



Session 11 - Best Practices for the Selection of Optimal
Forecast Solutions for Renewable Electricity Generation
Applications (Core Science Keynote)



Wednesday, January 26, 2022

1:30 PM - 3:00 PM

ONLINE – VERSION

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IEA Wind Task 36 & WEXICOM “Probabilistic Forecasting Games and Experiments” initiative: **How do Humans decide under Wind Power Forecast Uncertainty?**

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).





WEXICOM Project – WP2 –

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



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

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.



WP2
Image Credit: Jürgen Rossbach (MPIB)

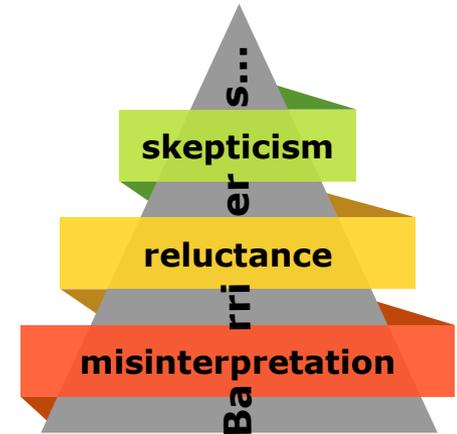
Goals and Objectives of the Initiative

Our aim is:

* test the **most known** and **observed barriers** of making use of uncertainty/ probabilistic/risk forecasts:

– *skepticism – reluctance – misinterpretation* –

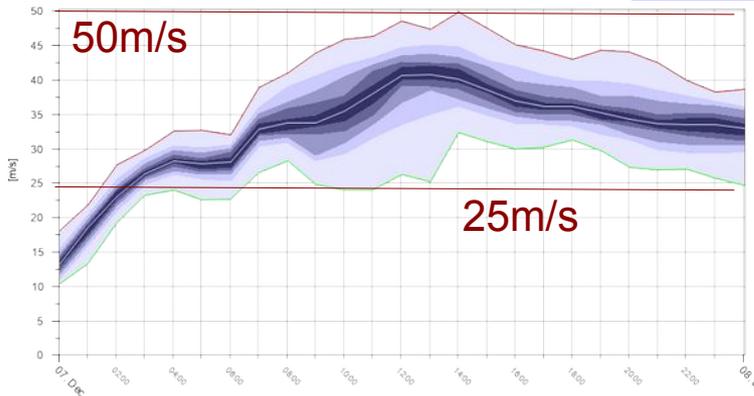
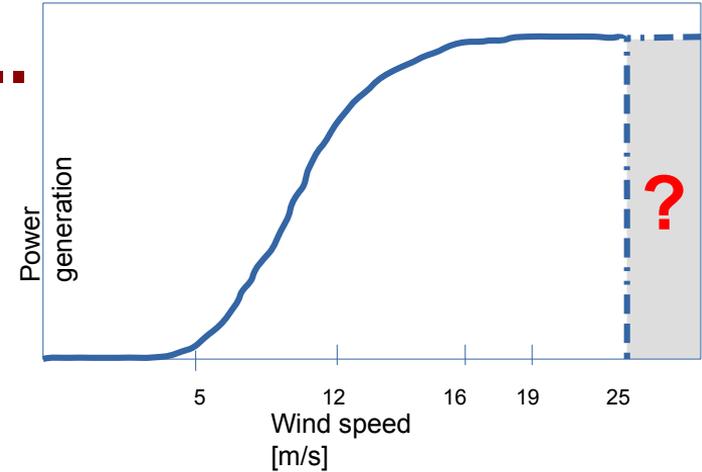
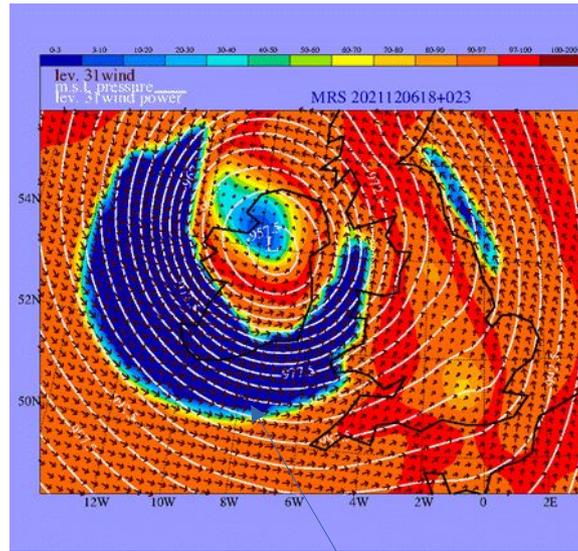
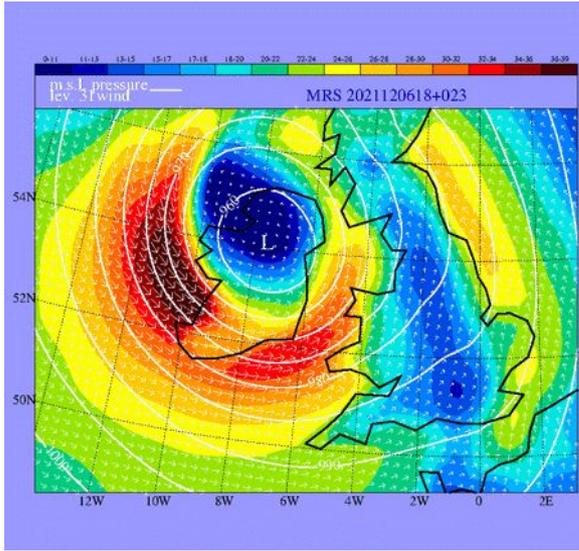
* **develop solutions to overcome** these personal barriers



Tools and design structures integrated in our experiments make use of:

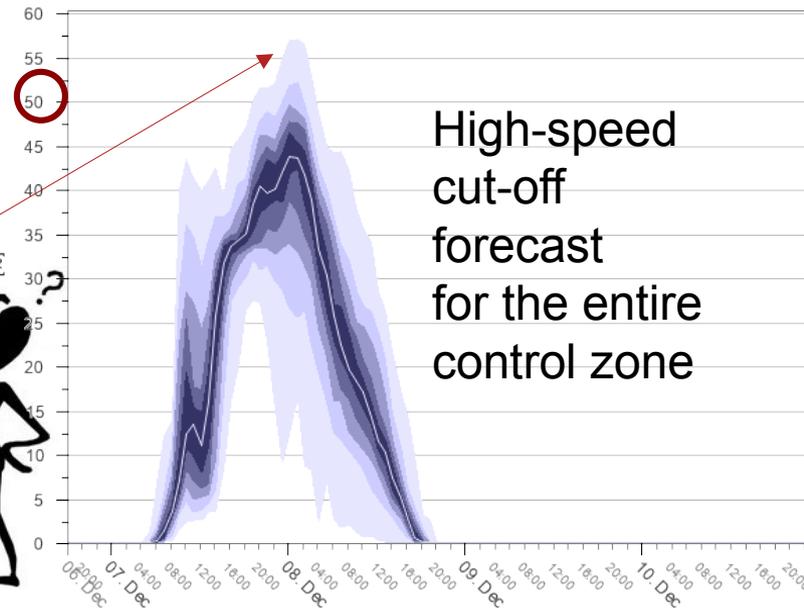
- i. Use of "**decision from experience**" principle rather than "**decision from description**"
- ii. Use of "**learning with feedback**" principle rather than "**theoretical learning**"
- iii. Use of **Gamification**: a game illustrates an action without the seriousness and responsibility that comes from real applications and "**a more relaxed atmosphere**"

Dealing with Extremes.... ...from forecast to impact...



Cut-off area

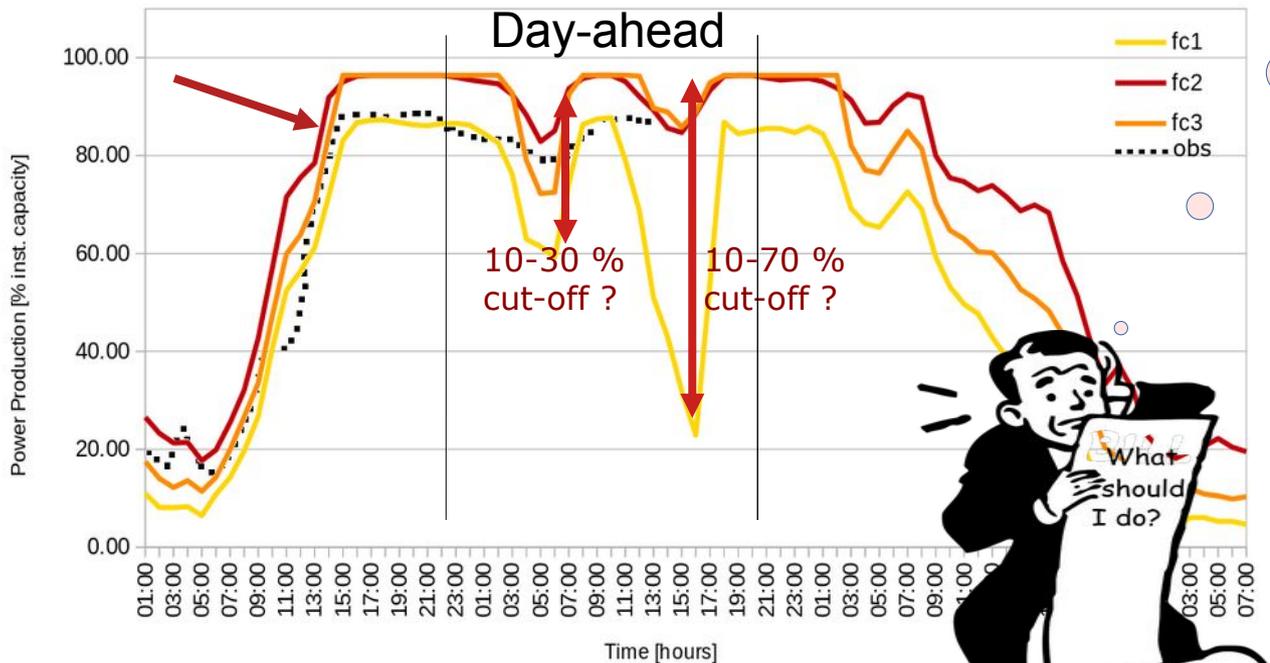
...if over 50% of capacity can drip, how do I have to handle this.. ?



Dealing with Extremes....

Scene: Decision to be made for Day-ahead:
Wind Power Forecast

..if the power last night didn't cut off, it will probably also not do so now...



Randomly selected

deterministic forecasts do not provide a realistic uncertainty!

Deterministic forecasts can deviate a lot for unknown reasons* or provide confidence, where there is no reason for confidence...!

* especially at the steep part of the power curve



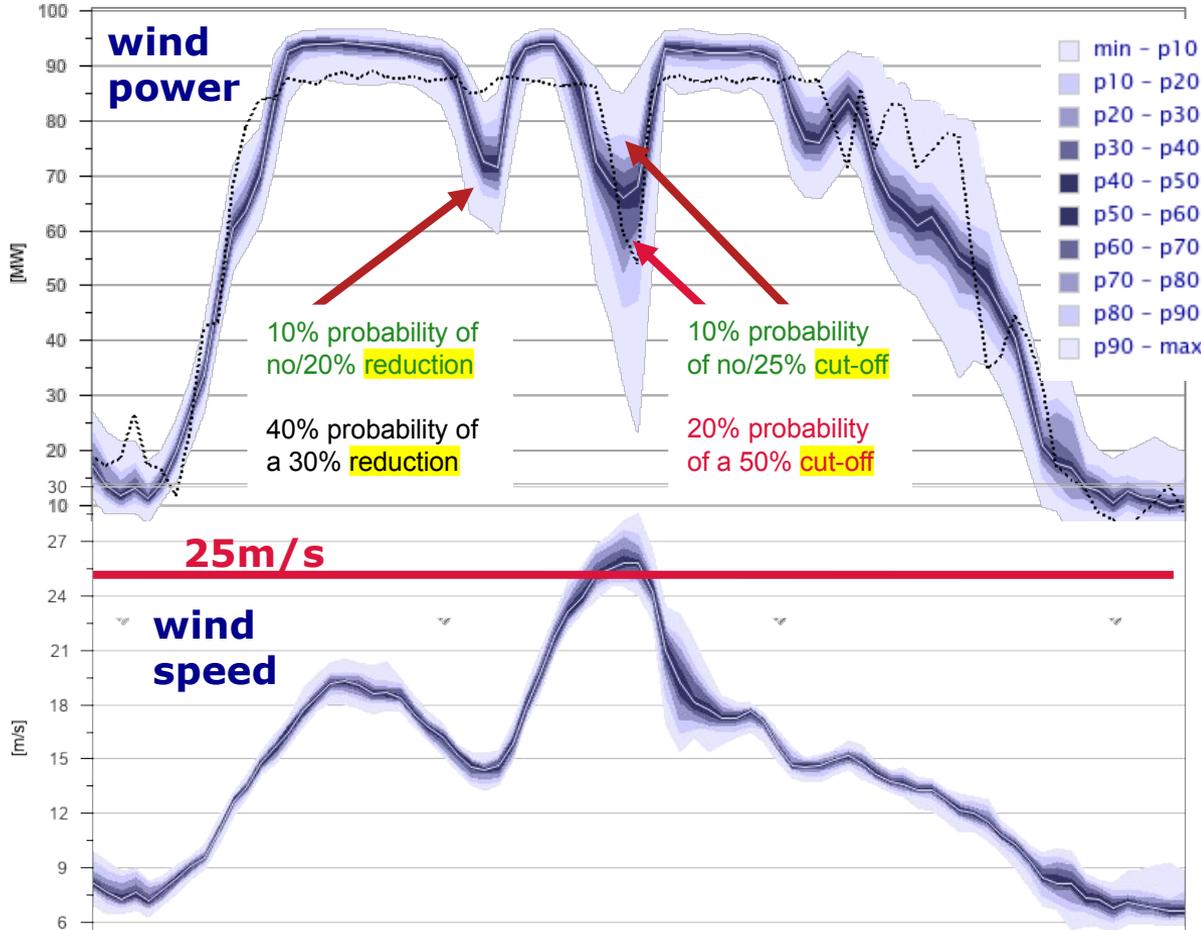
Dealing with Extremes....

iea wind
task 36/51



Scene: Decision to be made for Intra-day:

Wind Power + Wind Speed Forecast + **Uncertainty**



Considerations:

uninformed decision:

Decision on basis of 1-3 deterministic power forecasts

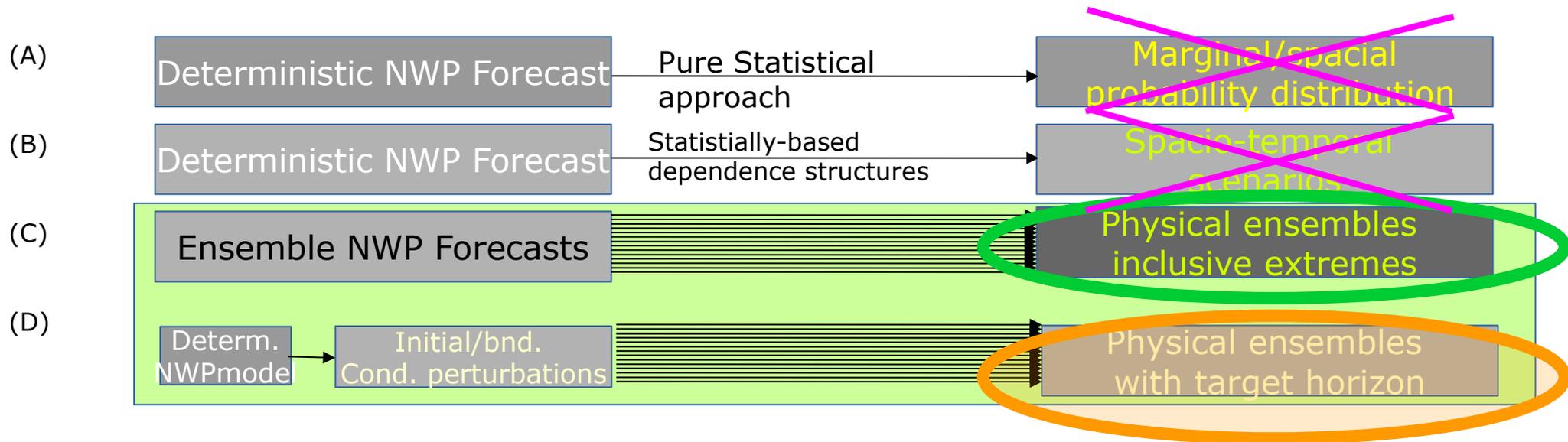
Deterministic forecasts can deviate a lot or provide confidence, where there is no reason for confidence...!

informed decision:

decision on the basis of at least **wind and power forecasts** + uncertainty → provides probability for worst case scenarios

High Speed Shut Down - also a question of methodology ? -

Know, which methodology works for your target problem !



For high-speed shutdown forecasts you need **to capture extremes**:

(A) + (B): statistical methods can only capture and predict, what has been there in the past

(A): Captures only climatology and cannot be aggregated over larger areas

(D): target horizons need calibration for the time component

Forecast Game Design: 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%.

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

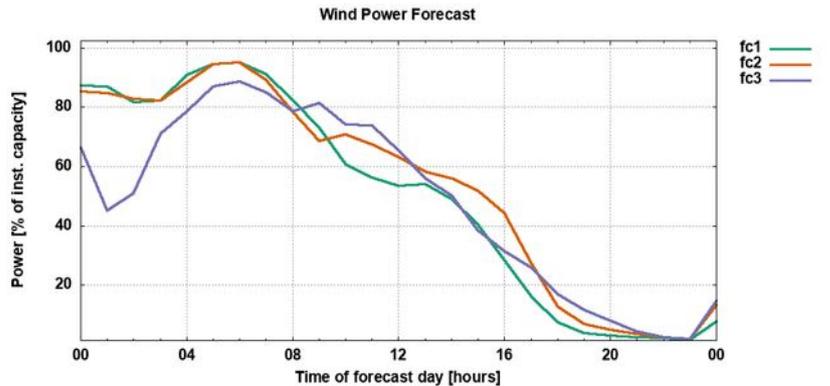
Experiment 2 (2021/2022): Wind park in complex terrain

* <https://iea-wind.org/task-36/work-packages/work-package-3-optimal-use-of-forecasting-solutions/probabilistic-forecast-games/>

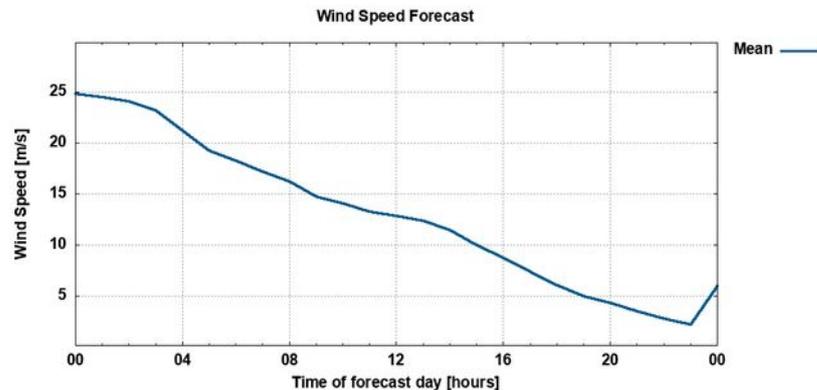
Forecast Game: decision-making in extreme events

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.



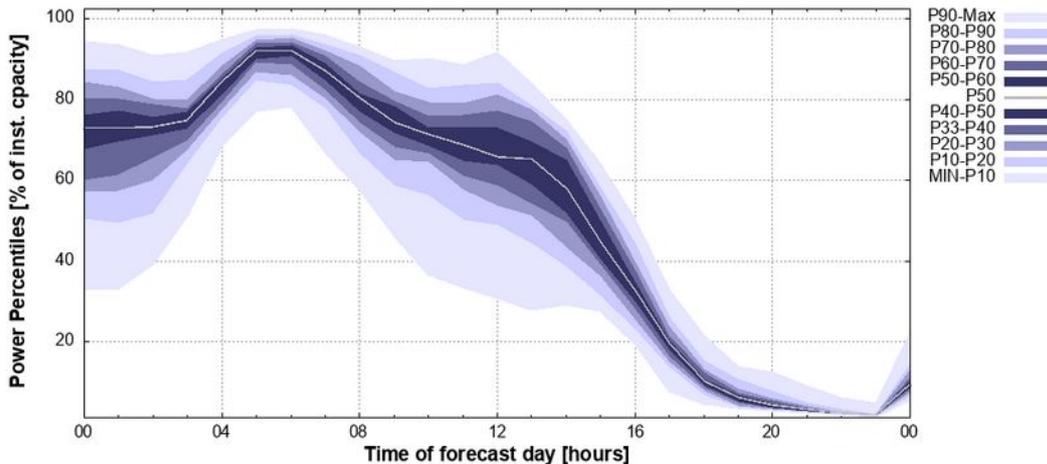
3 independent deterministic wind power forecasts in the unit [% of installed capacity] based on 3 different NWP (numerical weather prediction) models



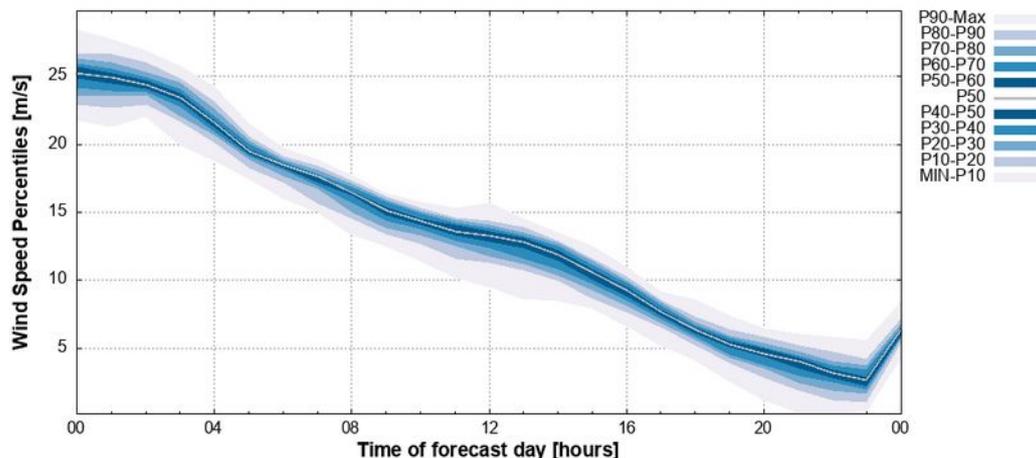
1 wind speed forecast in the unit [m/s], which is a mean forecast from 75 ensemble members and smoother than a typical deterministic forecast.

Forecast Game: decision-making in extreme events

Wind Power Forecast



Wind Speed Forecast



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 [% of installed capacity] generated from 75 NWP forecasts of a multi-scheme ensemble prediction system (MSEPS).

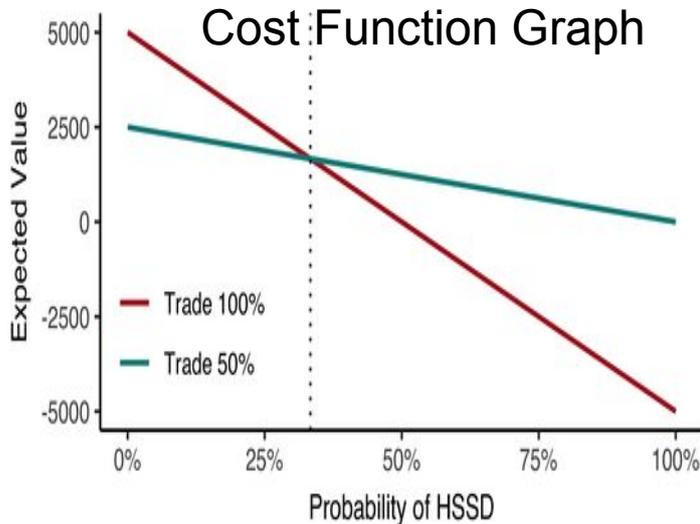
Note: The percentiles here are physically based uncertainty bands and provide an overview of the uncertainty of the forecast.

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.

Aspects on Cost Functions from 1st Experiment: "Offshore wind power trading in extreme events"

Cost Function Table

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



Percentiles in Forecast graphs

- min - p10
- p10 - p20
- p20 - p30
- p30 - p40
- p40 - p50
- p50 - p60
- p60 - p70
- p70 - p80
- p80 - p90
- p90 - max

Some interesting aspects of the cost function:

- if the probability of a HSSD exceeds 33% trading 50% will give higher payoff
- if the probability of a HSSD < 33% trading 100% will give higher payoff

Can/Could participants read this out ?

Deterministic forecasts: no information

Probabilistic forecasts:

→ percentiles provided information about the probability in wind and power !

1st Experiment Design (2020)

Value of probabilistic power forecasts

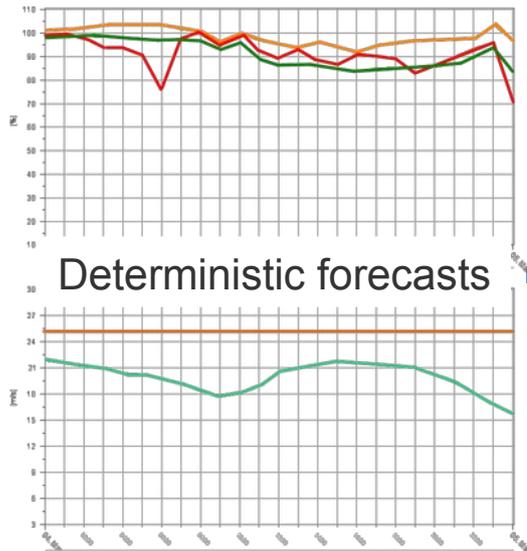
How do professionals decide based on probabilistic wind & power forecasts?

Design & Analysis: Dr. Nadine Fleischhut*, Dr. Corinna Möhrlen** & Dr. Ricardo Bessa (INESCTEC)

Host of Experiment: *Max-Planck Institute for Human Development, Hans-Ertl Center of 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?



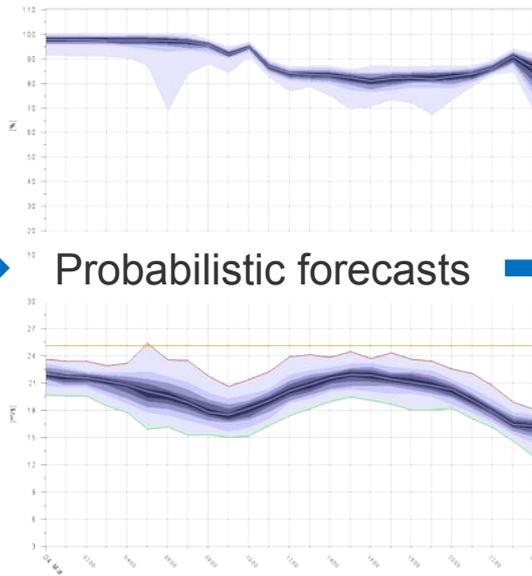
Power forecasts

Deterministic forecasts

Wind forecasts

→ 1st Decision

→



Probabilistic forecasts

→ 2nd Decision

Cost function

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

2nd Experiment Design (2021/22)

Value of probabilistic power forecasts

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

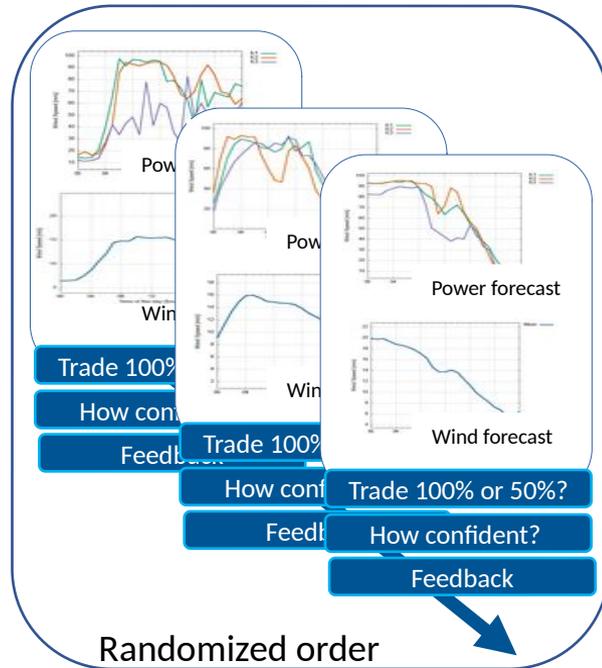
Design & Analysis: Dr. Nadine Fleischhut*, Dr. Corinna Möhrlen**

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Ensemble Forecasts: **MSEPS 75 Member EPS of WEPROG

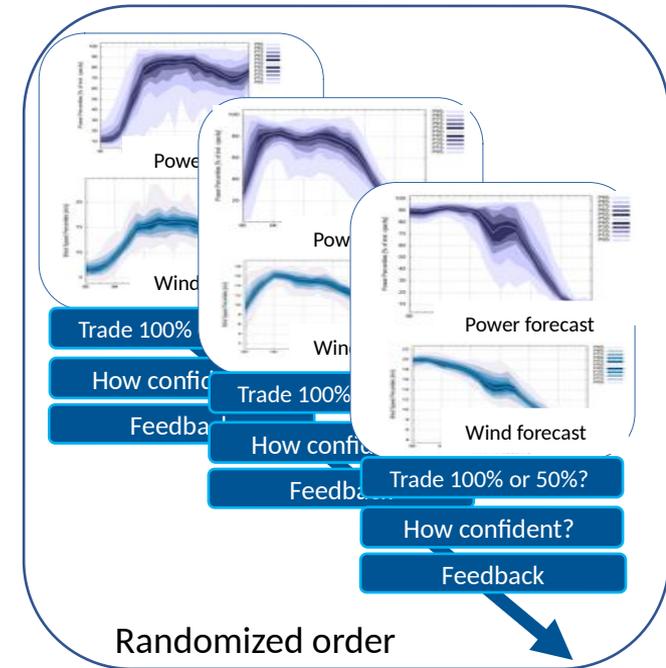
Trade 100% or only 50% wind energy - given the risk of high-speed shutdown?

Each participant →



20 decision situations with deterministic forecasts

↔ Blocks randomized

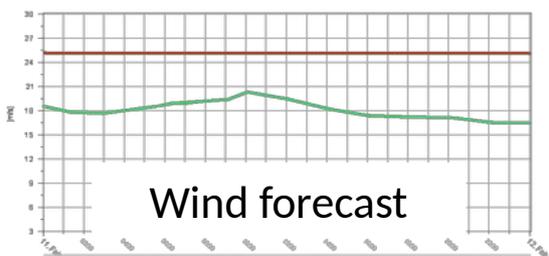
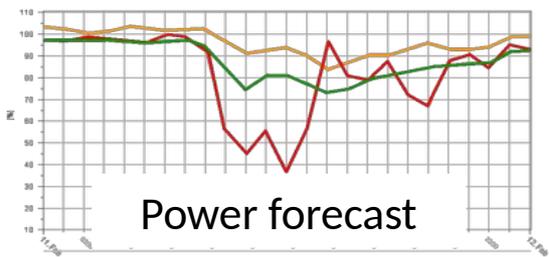


20 decision situations with probabilistic forecasts

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

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

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



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

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**

Trade 100%

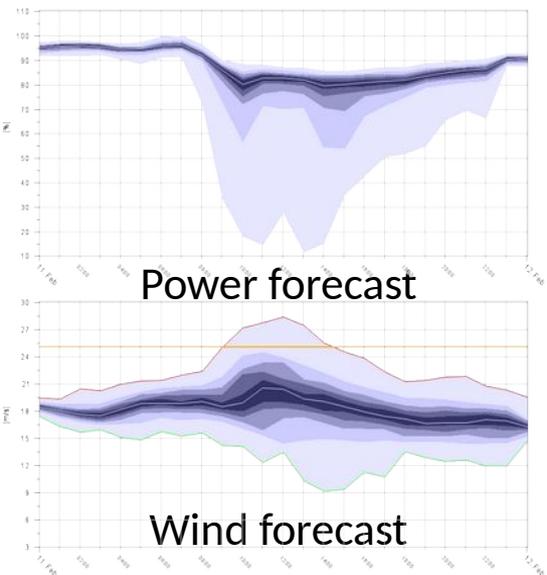
Trade 50%

Feedback

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

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

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



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

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

Trade 100%

Trade 50%

Feedback

Summary and Take-away

Probabilistic forecasts can benefit decision making...

Can we break down the barriers ?

Do we need to go from „description“ to „impact“ ?

Tailor information: Probabilistic information can improve decisions

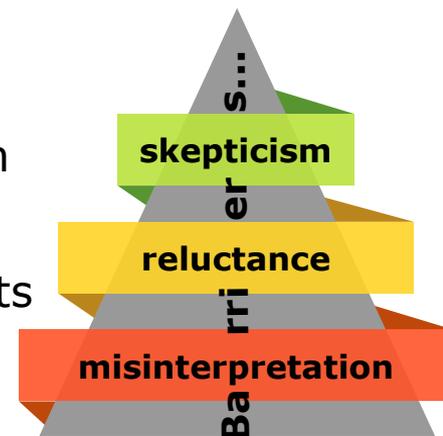
- Define the decisions that have to be made precisely

Risk communication: Improve risk perception via transparent representations

- Evidence-based design and evaluation of different representations
- From pure **forecast description** to **impact from forecast**

Decision support: **Define how to decide** based on probabilistic information

- Allow users to learn by feedback instead of by description
- Provide cues for interpretation or directly provide impacts from forecasts
- Put information in perspective (e.g. possible impact from the forecast)
- Provide simple and robust heuristics /decision strategies & the impact



2nd 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 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

Link for the 2nd experiment

Open to Play!

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

iea-wind.org

→ Task 36 → Workpackage 3

→ Forecast Games

Any questions ?
... if not ...



Join at www.kahoot.it
or with the Kahoot! app

Kahoot!

AMS-2022-Teaser



Get ready to join

Game PIN:

Join at www.kahoot.it
or with the Kahoot! app

931 7947



Scores Report from the Kahoot! Game

Report

Report options 

Live 

AMS2022-Teaser 

January 26, 2022, 5:41 PM

Hosted by ieawind36.wp3

Summary Players (11) Questions (10) Feedback

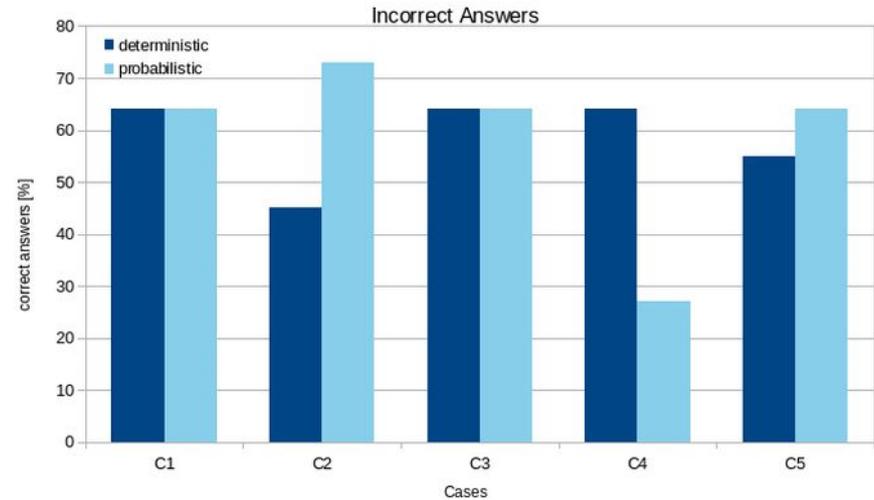
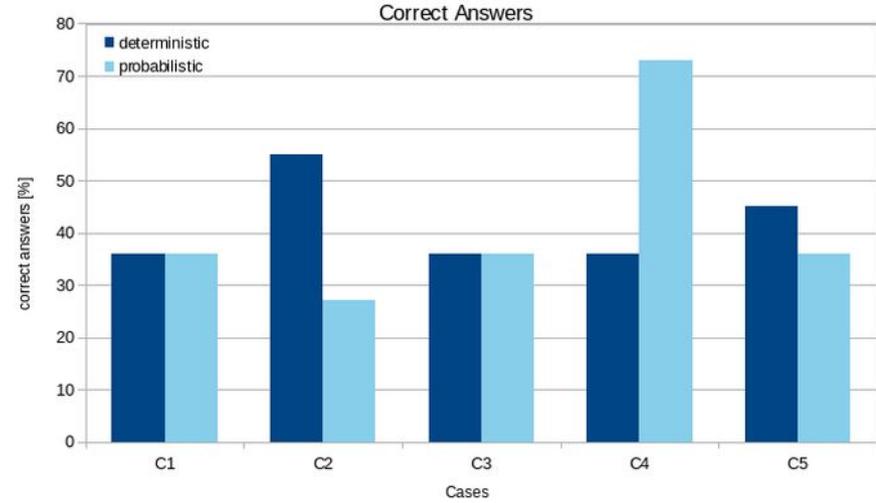
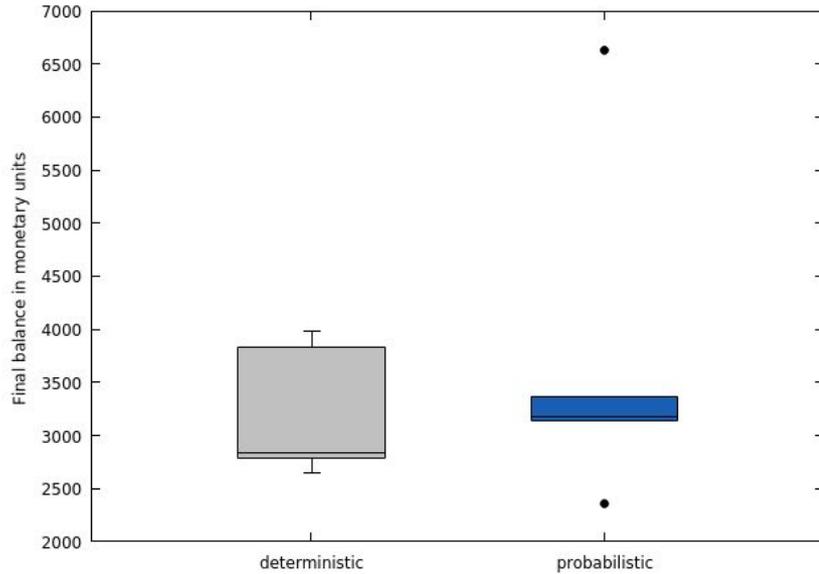
 Expanded view  Compact view

All (10)		Difficult questions (1)		Search	
Question	Type	Correct/incorrect			
1 Given the <u>3 Wind Power Forecasts</u> (upper fig) and 1 wind speed (lower fig) - how much do you w...	Quiz	 36%			
2 Given the <u>3 Wind Power Forecasts</u> (upper fig) and 1 wind speed (lower fig) - how much do you w...	Quiz	 55%			
3 Given the <u>3 Wind Power Forecasts</u> (upper fig) and 1 wind speed (lower fig) - how much do you w...	Quiz	 36%			
4 Given the <u>3 Wind Power Forecasts</u> (upper fig) and 1 wind speed (lower fig) - how much do you w...	Quiz	 36%			
5 Given the <u>3 Wind Power Forecasts</u> (upper fig) and 1 wind speed (lower fig) - how much do you w...	Quiz	 45%			
1 Given the Wind Power (upper fig) and wind speed (lower fig) <u>Uncertainty Forecast</u> - how much d...	Quiz	 36%			
2 Given the Wind Power (upper fig) and wind speed (lower fig) <u>Uncertainty Forecast</u> - how much d...	Quiz	 27%			
3 Given the Wind Power (upper fig) and wind speed (lower fig) <u>Uncertainty Forecast</u> - how much d...	Quiz	 36%			
4 Given the Wind Power (upper fig) and wind speed (lower fig) <u>Uncertainty Forecast</u> - how much d...	Quiz	 73%			
5 Given the Wind Power (upper fig) and wind speed (lower fig) <u>Uncertainty Forecast</u> - how much d...	Quiz	 36%			

Scores Report from the Kahoot!

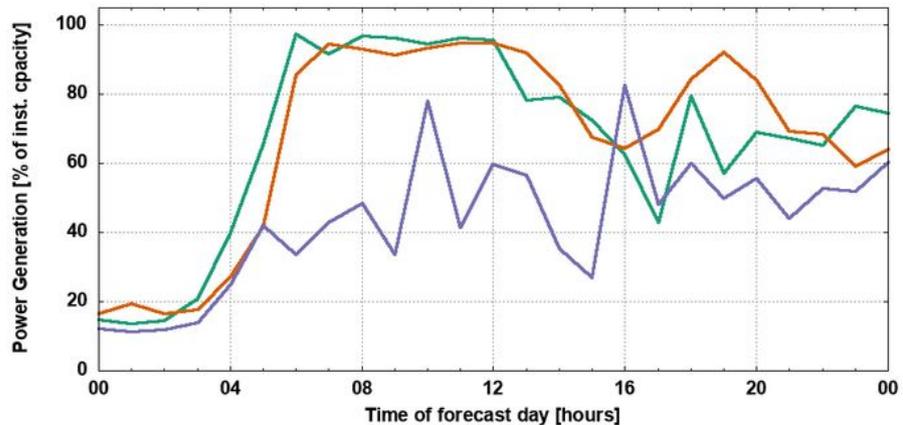
Final balance

AMS2022-Teaser

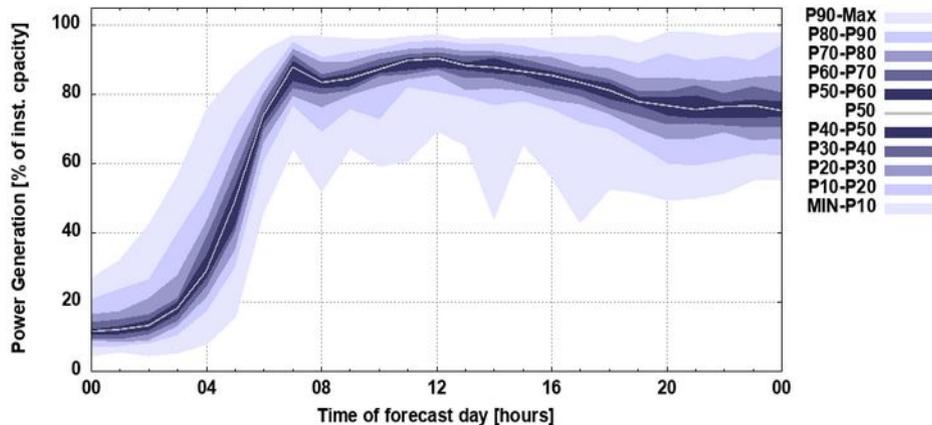


CASE 2: High Speed Event

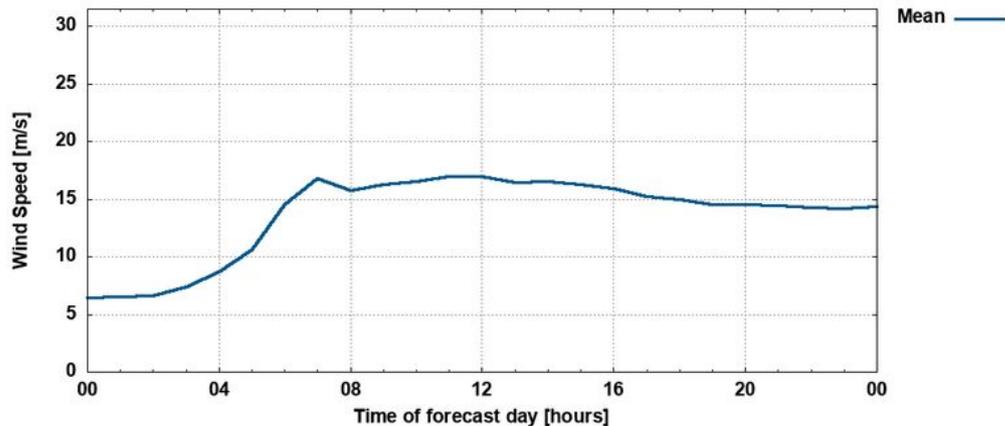
Wind Power Forecast



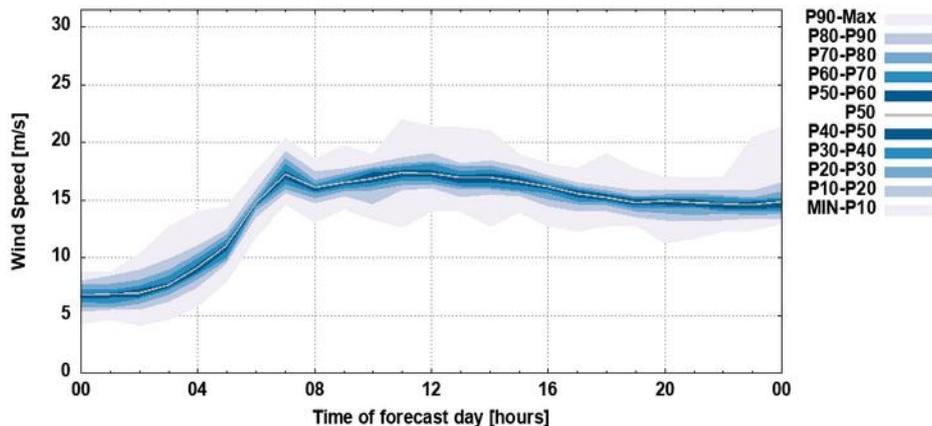
Wind Power Forecast



Wind Speed Forecast

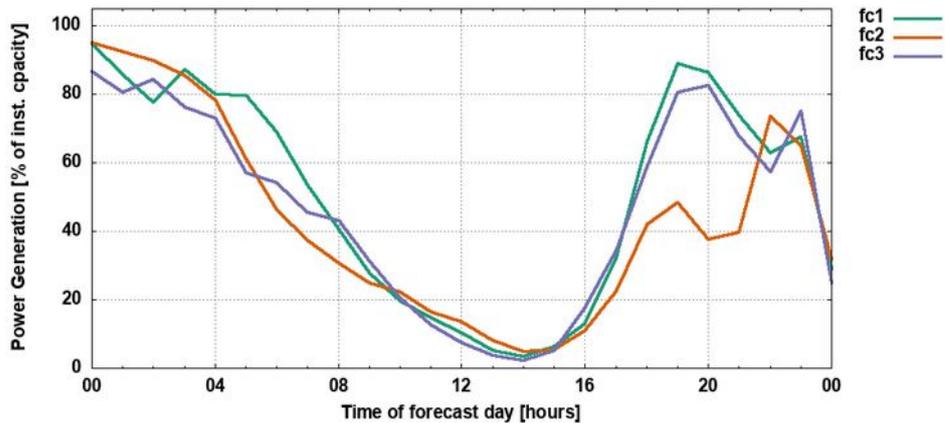


Wind Speed Forecast

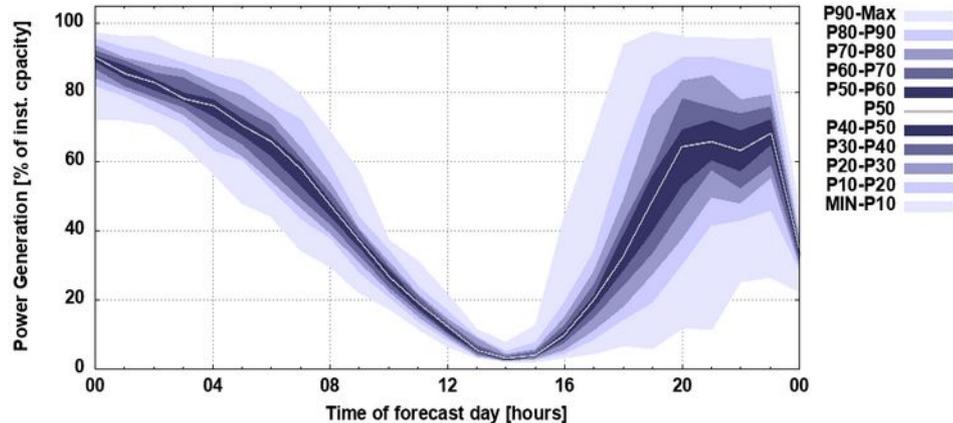


CASE 4: High Speed Event

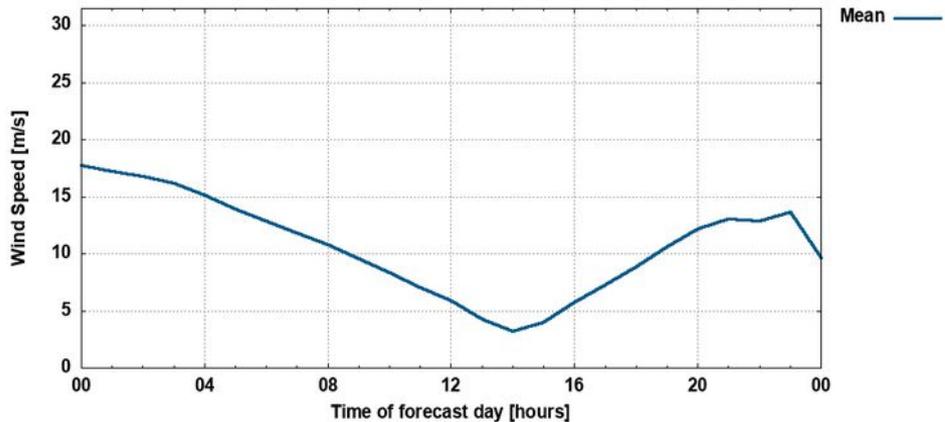
Wind Power Forecast



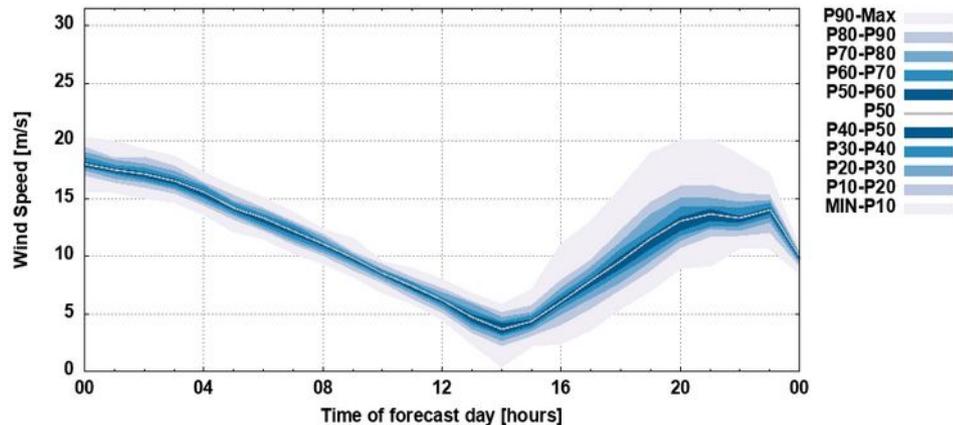
Wind Power Forecast



Wind Speed Forecast



Wind Speed Forecast



Result from the Kahoot AMS2022 Teaser



THANK YOU

Follow us:

Project webpage <http://www.ieawindforecasting.dk/>

Task-page: <https://www.ieawindforecasting.dk/work-packages/workpackage-3>

Publications: <https://www.ieawindforecasting.dk/publications>

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

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Contact Operating Agent:

Dr. Gregor Giebel, DTU Wind
grgi@dtu.dk



Link for the 2nd experiment

Version **Open to Play!**

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

Contact Behavioural & Cognitive Scientist:

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

Additional Slides