IEA Wind Task 36

Forecast Games and Experiments Initiative:

Example: Offshore wind power decision making in extreme events

ESIG Workshop

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WEPROG

Background of this project: IEA Task 36: Forecasting for Wind Energy

Task Objective is to encourage improvements in:
1) weather prediction
2) power conversion
3) use of forecasts

Task Organisation is to encourage international collaboration between:
- Research organisations and projects
- Forecast providers
- Policy Makers
- End-users and stakeholders

Task Work is divided into 3 work packages:
WP1: Weather Prediction Improvements inclusive data assimilation
WP2: Development of a benchmarking platform & best practice guidelines
WP3: Communication of best practice in the use of wind power forecasts

Follow us on our webpage: www.ieawindforecasting.dk

Overall goal of this initiative:

Experimental investigation of potential benefits of uncertainty forecasts in decision making

Provision of training tools to demonstrate the use and benefits of using uncertainty forecasts

Simulating real-life decision scenarios with feedback to

- learn how to use forecasts
- stimulate discussion
- gather new ideas to communicate the forecasts

Background for the Offshore TradingGame

Meteorology acknowledges since ~30 years that:

→ Deterministic methods "hide" uncertainty inherent in every forecast

Reseach in psychology and human development on decision making in weather forecasting (e.g. Joslyn 2013, LeClerc, 2015, Fundel, 2019)
suggest that:

→ including uncertainty estimates in weather forecasts leads to:

- decisions made with uncertainty information are better/more informed
- increases trust in forecasts
- gives people a better idea of what to expect in terms of
  + the range of possible outcomes
  + the amount of uncertainty in the particular situation

→ Type of uncertainty forecast and appropriate communication is crucial

Outset and Summary of the first Forecast Game: Offshore wind power decision making in extreme events

3 Postulates:

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 a year.
3) Reducing these costs is more important than improving the general forecast by 1-2%.

The Game:

Decisions to be made whether or not high-speed cutoff takes place
- in 12 cases
- whether to trade 50% or 100% of the generating power of an offshore wind park

Decision Tools:
- 3 deterministic forecasts showing the wind power and wind speed
- ensemble forecasts showing wind power and wind speed inclusive uncertainty 9 bands

Participants:

Participants are fully annonymous and due to the public availability of the game, no information about them was saved. It was intrduced at the IEA Task 36 workshop in Glasgow in January 2020 and announced in the IEA community

Forecast Game: Offshore wind power decision making in extreme events

Dealing with Extremes: we need to remember 2 important features:

--→ Definition of the Extreme and the thresholds

Here: we look at "high-speed shutdown" (HSSD) or "cut-off wind" events :
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).

--→ Methodology for the probabilistic forecasts:

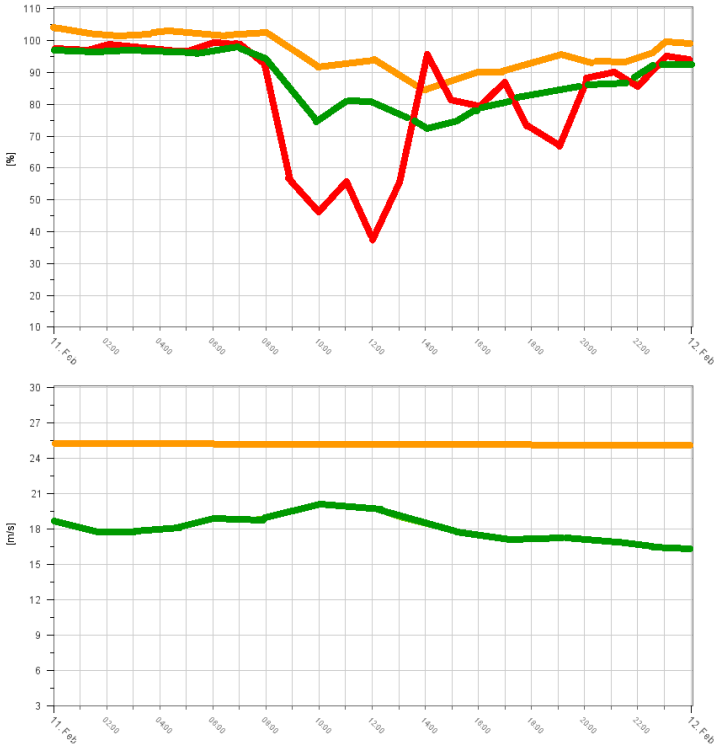
We chose a physical Ensemble Prediction System with 75 member (MSEPS)

...to ensure that the uncertainty information is adhoc and for every forecasting hour

Forecast Game: Offshore wind power decision making in extreme events

Type of forecasts used in the game

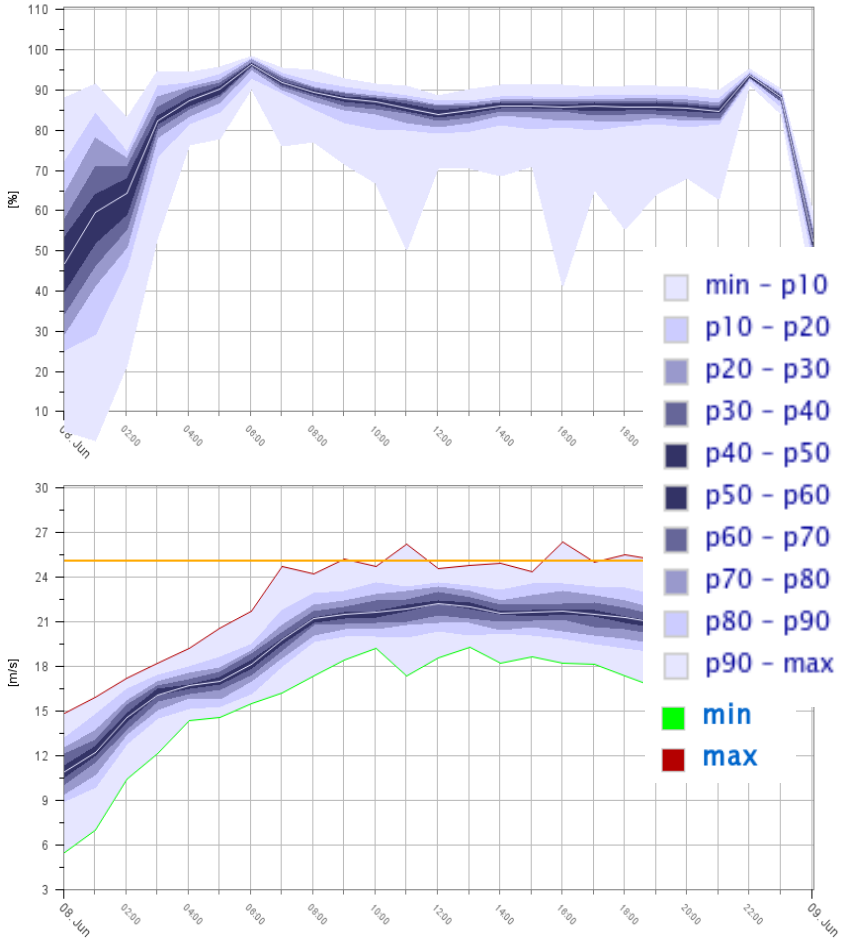
In the game are determinsitic and probabilistic forecasts for the **day-ahead horizon**.
All forecasts are generated with input of NWP (numerical weather prediction) forecasts from the 00UTC cycle the day before.



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. **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: 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.

Forecast Game: 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:

- wind farm is 100MW, the spot market price is 50 EUR/MWh.
- balance costs = spot market prices
- The cost function will only consider choice for the hours, where 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, trading **100% is a risky choice** that can both increase income and loss.
The more conservative **50% trading strategy limits the risk of a loss:** (1) balance costs = spot market prices, (2) with curtailment wind farm can avoid balance costs.

ANALYSIS SUMMARY

For the game and this group of 120 participants*, using probabilistic Forecasts lead to…

- ➔ Slightly higher income
- ➔ More correct decisions
- ➔ Less risky decisions

needs further testing, e.g. systematic experimental design, representative test cases, …

Results in line with research, indicates benefits of probabilistic forecasts , but remember…. this was only a first game, not yet a structured experiment...

- ➔ Participants changed their mind in 18% of the cases
- ➔ 91% of participants changed their mind at least once

- ➔ Noticable: no one wanted to make decisions with deterministic forecasts alone!

Results can be viewed at the end of the presentation or here:
https://meteorology.mpib.dev/power_wind-forecasts/results.html

*see slide 5

Forecast Game: Offshore wind power decision making in extreme events

- Summary and Take away -

Uncertainty forecasts show what is hidden in deterministic "best guesses": decision making is not more simple, but is more informed and more "honest"

Education/experience needed in how to communicate uncertainty forecasts

Some of the question we want to answer in the next round of experiments:

- ➔ Can probabilistic wind power forecast improve decision?
- ➔ Does feedback from uncertainty forecast make it easier to learn ?
- ➔ How good can people transfer knowledge to other decision tasks ?

Questions or Comments ?

Please contact us if you are interested in participating in a larger, structured experiment…

…. we also appreciate any kind of feedback on current experiment...

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Forecast Game: Offshore wind power decision making in extreme events

ANALYSIS – and the winner is…. -

The 2 best players with the highest income of 27.500€ have achieved this with the probabilistic forecasts. The best player with deterministic forecasts has achieved 25.000 €.

The table can be sorted by how much a participant made based on the deterministic or probabilistic forecast.

Show 75 entries Search:

userID	probabilistic	deterministic
fcstX1 _ 30	27500	17500
Kassandra _ 51	27500	17500
Oleaster _ 53	25000	17500
Howareyafrancis _ 37	25000	15000
Auracle _ 1	25000	10000
statwars _ 36	22500	20000
Gggrte _ 51	22500	20000
Tester101 _ 18	22500	17500
GatForecast _ 25	22500	17500
xinloi _ 52	22500	15000
argument _ 16	22500	12500
WindGuy _ 41	22500	12500
ads1512 _ 19	22500	12500
SmartyGuy _ 30	22500	12500
jb1234 _ 32	22500	12500

The table can be sorted by how much a participant made based on the deterministic or probabilistic forecast.

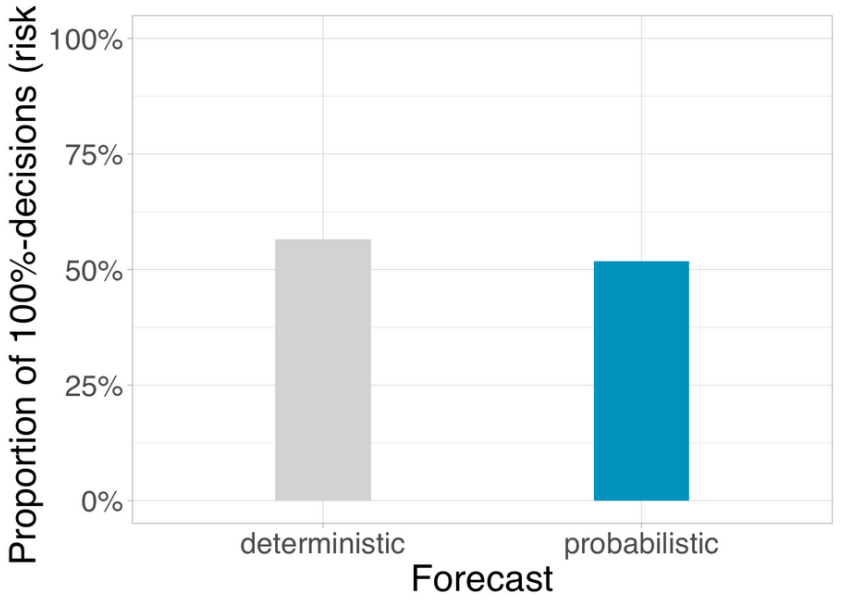
Show 75 entries Search:

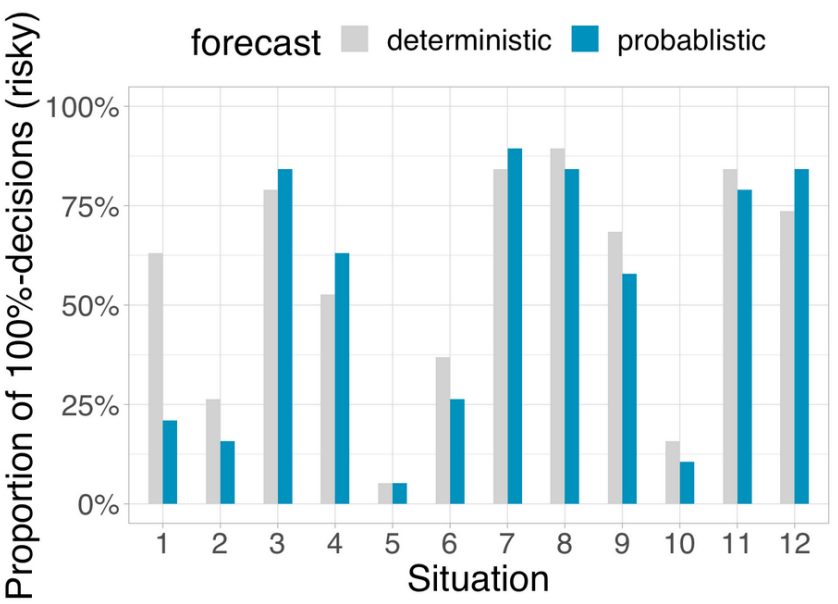
userID	probabilistic	deterministic
yggdrasil _ 34	12500	25000
testtest _ 47	17500	22500
statwars _ 36	22500	20000
Gggrte _ 51	22500	20000
itzybilitzy _ 35	20000	20000
NikNik _ 9	17500	20000
mattttt _ 1	15000	20000
Anemoi _ 11	12500	20000
qwerty _ 5	12500	20000
fcstX1 _ 30	27500	17500
Kassandra _ 51	27500	17500
Oleaster _ 53	25000	17500
Tester101 _ 18	22500	17500
GatForecast _ 25	22500	17500
Sidhe1 _ 27	20000	17500
Trader 48	20000	17500

Forecast Game: Offshore wind power decision making in extreme events

ANALYSIS – risky decisions -

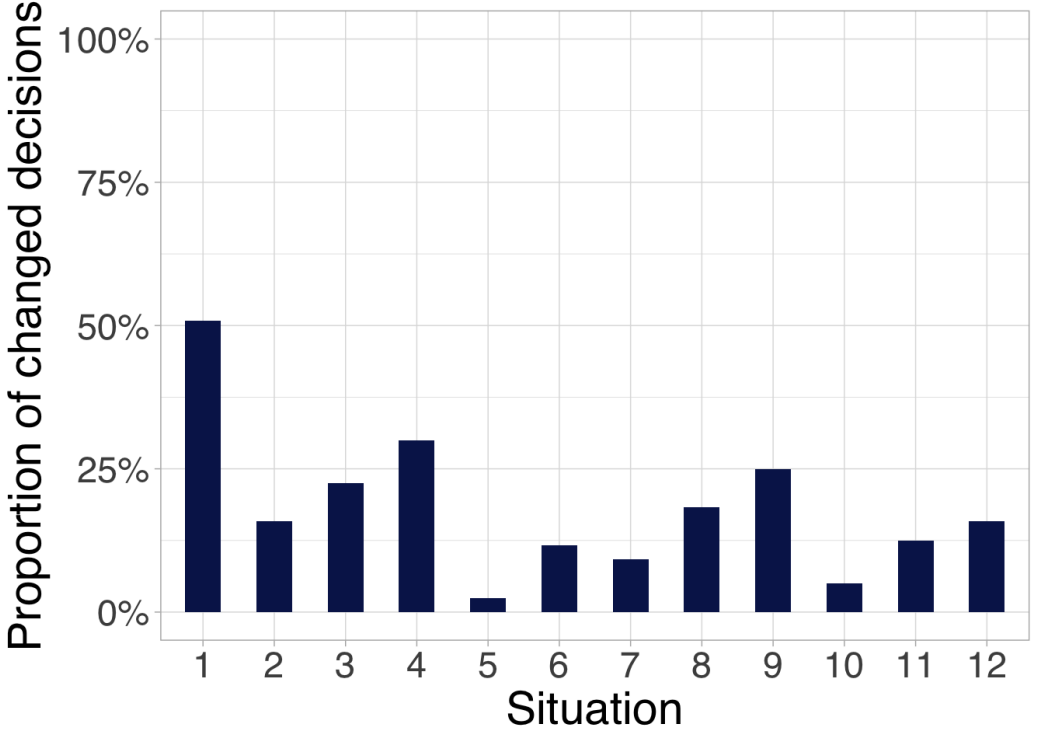
Proportion of risky decisions ("trading 100%)





ANALYSIS – changed decisions -

Proportion of changed decisions based on the probabilistic forecast



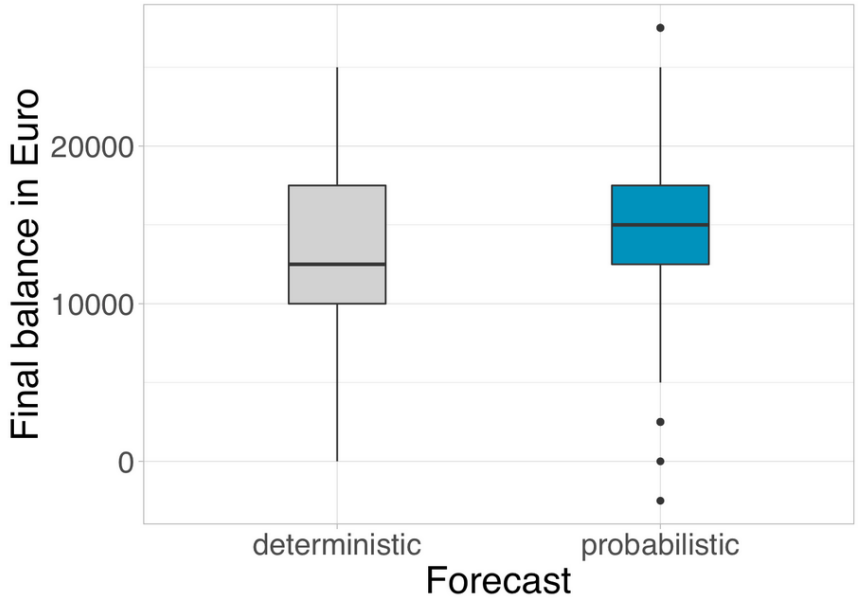
Across all decisions, **participants changed** their **mind in 18 % of the situations**.

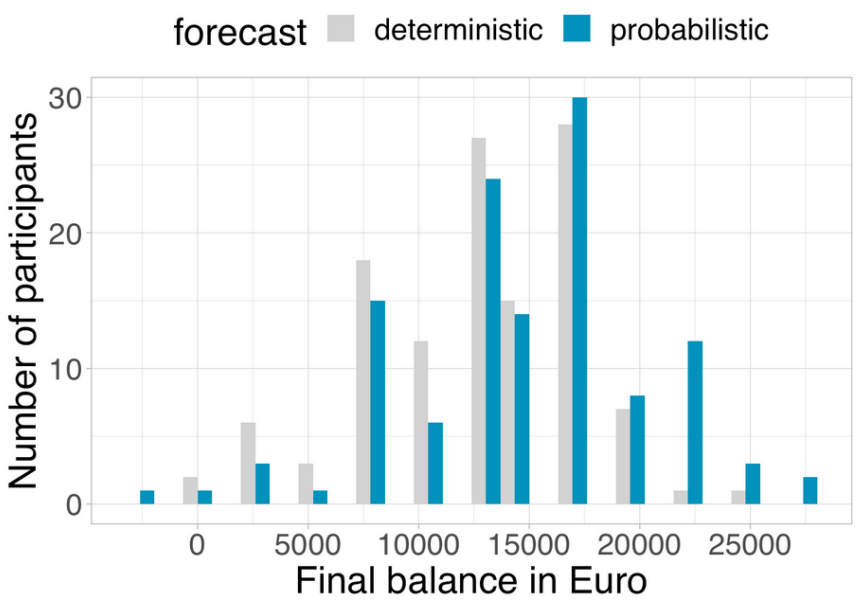
On an individual level, **91 % of the participants changed their mind at least once** based on the probabilistic forecast.

Forecast Game: Offshore wind power decision making in extreme events

ANALYSIS – final balance -

Distribution and histogram of participants' final balance based on deterministic vs. probabilistic forecasts

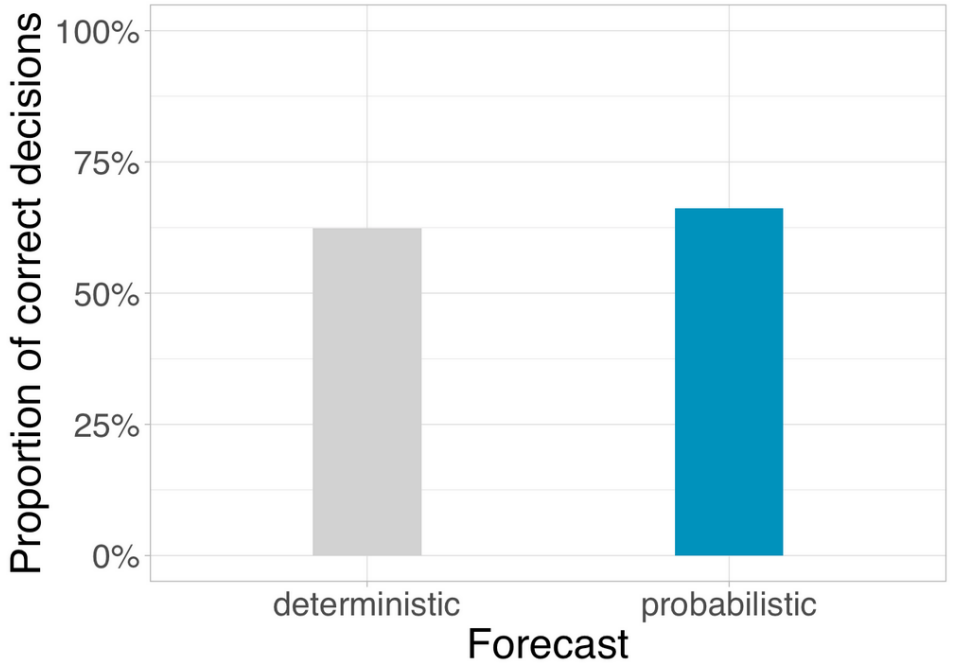


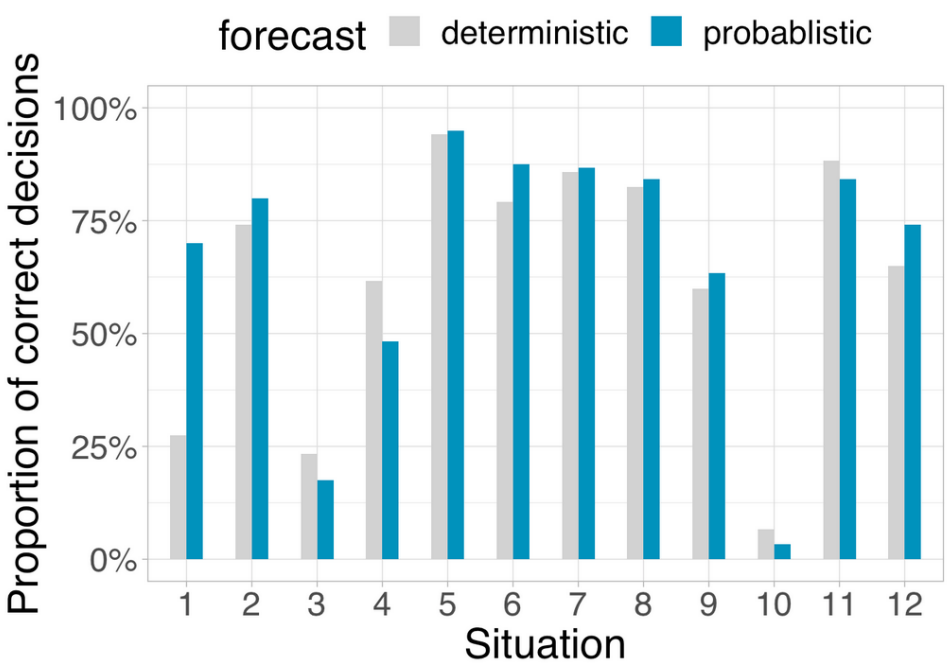


Forecast Game: Offshore wind power decision making in extreme events

ANALYSIS – correct decisions -

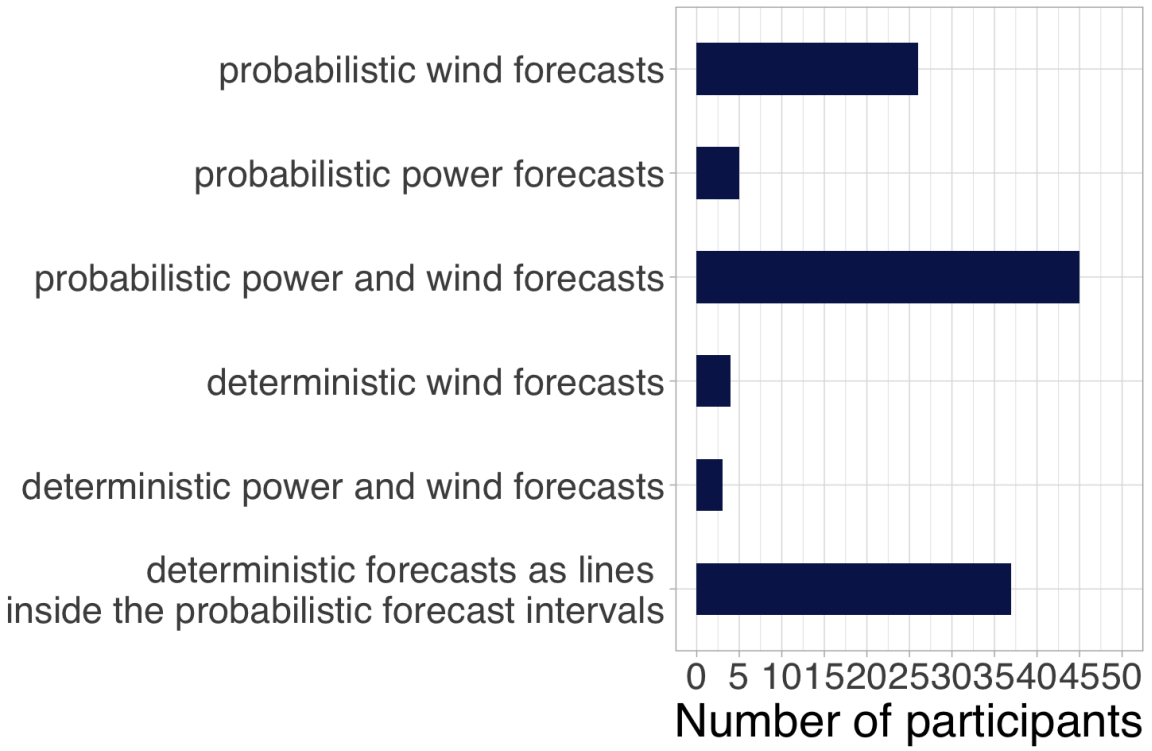
Proportion of correct decisions based on deterministic vs. probabilistic forecasts





ANALYSIS of Questions – preferred information -

Histogram of participants' preferred information



No one preferred to make decisions based on deterministic power forecast alone.