IEA Wind Task 36 & WEXICOM “Probabilistic Forecasting Games and Experiments” initiative:

How do Humans decide under Wind Power Forecast Uncertainty?

Electric City Conference 2021 – Forecasting - WindEurope's annual on- and offshore wind energy event
25th Nov. 2021, 11.45-12.30 Copenhagen

‘It is better to be roughly right than precisely wrong.’
— John Maynard Keynes (attributed)

Dr. Corinna Möhrlen, WEPROG
Dr. Gregor Giebel, DTU
Dr. Ricardo Bessa, INESC TEC
Dr. Nadine Fleischhut, MPI-B
Goals and Objectives of the Initiative

...the overarching goal is to demonstrate the value of using probabilistic forecasts in the Renewable Energy Sector

→ What we develop: unified and inter-disciplinary approaches

→ How we work: merge of separate fields and competencies
  Energy-Meteorology
  Statistical Mathematics
  Behavioural & Cognitive Science

→ What we use: behavioural decision experiments
  * simulate real-time problems (“gamification”) for specific user groups
  * formulate strategies for applications & research
  * design experiments to study communication and knowledge gaps
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 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).
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

See e.g. Bessa et al. 2017, Haupt et al. 2019
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.
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.
Which cues ("predictors") do people use and why?

Simple heuristic decision tree?

Wind forecast close to threshold?

- Yes
  - Simultaneous drop in power forecast?
    - No
      - No High-Speed Shut down
    - Yes
      - High-Speed Shut down with $p = \ ?$
        - Depending on the uncertainty?
  - No
    - No High-Speed Shut down
When dealing with Extremes....

Decision Clues...

Remember:
Each uncertainty band contains 10% of the 75 forecasts, i.e.
P10 = 10%
P20 = 20%
...
P90 = 90% of forecasts below that value!
Forecast Game: decision-making in extreme events
- Aspects to consider on Cost Function -

Cost Function Table

<table>
<thead>
<tr>
<th>Trading</th>
<th>HSSD*</th>
<th>No HSSD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>-5.000</td>
<td>5.000</td>
</tr>
<tr>
<td>50%</td>
<td>0</td>
<td>2.500</td>
</tr>
</tbody>
</table>

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

Deterministic forecasts: no information

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

Percentiles in Forecast graphs
- min - p10
- p10 - p20
- p20 - p30
- p30 - p40
- p40 - p50
- p50 - p60
- p60 - p70
- p70 - p80
- p80 - p90
- p90 - max

Cost Function Graph
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).

Link for the 2nd experiment
Open to Play!
https://arc-vlab.mpib-berlin.mpg.de/wind-power/experiment/

...check out our poster PO008 for the link or our webpage
iea-wind.org/task36 → workpackage 3 → Forecast Games
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?

Design & Analysis: Dr. Nadine Fleischhut*, Dr. Corinna Möhrlein**
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?
Forecast Game: 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

<table>
<thead>
<tr>
<th>Trading</th>
<th>HSSD*</th>
<th>No HSSD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>-5.000</td>
<td>5.000</td>
</tr>
<tr>
<td>50%</td>
<td>0</td>
<td>2.500</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th></th>
<th>HSSD</th>
<th>No HSSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading 100%</td>
<td>-5000</td>
<td>5000</td>
</tr>
<tr>
<td>Trading 50%</td>
<td>0</td>
<td>2500</td>
</tr>
</tbody>
</table>

High-speed shutdown occurred.
If you trade 100%, you lose 5000 EUR
If you trade 50%, you neither lose or gain anything.

You chose to trade 100%.
You current balance therefore is: -5000
How do professionals decide based on probabilistic wind/power forecasts?

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

**High-speed shutdown occurred.**

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

You chose to trade 50%.
You current balance therefore is: 0
Any questions? ... if not ...

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

Follow us:

Webpage: https://iea-wind.org/task-36/
Publications: https://iea-wind.org/task-36/task-36-publications/
YouTube Channel: https://www.youtube.com/channel/UCsP1rLoutSXP0ECZKiczXg

Contact WP Leader:
Dr. Corinna Möhrlen, WEPROG
com@weprog.com
Dr. Ricardo Bessa, INESC TEC
ricardo.j.bessa@inesctec.pt

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>

Link for the 2nd experiment
Open to Play!
https://arc-vlab.mpib-berlin.mpg.de/wind-power/experiment/