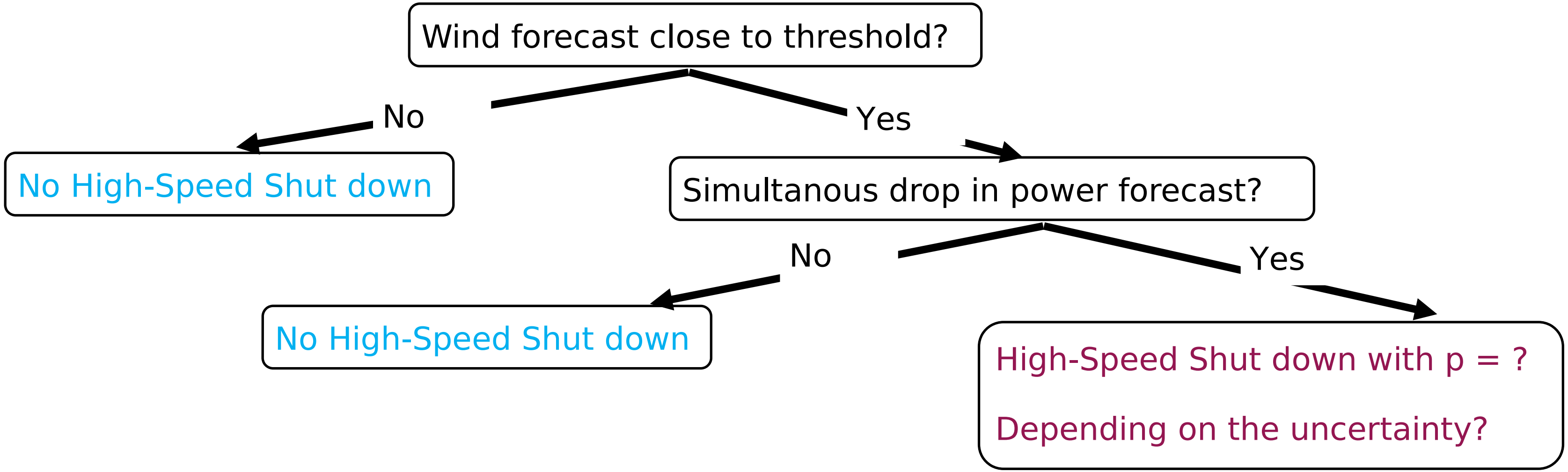
Definition: A percentile indicats the value below which a given percentage of foreasts from the 75 available forecasts falls. E.g., the 20th percentile is the value below which 20% of the forecasts are found.

Heuristic Decision strategies

task 36

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

Simple heuristic decision tree?



task 36

"Probabilistic Forecasting Games & Experiments" initiative:
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.**

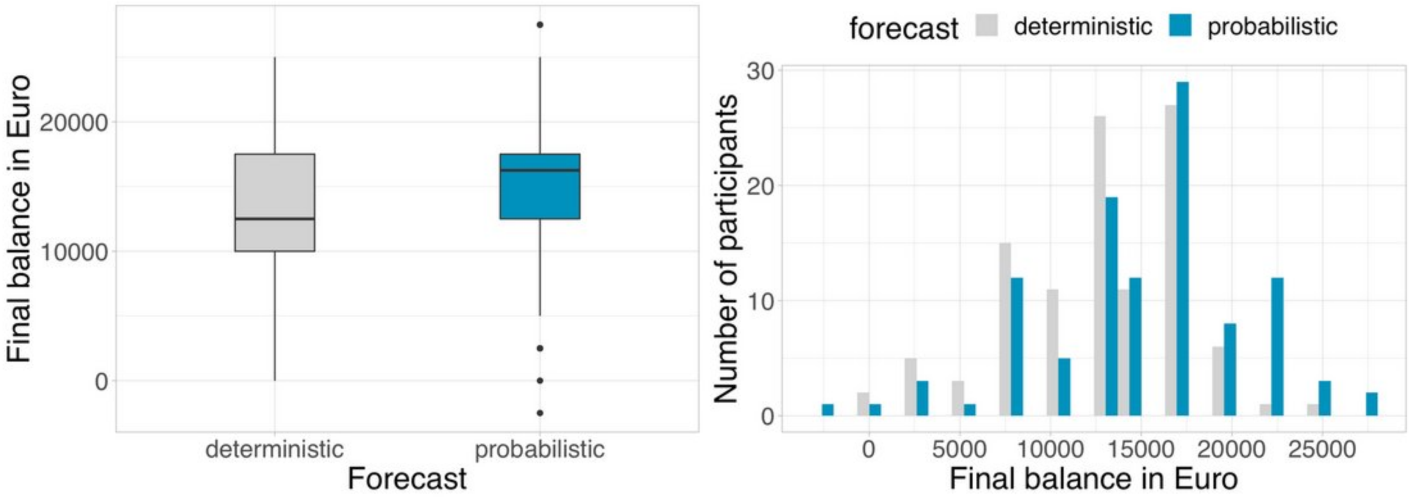
Forecast Game:
Offshore wind power decision making in extreme events

ANALYSIS – final balance -

108 participants:
Best score deterministic: 25.000 EUR
Best score probabilistic: 27.500 EUR

Probabilistic forecasts lead to:
- higher income
- less spread in performance

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



2^{nd} Experiment Design (2021)

Value of probabilistic power forecasts

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

How well can you use probabilistic or determinstic 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

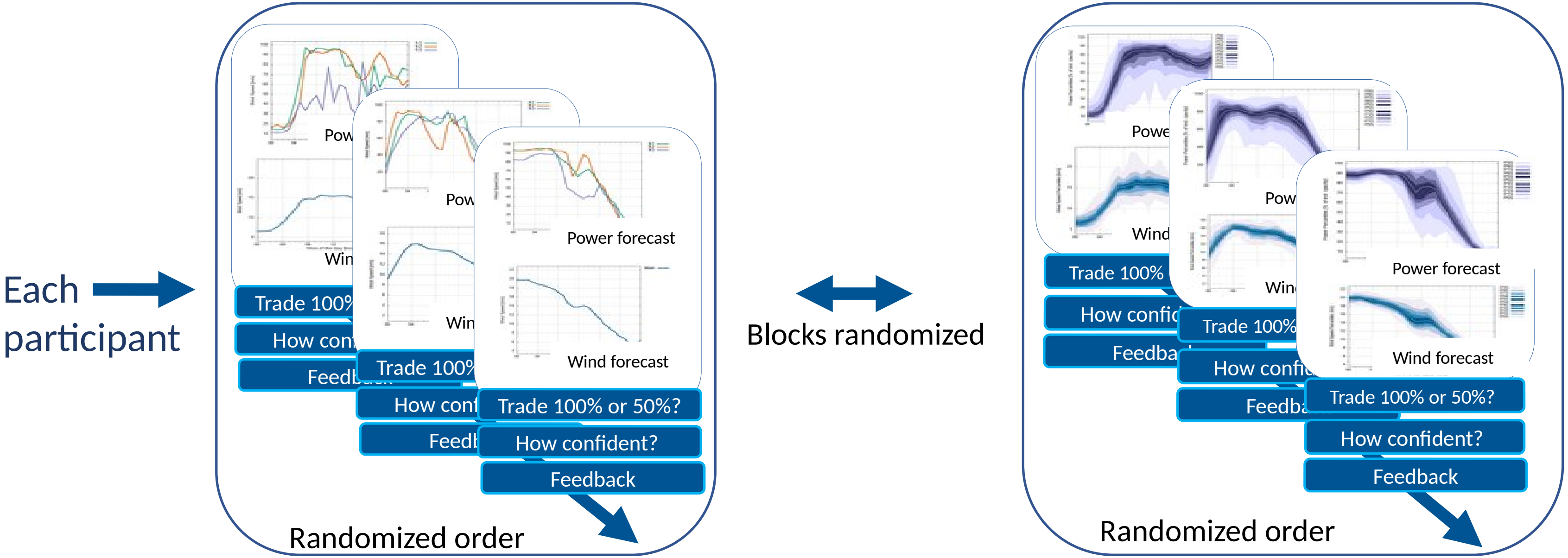
task 36

Hans-Ertel-Zentrum für Wetterforschung
Max-Planck-Institut für Bildungsforschung
Max Planck Institute for Human Development
WEPROG

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

Design & Analysis: Dr. Nadine Fleischhut*, Dr. Corinna Möhrlen**
Host of Experiment: *Max-Planck Insititute 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).

2nd Experiment Design (2021)
Value of probabilistic power forecasts

task 36

Max-Planck-Institut für Bildungsforschung
Max Planck Institute for Human Development
WEPROG

Setup Summary of the experiment:

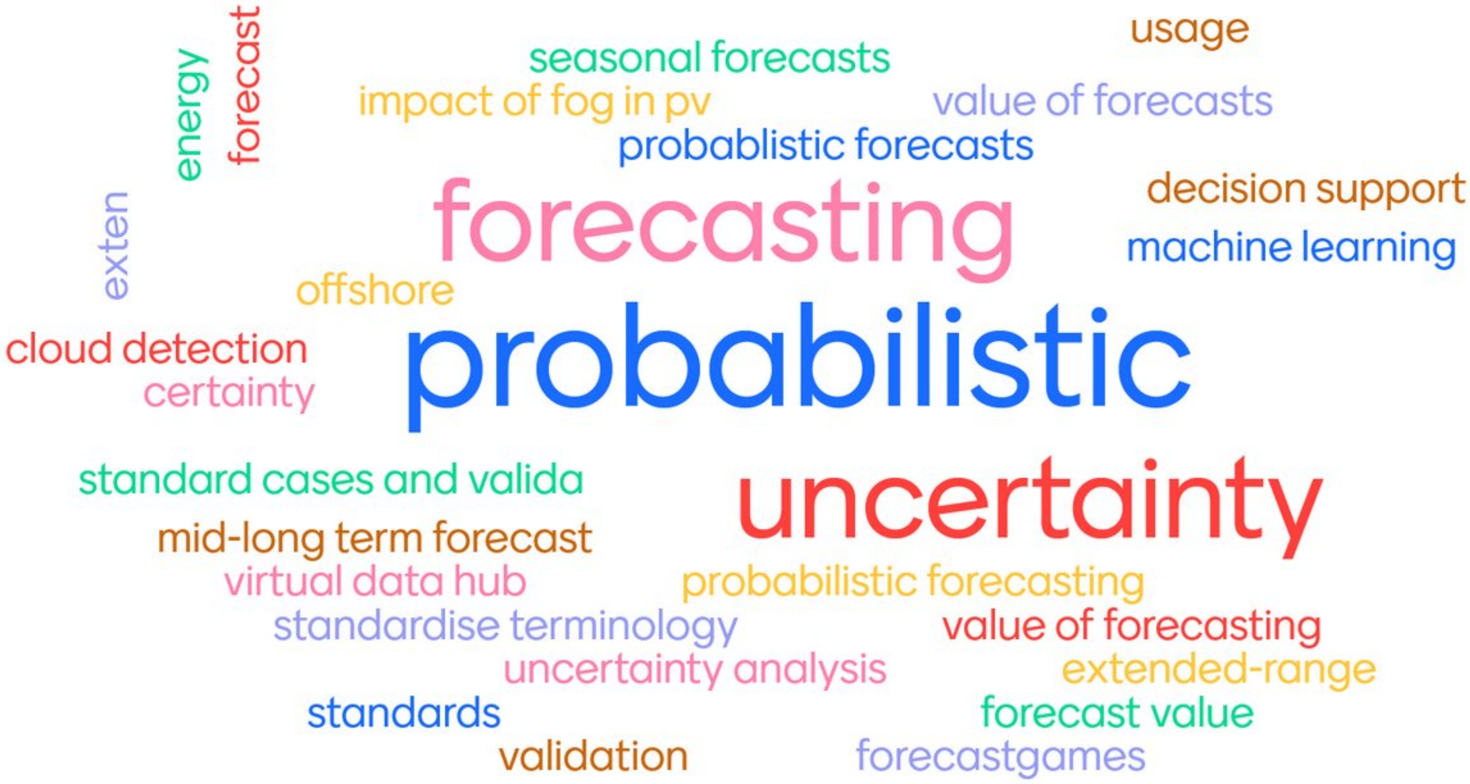
1) Every participant makes all decisions based on deterministic as well as on probabilistic ensemble forecasts. For each forecast type, the situations are presented in blocks randomized among each other.
2) For every participant, the order of blocks is randomly chosen at the beginning.
3) For each decision 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 aked 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

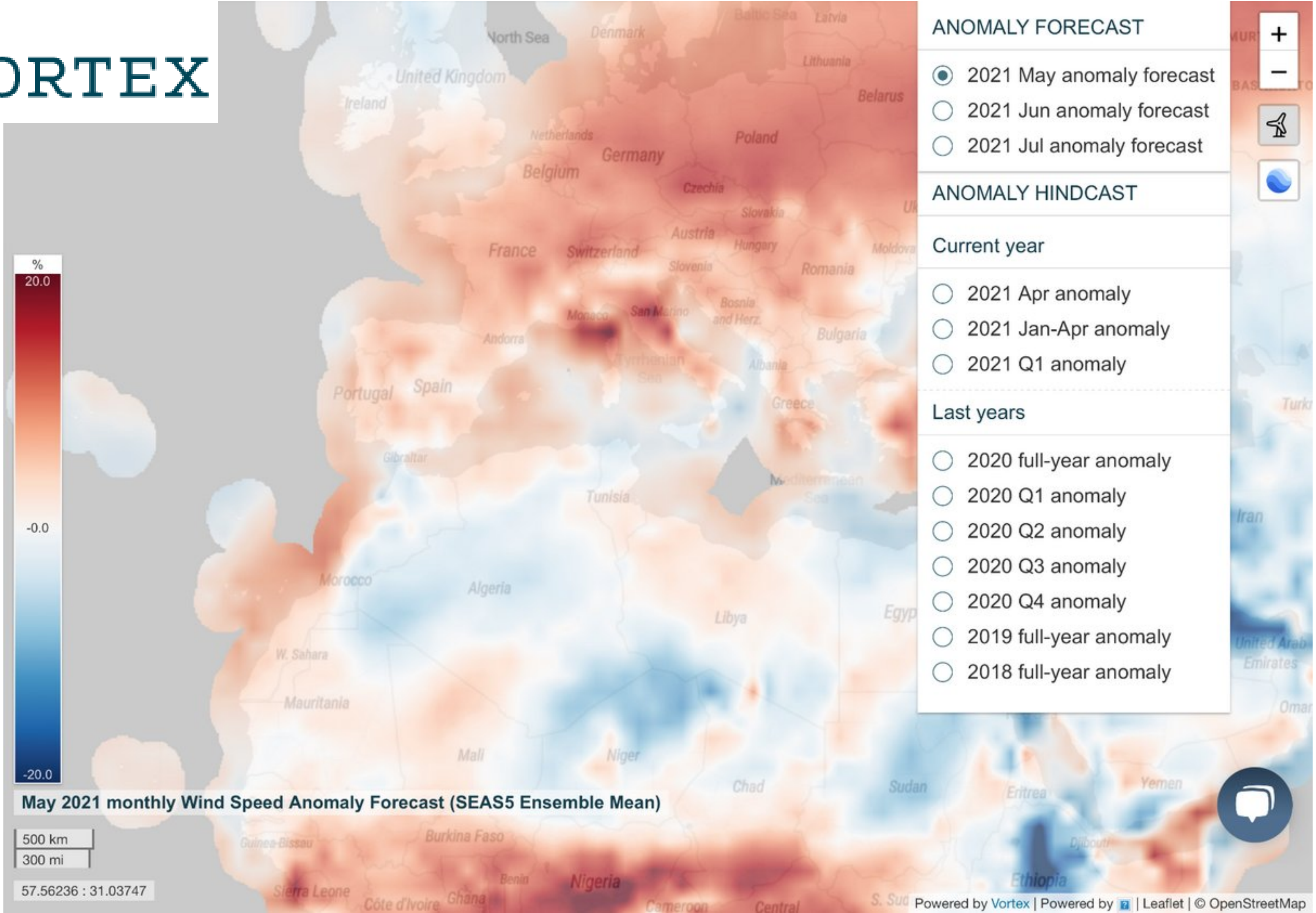
Preparations for the next phase of forecasting collaboration are ongoing. A recent Task meeting yielded this word cloud.

Strong collaboration with other TCPs.

To start 2022.



VORTEX

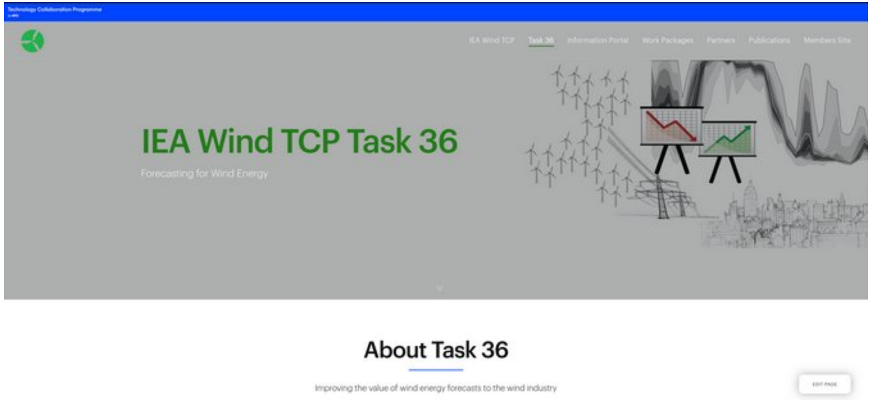


ANOMALY FORECAST
2021 May anomaly forecast
2021 Jun anomaly forecast
2021 Jul anomaly forecast
ANOMALY HINDCAST
Current year
2021 Apr anomaly
2021 Jan-Apr anomaly
2021 Q1 anomaly
Last years
2020 full-year anomaly
2020 Q1 anomaly
2020 Q2 anomaly
2020 Q3 anomaly
2020 Q4 anomaly
2019 full-year anomaly
2018 full-year anomaly
%
20.0
-0.0
-20.0
May 2021 monthly Wind Speed Anomaly Forecast (SEAS5 Ensemble Mean)
500 km
300 mi
57.56236 : 31.03747
Powered by Vortex | Powered by | Leaflet | © OpenStreetMap
North Sea
Denmark
United Kingdom
Ireland
Netherlands
Germany
Belgium
Poland
Belarus
Lithuania
Latvia
Czechia
Slovakia
Austria
Hungary
France
Switzerland
Slovenia
Romania
Moldova
Monaco
San Marino
Bosnia and Herz.
Andorra
Bulgaria
Albania
Portugal
Spain
Greece
Gibraltar
Tunisia
Morocco
Algeria
Libya
W. Sahara
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Yemen
Iran
United Arab Emirates
Oman
Burkina Faso
Guinea-Bissau
Nigeria
Benin
Sierra Leone
Côte d'Ivoire
Ghana
Cameroon
Central
Ethiopia
Djibouti

Task 36 Web Presence

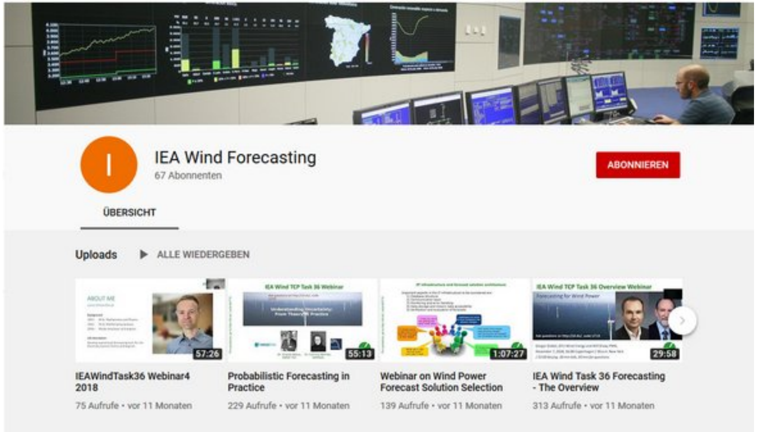
Website

www.iea-wind.org/task-36



YouTube Channel

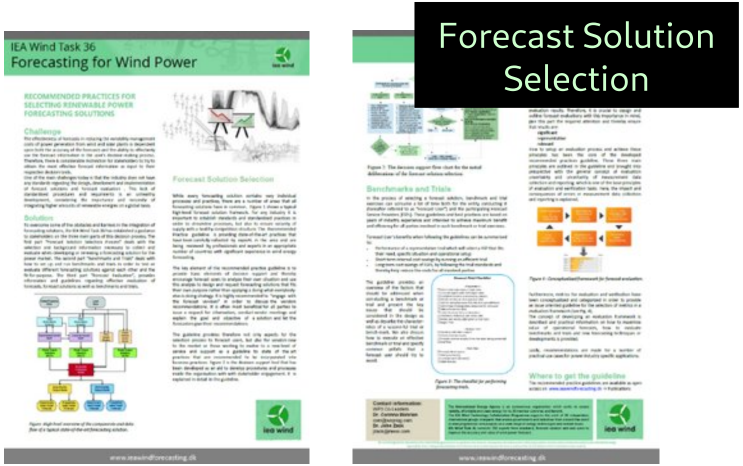
https://www.youtube.com/channel/UCsP1rLoutSXP0ECZKicczXg

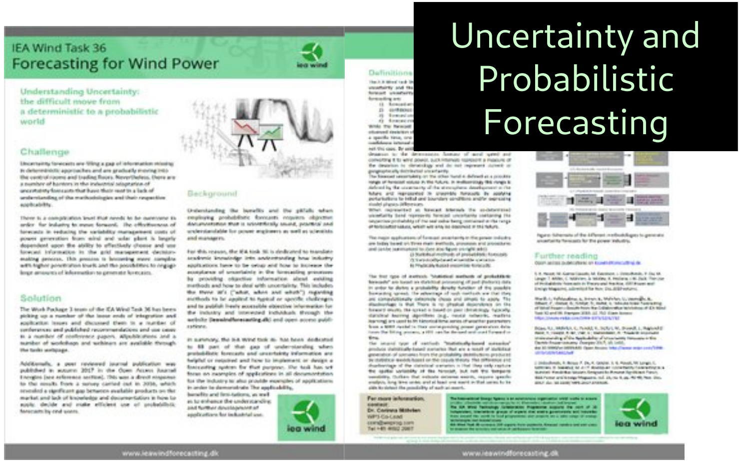


Handouts

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

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





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

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