iea wind
task 51

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

IEA Wind Task 51
"Probabilistic Forecasting Games and Experiments" initiative

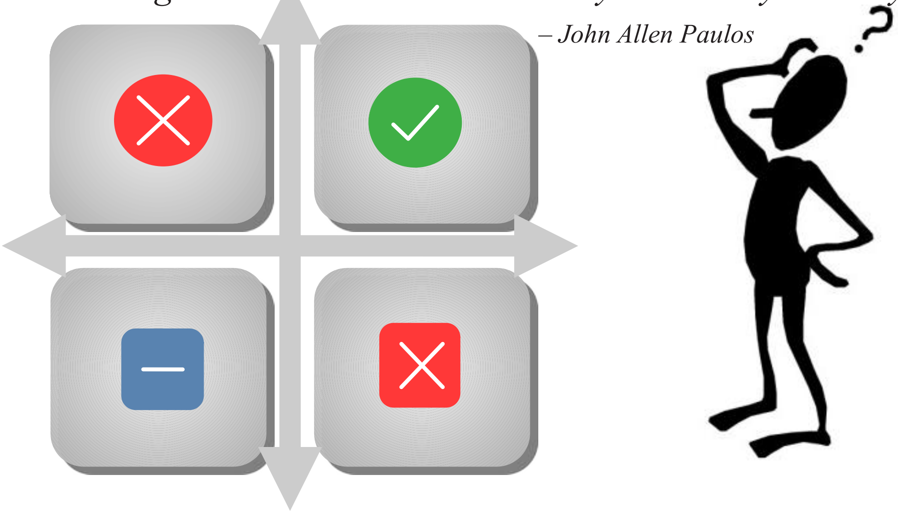
Windintegration Workshop 2022

Den Haag, 14.10.2022 – Session 10B 11:00-13:30

Corinna Möhrlen, WEPROG
Nadine Fleischhut, MPI
John Zack, MESO

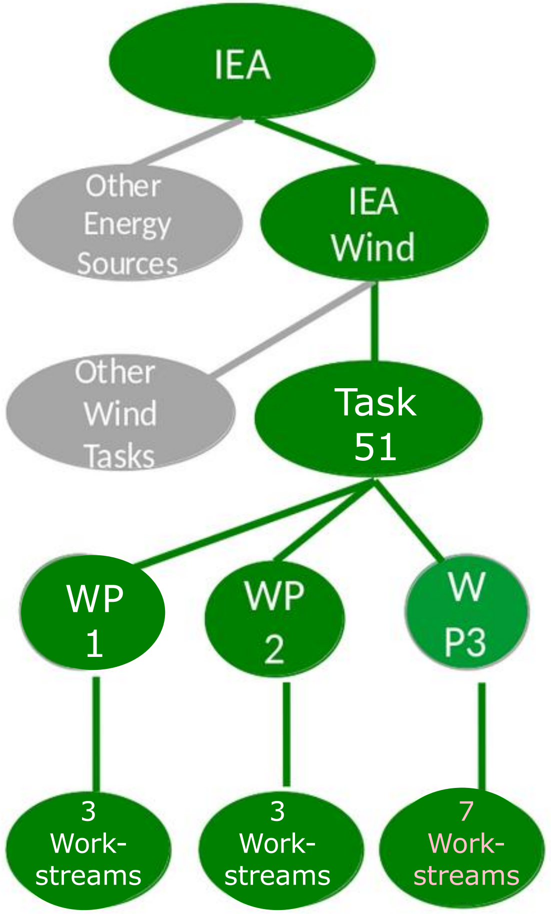
"Uncertainty is the only certainty there is,
and knowing how to deal with uncertainty is the only security we have."

– John Allen Paulos



LINK to Game:
iea-wind.org/task51

IEA Task 51 - Forecasting for the Weather-Driven Energy System



What is the IEA (International Energy Agency)? (www.iea.org)

- International organization within OECD with 30 members countries and 8 associates
- Promotes global dialogue on energy, providing authoritative analysis through a wide range of publications
- One activity: convenes panels of experts to address specific topics/issues

Task 51: Forecasting for the Weather-Driven Energy System:

- One of 17 Tasks of IEA Wind: https://community.ieawind.org/home
- Phase 1: 2022-2025
- Operating Agent: Gregor Giebel of DTU Wind Energy
- Objective: facilitate international collaboration to **improve wind energy forecasts**
- Participants: (1) research organization and projects, (2) forecast providers, (3) policy-makers and (4) end-users & stakeholders

Task 51 Scope: 3 "Work Packages" divided into 13 "Work Streams"

- WP1: Global Coordination in Forecast Model Improvement
- WP2: Benchmarking, Predictability and Model Uncertainty
- **WP3: Optimal Use of Forecasting Solutions – WS8: Decision Making**

Task homepage: https://www.iea-wind.org/task51

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WEXICOM Project – WP2 -

https://www.geo.fu-berlin.de/en/met/wexicom/

ARC Center for Adaptive Rationality
Max Planck Institute
for Human Development

How to communicate probabilistic impact forecasts?

WP2: Effectively communicating probabilistic impact forecasts for severe weather conditions using cognitive and behavioural science

Research Team:

- Dr. Nadine Fleischhut
- Prof. Dr. Ralph Hertwig
- Dr. Stefan M. Herzog

WP2
Image Credit: Jürgen Rossbach (MPIB)

Despite good forecasts and warnings, people may misperceive weather risks and fail to respond appropriately. Their understanding of forecast uncertainty has long been a major concern (Joslyn and Savelli, 2010, Spiegelhalter et al., 2011); more recently, understanding weather risks and impacts has emerged as another.

One currently advocated solution for helping people understand weather risk is to move from weather forecasts to impact forecasts; essentially, translating how the weather will be into what the weather will do (WMO, 2015). While the approach sounds promising, it remains unclear whether impact forecasts would in fact be beneficial for behaviour.

The main goal of this work package is to develop representations for communicating impact forecasts and to test their effect on risk perception, expectations, and behaviour. Using a crowdsourcing approach, we will develop and test ways to translate impact model forecasts into a meaningful risk representation for the public. Another part of the workpackage will investigate the potential benefits of impact forecasts for emergency manager.

Our results will shed light on the extent to which communicating impact forecasts can live up to its promise and improve our understanding of how to communicate impact forecasts to professional users and the public.

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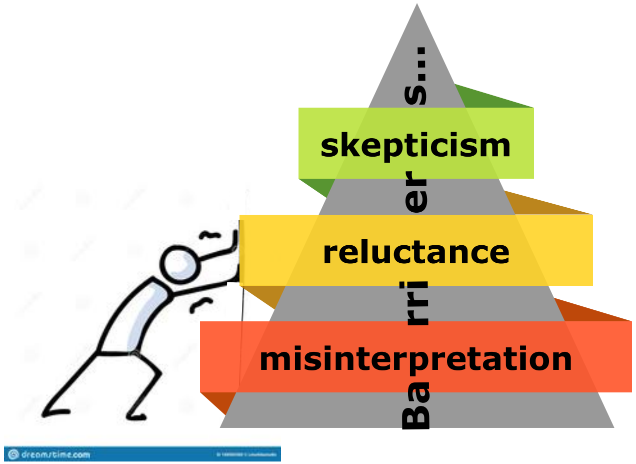
Goals and Objectives of the Initiative

LINK to Game:
iea-wind.org/task51

Our aim is:
break down barriers of making use of probabilistic forecasts



Our experiments are designed with the following principles:

i. from "~~**decision from description**~~" → **"decision from experience"**

ii. from "~~**theoretical learning**~~" → **"learning with feedback"**

iii. from "~~**classroom setup**~~" → **"Playing games of (complex) problems in a relaxed atmosphere"**

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2nd Forecast Game Design: Decision-making in extreme events and in complex terrain

LINK to Game: iea-wind.org/task51

3 Postulates:

1) Success in trading is highly dependent on the costs of balancing power needed due to forecast errors
2) 5% of the cases with large forecast errors are responsible for 95% of the costs over a month/year.
3) Reducing these costs is more important than improving the general forecast by 1-2%.

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

A high-speed shutdown event occurs typically in the **wind range above 20-27m/s**, mostly known as the *cut-off wind threshold of 25 m/s*.

Note: wind turbines use both **wind gusts and** the **mean wind** to determine, whether or not they turn into high-speed shutdown (HSSD).

Game experiments for decision making in extreme events*:

Experiment 1 (2020): Offshore wind park

Experiment 2 (2021/2022): Wind park in complex terrain

* https://iea-wind.org/task51/task51-work-streams/ws-decision-making-under-uncertainty/

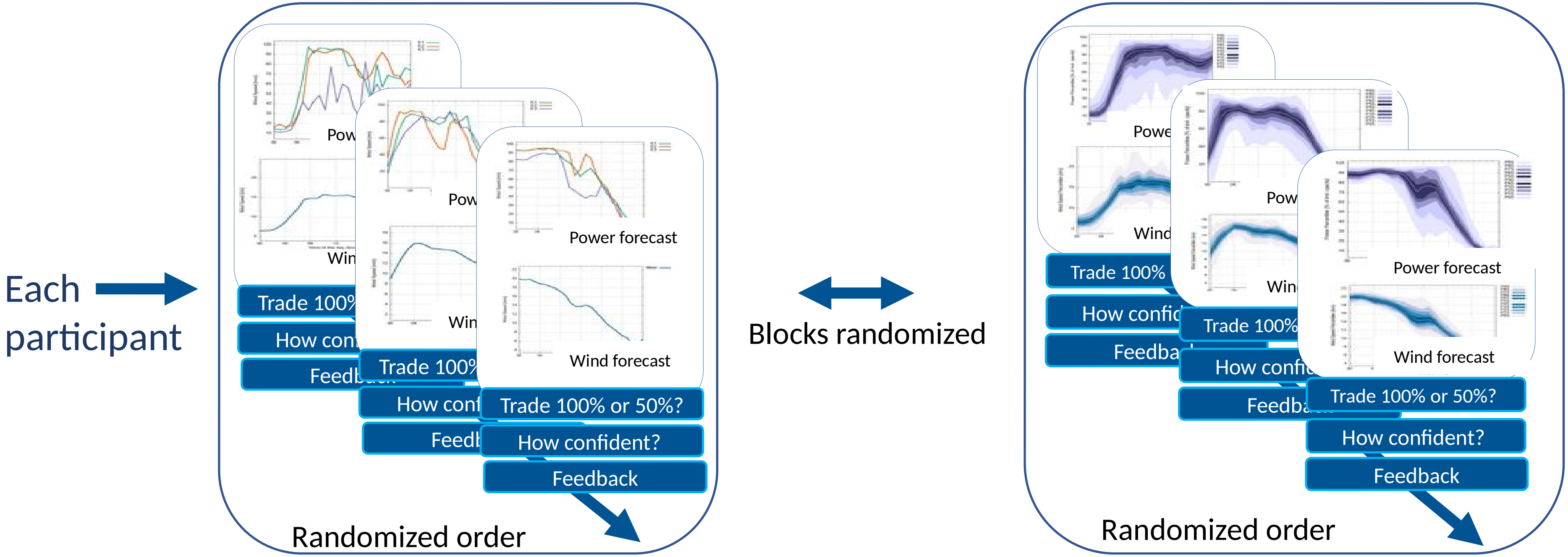
2nd Experiment (2022)

Decision-Making in Extremes for a Wind Farm in complex terrain

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?



22 decision situations with deterministic forecasts

Same 22 decision situations with probabilistic forecasts

Decision-Making in Extremes for a Wind Farm in complex terrain

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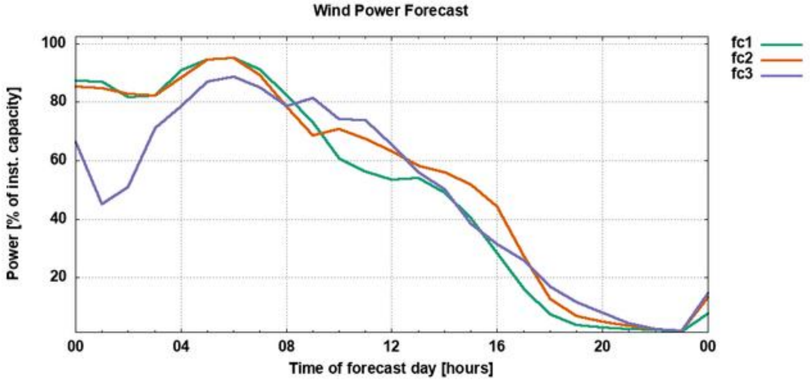
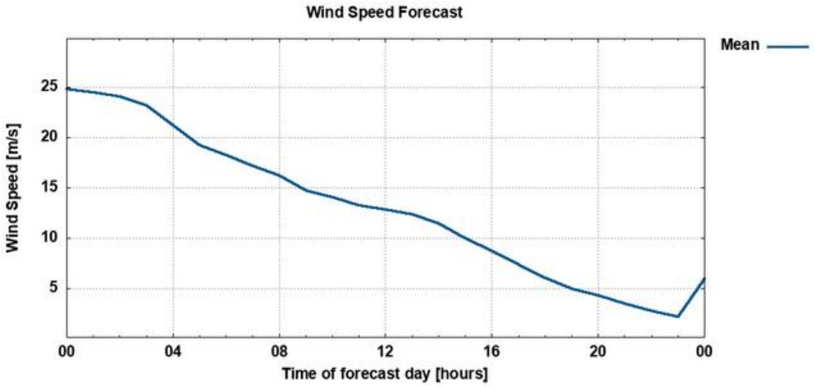
Type of forecasts used in the game

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

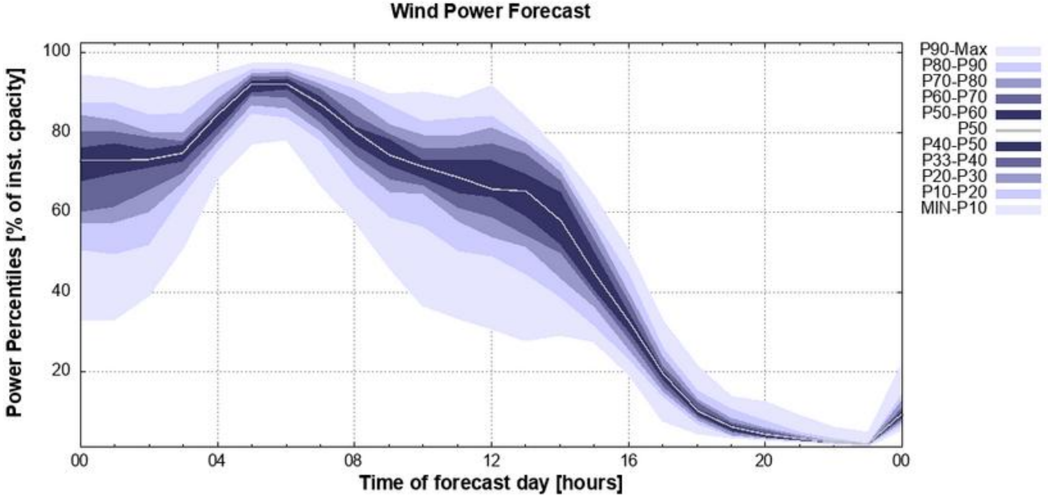


3 independent deterministic wind power forecasts in the unit [% of installed capacity] based on 3 different NWP (numerical weather prediction) models

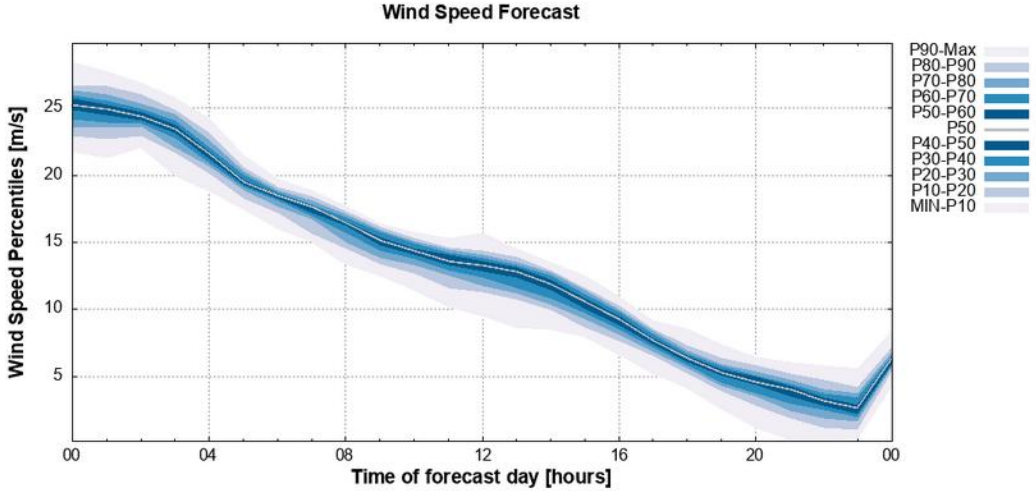


1 wind speed forecast in the unit [m/s], which is a mean forecast from 75 ensemble members and smoother than a typical deterministic forecast.

Decision-Making in Extremes for a Wind Farm in complex terrain



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 (MSEPS).



9 wind speed percentiles P10..P90 and a median (white line) in the unit [m/s] generated from 75 NWP forecasts of a multi-scheme ensemble prediction system (MSEPS).

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 forecasts are found.

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

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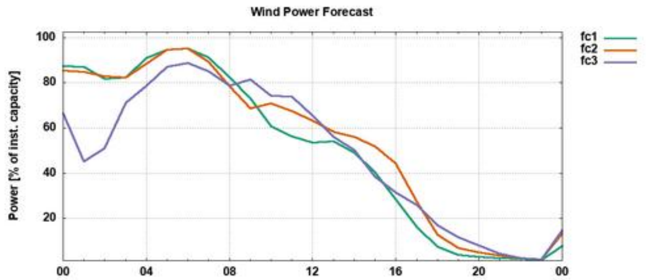
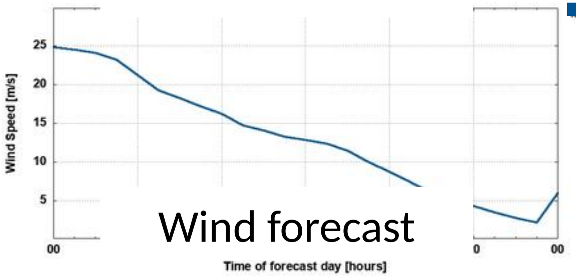
Trade 100% or only 50% wind energy – given the risk of high-speed shutdown?



Power forecast



Trade 100% | Trade 50%

How confident are you ?
50%|60%|70%|80%|90%|100%

Confidence interpretation:

50% → I am guessing
…
100% → I am sure about my decision

Cost Function

	HSSD	No HSSD
Trading 100%	-5000	5000
Trading 50%	0	2500

High-speed shutdown occurred.

If you trade 100%, you loose 5000 EUR
If you trade 50%, you neither loose or gain anything.

You chose to trade 100%.
You current balance therefore is: -5000

Feedback

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

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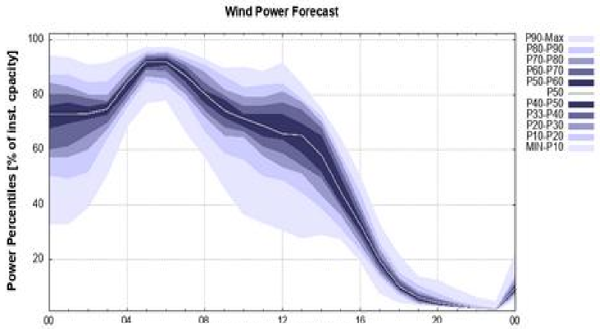
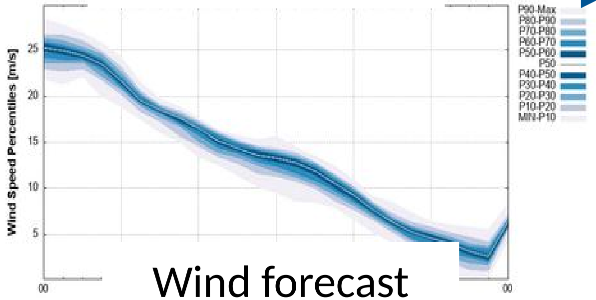
Trade 100% or only 50% wind energy – given the risk of high-speed shutdown?



Power forecast



Wind forecast

Trade 100% | Trade 50%

How confident are you ?
50% | 60% | 70% | 80% | 90% | 100%

Confidence interpretation:

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Cost Function

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Trading 100%	-5000	5000
Trading 50%	0	2500

High-speed shutdown occurred.

If you traded 100%, you loose 5000 EUR
If you traded 50%, you neither loose or gain anything.

You chose to trade 50%.
You current balance therefore is: 0

Feedback

2nd Experiment
Value of probabilistic wind 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

Let's Play!

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

LINK to Game: iea-wind.org/task51

Results from Playing the Game in Session 10A

Value of probabilistic wind power forecasts

Note:
Results of workshop are NOT representative – and only part of the experiment
//
More info on full experiment on slide 20

Results from Playing the Game in Session 10A

Value of probabilistic power forecasts

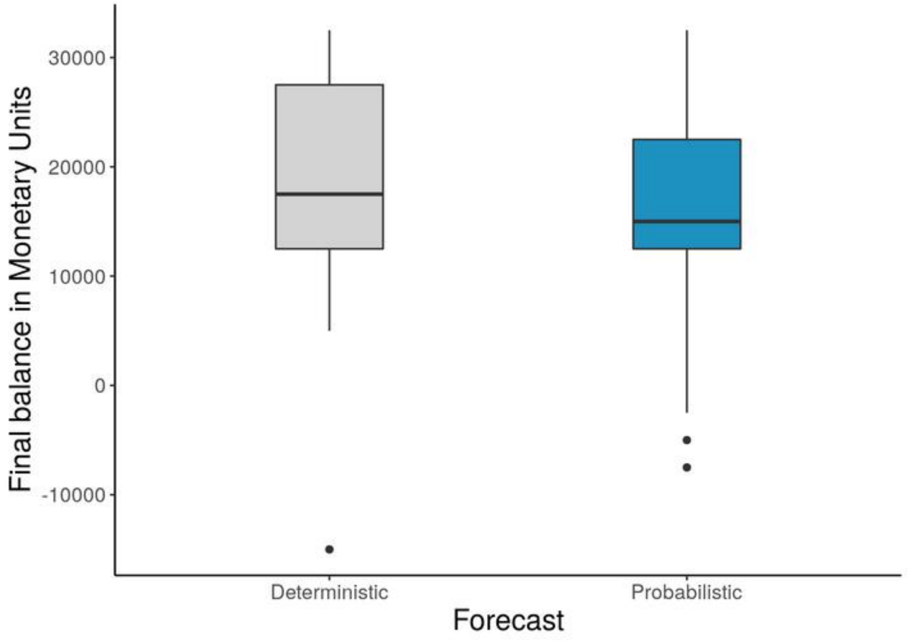
Nickname	Running number	Probabilistic score	Deterministic score
Sandfig	1319	32500	27500
ETrader	1309	32500	25000
131990	1288	27500	30000
Gosset	1308	27500	17500
DivaPlz	1284	27500	17500
ragelazy	1300	25000	27500
8760analysis	1314	22500	32500
harrylime	1293	22500	27500
chrstph	1281	20000	27500
Nick Name	1301	20000	12500
Alex C	1296	20000	5000
Laksh_KIT	1311	15000	17500
Riskaverse	1283	15000	17500
DangerMan	1282	15000	12500
Sandfig	1298	15000	5000
jack_1	1322	15000	-15000
daisuke	1313	12500	27500
FBvn74	1303	12500	20000
ESPINA	1286	12500	15000
Fmartin	1290	12500	12500
Bonzai	1310	12500	10000
MM13498	1289	7500	12500
LADADI	1295	5000	27500
PPS87ENA	1317	5000	5000
Aragorn	1292	-2500	5000

Nickname	Running number	Probabilistic score	Deterministic score
8760analysis	1314	22500	32500
131990	1288	27500	30000
Sandfig	1319	32500	27500
ragelazy	1300	25000	27500
harrylime	1293	22500	27500
chrstph	1281	20000	27500
daisuke	1313	12500	27500
LADADI	1295	5000	27500
ETrader	1309	32500	25000
pi1234	1285	-5000	25000
FBvn74	1303	12500	20000
Gosset	1308	27500	17500
DivaPlz	1284	27500	17500
Laksh_KIT	1311	15000	17500
Riskaverse	1283	15000	17500
ESPINA	1286	12500	15000
Dart-thrower	1294	-7500	15000
Nick Name	1301	20000	12500
DangerMan	1282	15000	12500
Fmartin	1290	12500	12500
MM13498	1289	7500	12500
Bonzai	1310	12500	10000
Alex C	1296	20000	5000
Sandfig	1298	15000	5000
PPS87ENA	1317	5000	5000

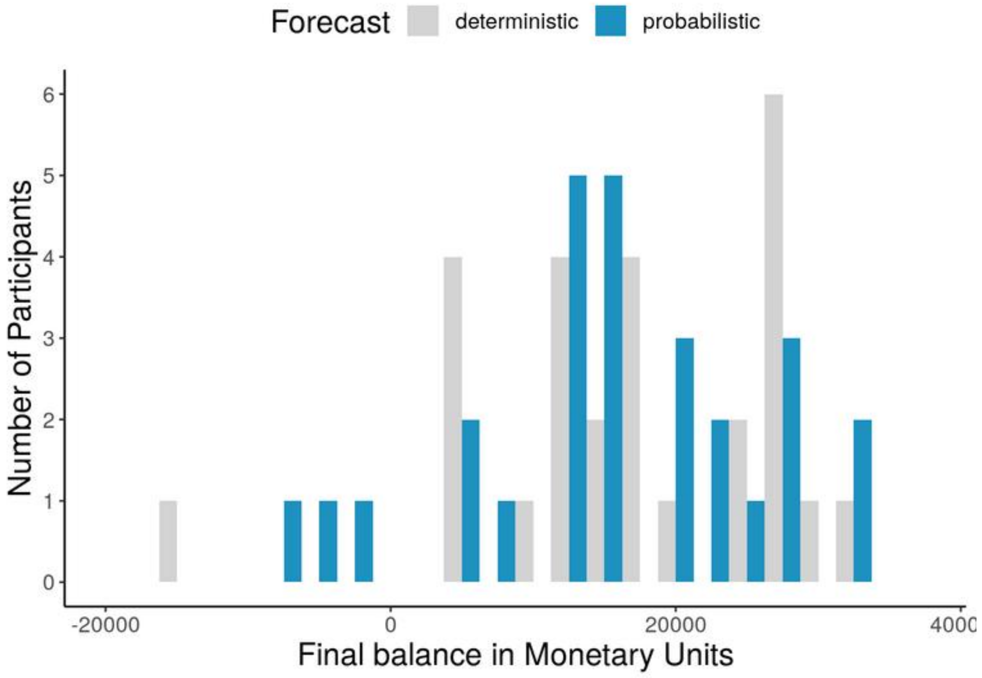
Results from Playing the Game in Session 10A

Value of probabilistic power forecasts

Participants' final balance based on deterministic and probabilistic forecasts



distribution of participants' final balance by forecast type

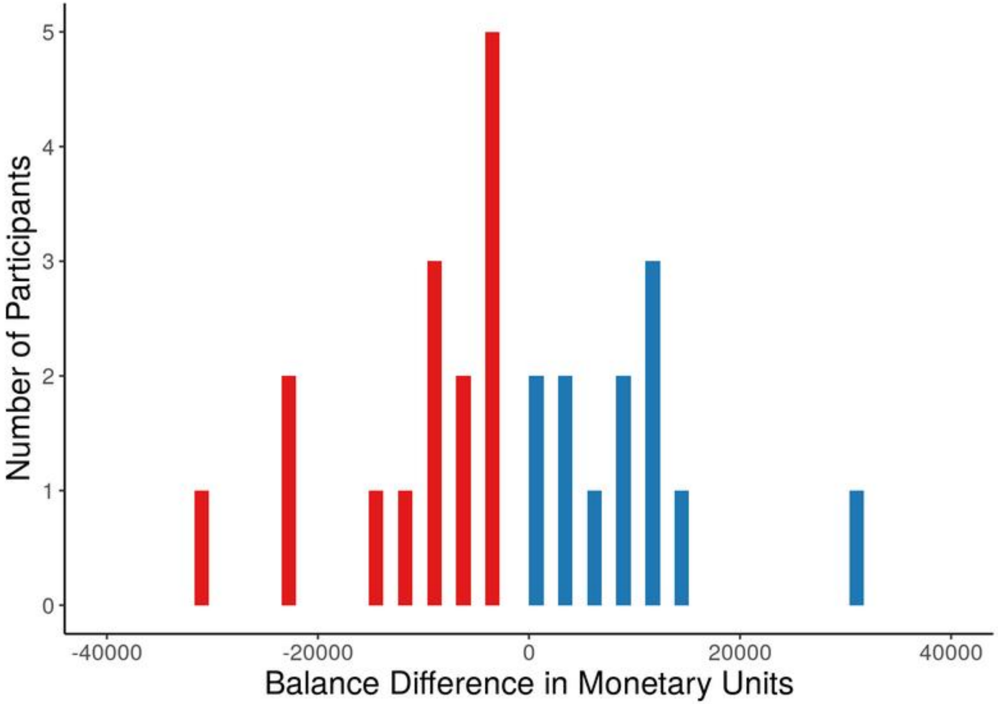


histogram of participants' final balance

Results from Playing the Game in Session 10A

Value of probabilistic power forecasts

Difference between participants' final balance based on the probabilistic forecast and the deterministic forecast



Blue bars (values >= 0) indicate that participants performed better with probabilistic forecasts.
(12 out of 27 ...)

Red bars (values < 0) indicate that participants performed better with deterministic forecasts.
(15 out of 27...)

Results from Playing the Game in Session 10A

Value of probabilistic power forecasts

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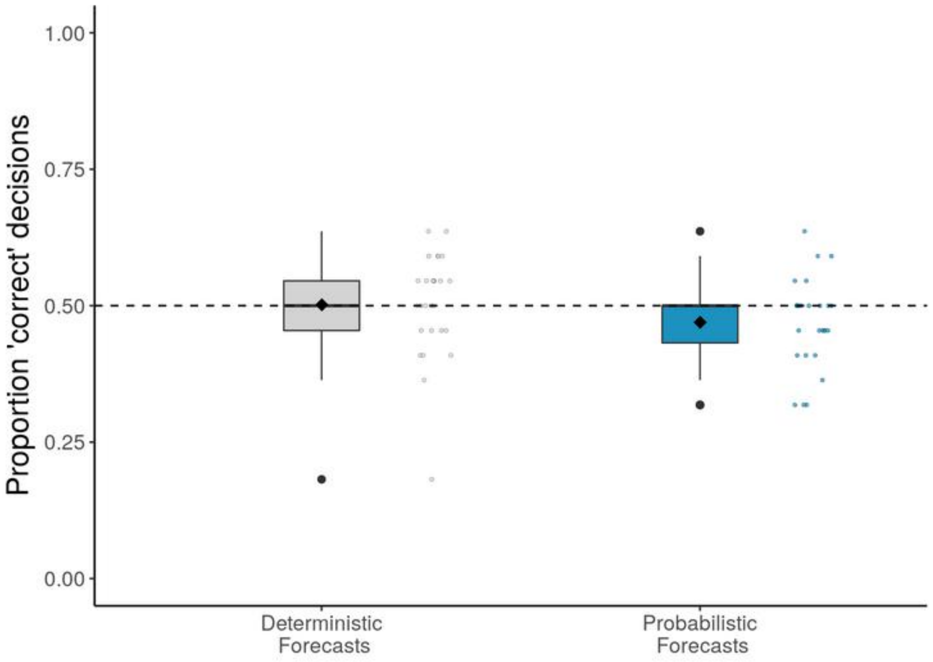
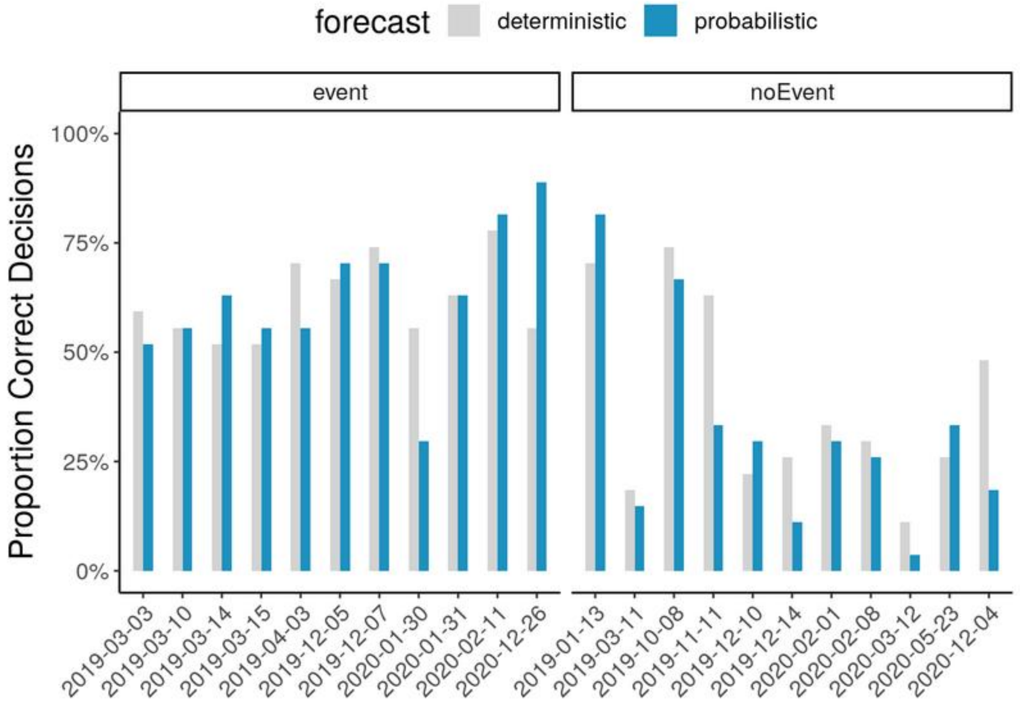
Proportion of correct decisions based on deterministic vs. probabilistic forecasts



distribution of participant's proportion of correct decisions by forecast type



Proportion of correct decisions by situation

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Result Example from Playing the Game in Session 10A

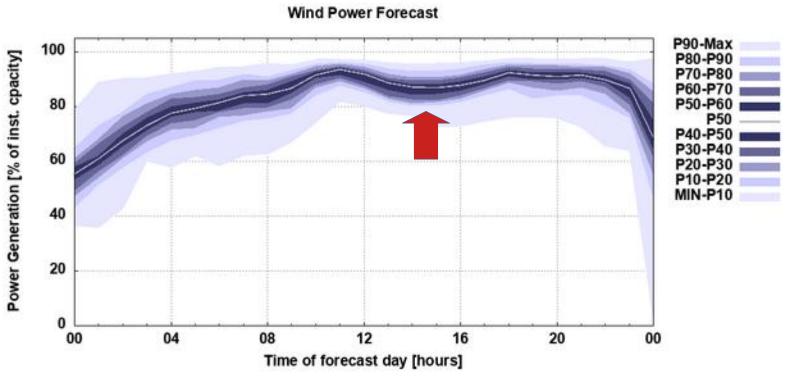
Value of probabilistic power forecasts

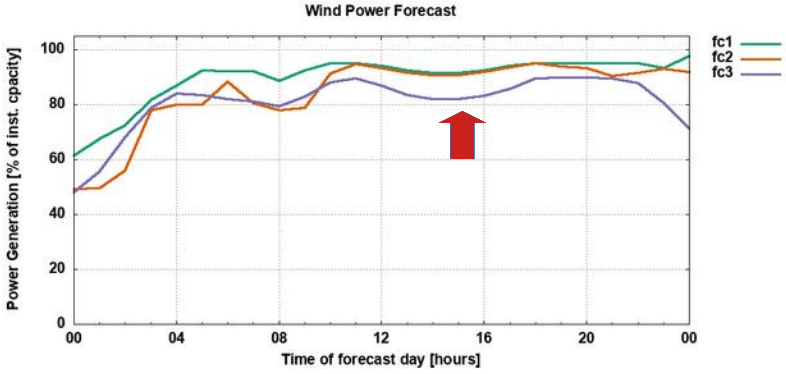
HSSD event with large difference of correct decisions with deterministic vs. probabilistic forecasts

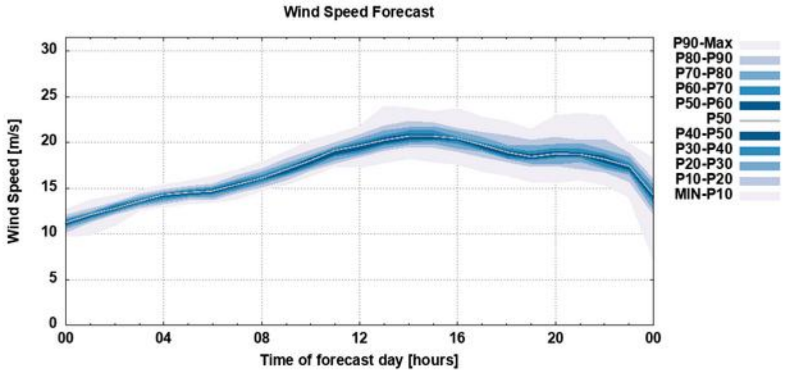
ca. 85% correct

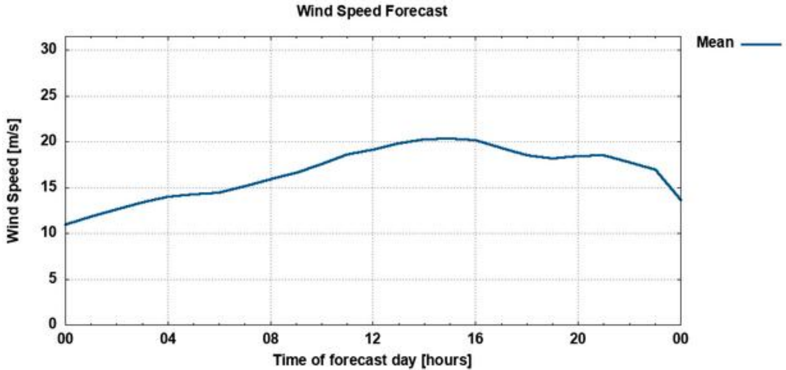
HSSD not (very) visible in forecast

ca. 55% correct







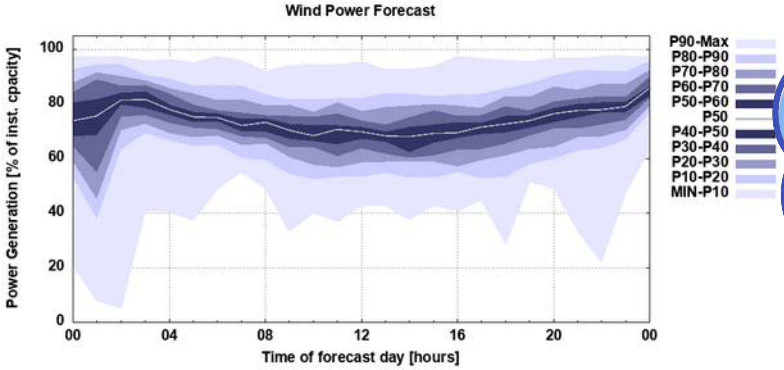


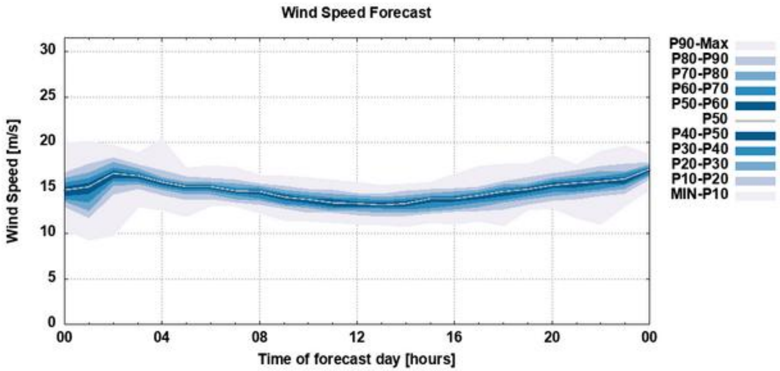
Result Example from playing the Game in Session 10A

Value of probabilistic power forecasts

No-HSSD event with large difference of correct decision with deterministic vs. probabilistic forecasts

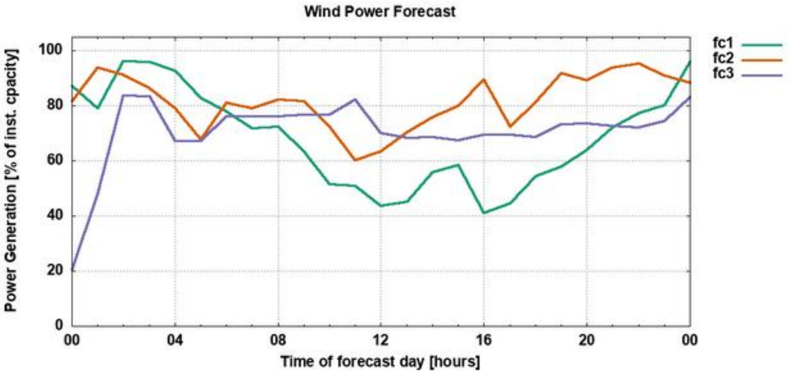
ca. 30% correct

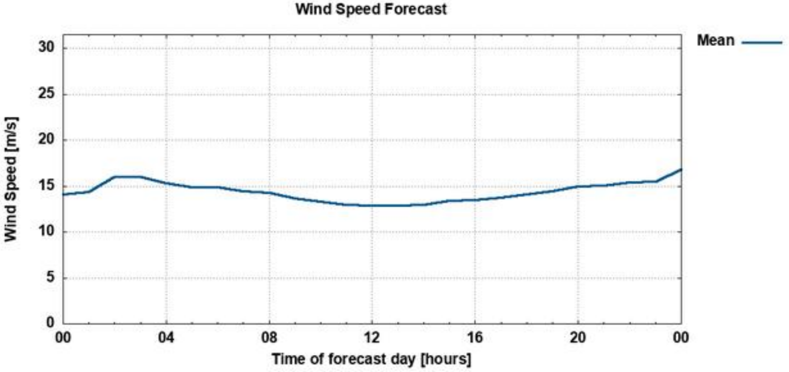




...more risk averse decisions on basis of Probability forecasts

ca. 65% correct





Summary of observations from playing the Game in Session 10A

Value of probabilistic power forecasts

The skew cost function:
- leads to more than 50% of safe decisions - participants thus are aware of the asymmetric cost function
- participants get more risk averse in the course of the game

A portion of cases appear difficult or not easy to interpret for participants:
- leads to scores that are little above a completely risk averse decision-making
- confidence is challenged, if participants have no clear strategy
- learning is difficult, if the feedback is insufficient/not helping the understanding
- demonstrates the dilemmas decision-makers deal with in a real-time environment

Correct detection of events
- participants decision of no-events are more correct with deterministic forecasts
- participants decision of events are slightly more correct with probabilistic forecasts

Observation: Participants seems to only benefit from probabilistic ensemble forecasts, if they already have a strategy and understanding of the task for the decision-making

Questions following the discussion at the workshop:

→ how much training and strategy building/experience is still necessary ?

→ could more informative feedback help improve the learning from mistakes ?

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THANK YOU for your attention...

Follow us:

Game webpage: https://meteorology.mpib.dev/wind-power-decisions/

Project webpage: http://www.iea-wind.org/task51

Task-page: https://iea-wind.org/task51/task51-work-streams/ws-decision-making-under-uncertainty/ or
https://iea-wind.org/task36/task36-work-packages/wp3-optimal-use-of-forecasting-solution/wp3-4-probabilistic-forecast-games/

Publications: https://iea-wind.org/task51/task51-publications/

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

Contact WS9/WP3 Lead:
Dr. Corinna Möhrlen, WEPROG
com@weprog.com

Contact Operating Agent:
Dr. Gregor Giebel, DTU Wind
grgi@dtu.dk

Contact Behavioural & Cognitive Scientist:
Dr. Nadine Fleischhut, MPI for Human Development,
Hans-Ertel Center for Weather Research
Nadine Fleischhut <fleischhut@mpib-berlin.mpg.de>

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Link for the 2nd experiment

Version **... still Open to Play!**

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

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