



# iea wind Task 51 "Forecasting for the weather-driven Energy System"

## Wind & Solar Integration Workshop

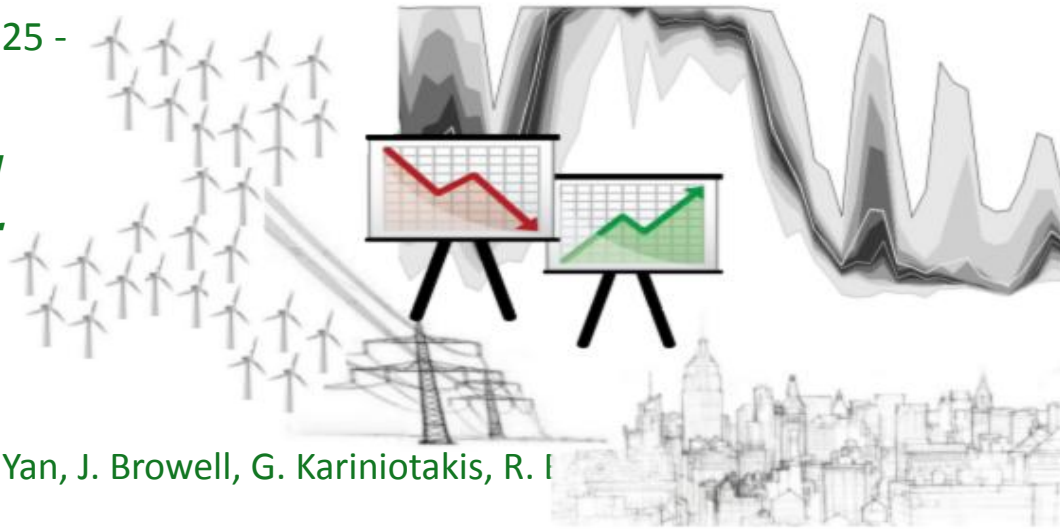
Session 3D

Berlin, Germany – 8<sup>th</sup> October 2025 -

### ***Extreme Power System Events within IEA Wind Task 51 Forecasting for the weather-driven Energy System***

Corinna Möhrle (WEPROG)

G. Giebel, H. Frank, C. Draxl, J. Zack†, J. Yan, J. Browell, G. Kariniotakis, R. I



# Tribute to John Zack in a nutshell

non judgemental  
pioneer  
humble  
Inspirational  
wizard  
weather & energy  
compassionate  
teamworker

...in the wind's whisper,  
John's legacy forever  
flows through our  
community...



John can be called out a true **pioneer** in the field of meteorology and energy. We, his colleagues, often thought of him being a **wizard** for his uncanny ability to see the bigger picture in the complexity of **weather and energy** systems. He was not only able to see how weather and climate trends develop, but also how they challenge the electric grid and how we can mitigate challenges with forecasting tools to harness as much of the energy produced by renewable resources. Despite his remarkable achievements in meteorology as well as the developments in the energy transition from small to large amounts of renewable energy on the grid, he always remained humble, always ready to listen and learn from others.

John's **non-judgemental** attitude made him a **compassionate** friend and an exceptional **teamworker**. He inspired everyone around him, not just through his own groundbreaking work, but also through his kindness and willingness to support others. His **inspirational** journey shows that with empathy and collaboration, it's possible to change the world for the better.

# IEA Wind Task 34 "Wind Energy Forecasting" (2016-2021)



iea wind

non-judgemental  
pioneer  
humble  
Inspirational  
wizard  
weather & energy  
compassionate  
teamworker

# IEA Wind Task 51 "Forecasting for the Weather Driven Energy System"



Glasgow Workshop, January 2020



Webinar December 2021, IEA Wind Task 36 Forecasting for Wind Energy - Day 1



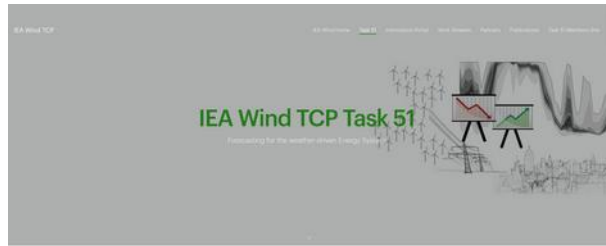
John has been **chairing and/or presenting** since 2018 at **30 workshops** and conferences and been part of **10 publications**, the largest effort the editing and writing of the *IEA Wind Recommended Practice for the Implementation of Renewable Energy Solutions*, published as an Open Access Book in 2022.



Workshop day 1: State of Art and Research Gaps in Forecasting for the Weather Driven Energy System.

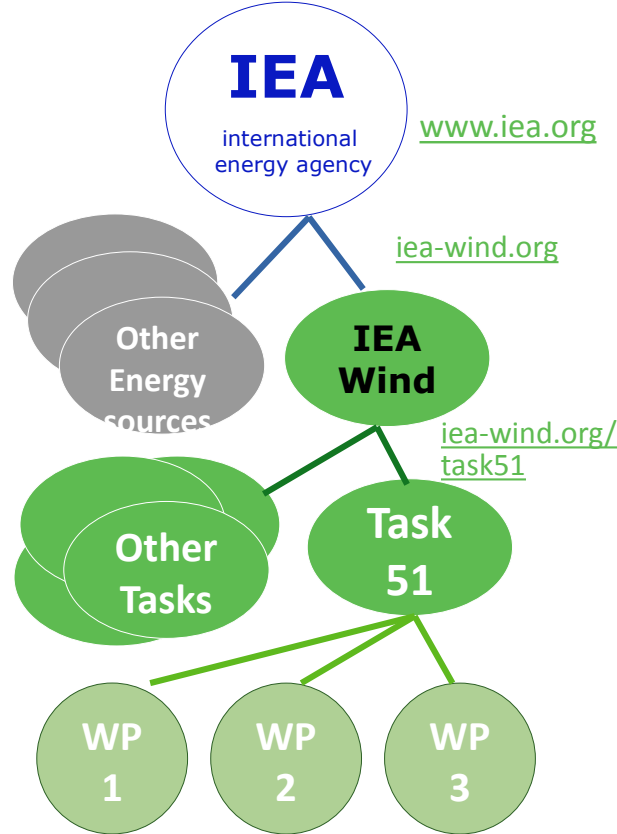
# Task 51: Forecasting for the weather-driven Energy System

**Task 51 homepage:**  
<https://iea-wind.org/task51>



About Task 51

Forecasting for the Weather-Driven Energy System – Improving the value of renewable energy forecasts to the wind industry



- Task 51 members (12)
- AT, CN, DE, DK, ES, FI, FR, IE, PT, SE, UK, US



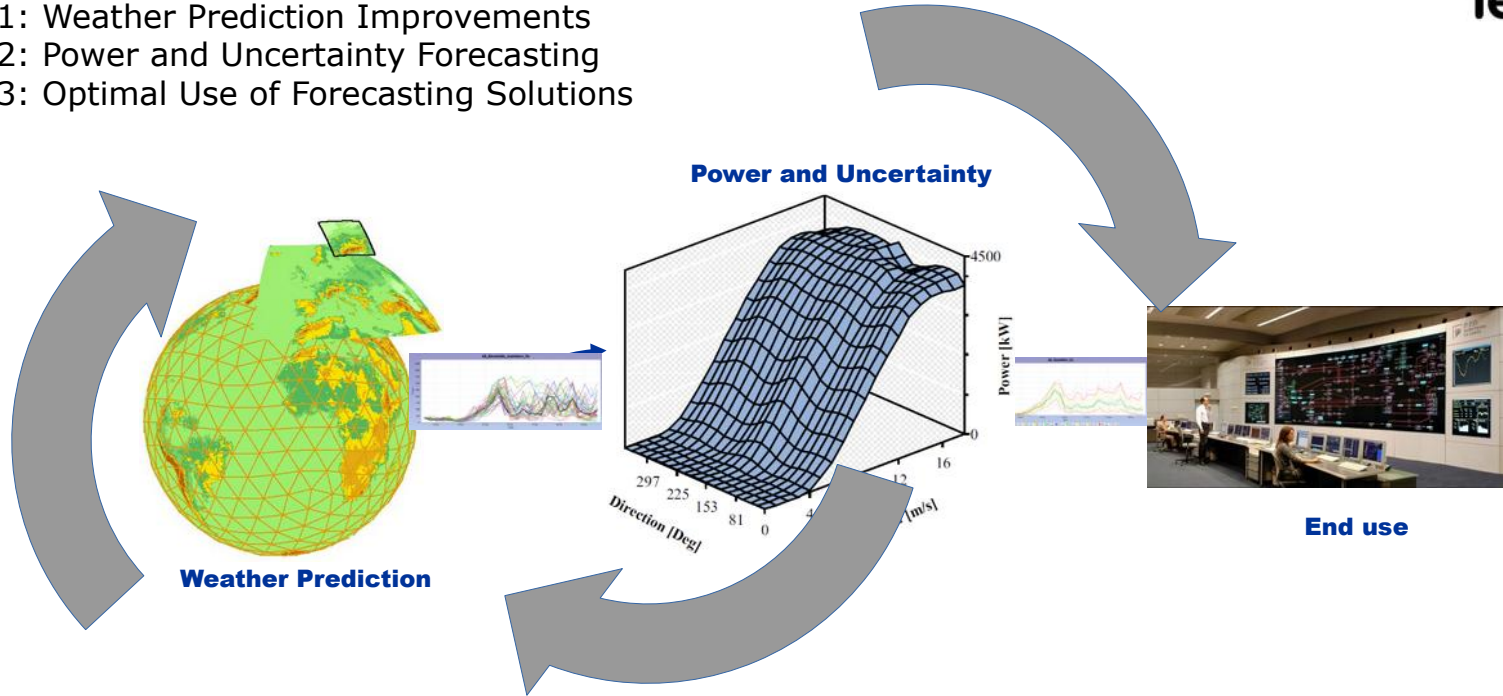
# IEA Wind Task 51 Work distribution

**Task Work is divided into 3 work packages:**

WP1: Weather Prediction Improvements

WP2: Power and Uncertainty Forecasting

WP3: Optimal Use of Forecasting Solutions



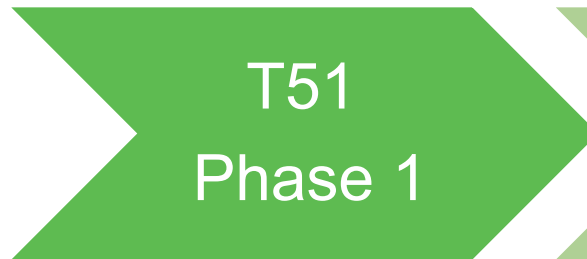
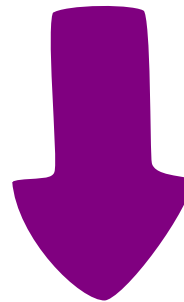
# Forecasting for Wind Energy

2016-2018

2019-2021



Redefinition



2022-2025



2026-2029

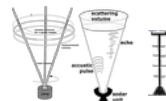
Forecasting for the weather-driven  
Energy System



iea wind

# IEA Wind Task 51 Work distribution – phase 1

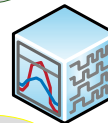
Work Streams:	WP1 Weather	WP2 Power	WP3 Applications
Atmospheric physics and modelling (WP1)	★		
Airborne Wind Energy Systems (WP1)	★		
Seasonal forecasting (WP1)	★		
State of the Art for energy system forecasting (WP2)		★	
Minute scale forecasting (WP2)		★	
Data science and artificial intelligence (WP3)			★
Extreme power system events (WP3)			★
Uncertainty / probabilistic forecasting (WP3) & for underserved areas			★
Decision making under uncertainty (WP3)			★
Privacy, data markets and sharing (WP3)			★
Value of forecasting (WP3)			★



Modelling & data assimilation



workshops



Verification Platform



Publications

## Collaborations

WMO, PVPS T16

IEA Task 48 Airborne Wind Energy

Hydro TCP, Hydrogen TCP, Biomass TCP

PVPS Task 16, Hydro TCP, Hydrogen TCP, IEC SC8A WG2, ...

Wind Tasks 52 Lidar, Task 44 Farm Flow Control and 50 Hybrids

PVPS Task 16

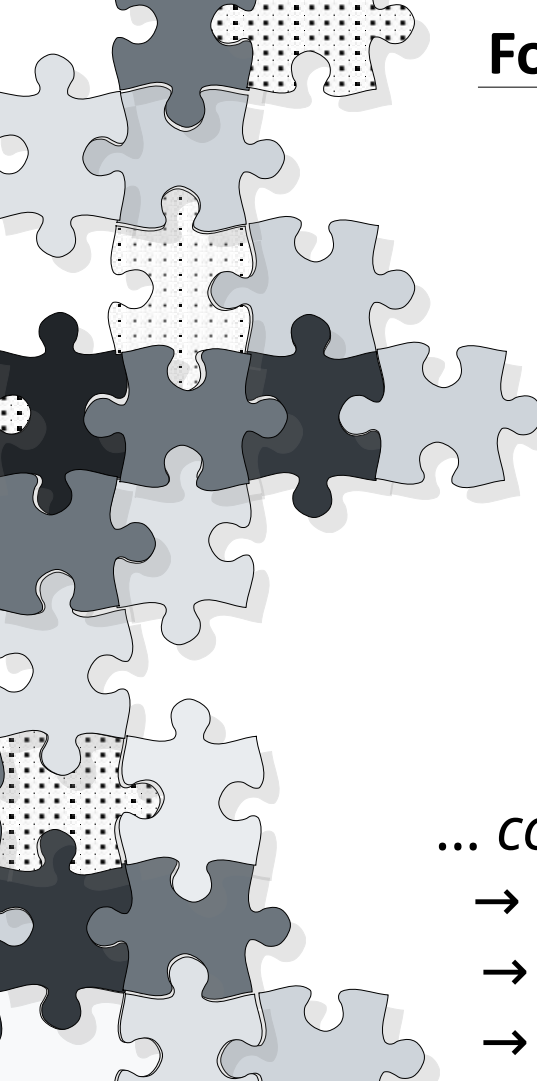
Task 25, ESIG, IEA ISGAN, PVPS T16, G-PST, DESTINE

ESIG, IEEE WG Energy Forecasting, PVPS Task 16, IEC SC8AWG2

EMS, WEMC, WEXICOM

PVPS Task 16, Wind Tasks 52 Lidar, DestinE, IEC SC8AWG2

PVPS Task 16



# Forecasting for the weather-driven Energy System

“

..to succeed with the energy transition, we need to **close the gap** between research and industry applications...

”

- ... *complex systems* require
- *Structured* solutions
  - *Cooperation* on all levels
  - a *holistic view* for solution development

# IEA's take on the VRE integration development: *Introduction to iea's VRE integration phases*

## Phases of VRE integration framework

### Low phases

**Phase 1: VRE has no significant impact at the system level**

**Phase 2: VRE has a minor to moderate impact on the system**

**Phase 3: VRE determines the operation pattern of the power system**

### High phases

**Phase 4: VRE meets almost all demand at times**

**Phase 5: Significant volumes of surplus VRE across the year**

**Phase 6: Secure electricity supply almost exclusively from VRE**

*VRE = variable renewable energy*

**The framework allows policy makers to identify VRE integration measures that need to be prioritised at each phase to ensure its timely implementation.**

**NOTE: Phases are not to be understood as decarbonisation measure, but as **integration challenge !!!****

Full presentation available here:

[Integrating Solar and Wind - Global experience and emerging challenges - launch webinar - Event - IEA](https://www.iea.org/events/integrating-solar-and-wind-global-experience-and-emerging-challenges-launch-webinar-Event-IEA)

<https://www.iea.org/events/integrating-solar-and-wind-global-experience-and-emerging-challenges-launch-webinar>

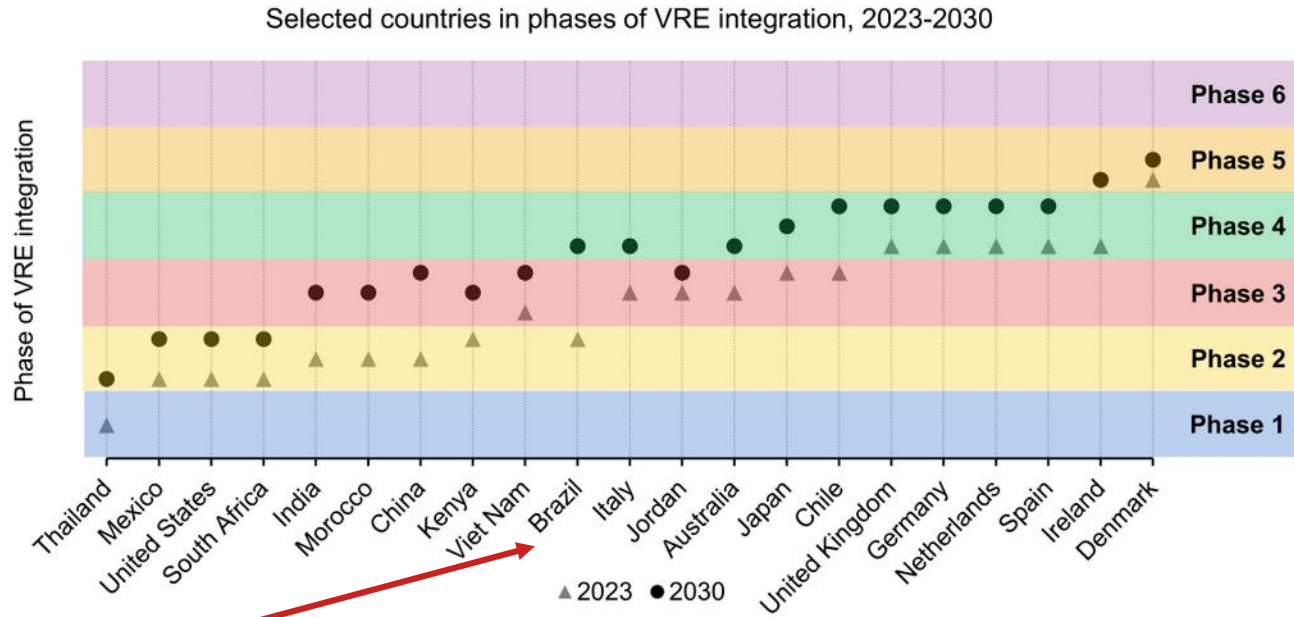
# IEA's take on the VRE integration development: Introduction to *iea's VRE integration phases*

30



## Legend

- 2030
- ▲ 2023

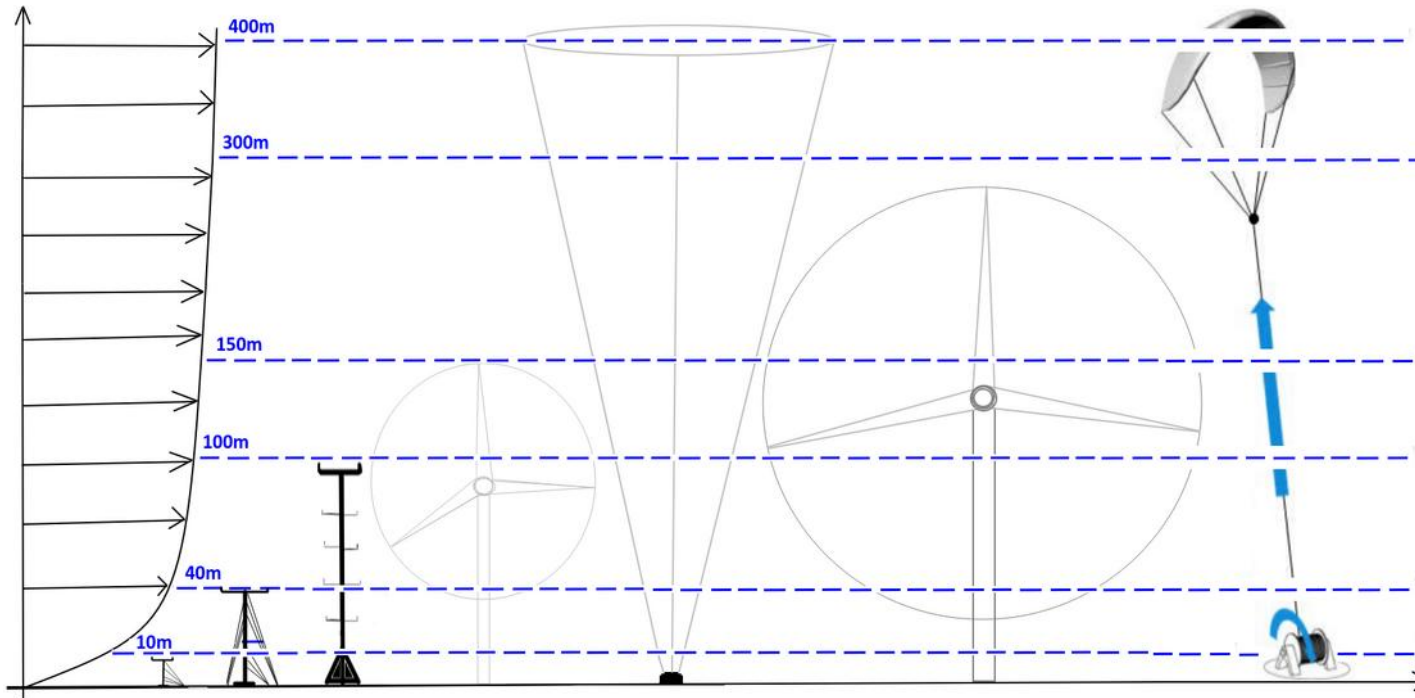


NOTE: Some countries are in low phases due to hydro power prevalence – not necessarily because they are not far enough in the decarbonisation!!

Some countries are currently classified at high phases with high wind penetration, but more systems will be at high phases by 2030, driven by solar PV penetration.

# From groups of single wind turbines to large-scale Wind Energy Systems

Penetration level: From 0.4% wind ... >40% wind in electric grids  
...2000 ...2025



# Workstream Atmospheric Modelling and Physics & first simulations for airborne wind



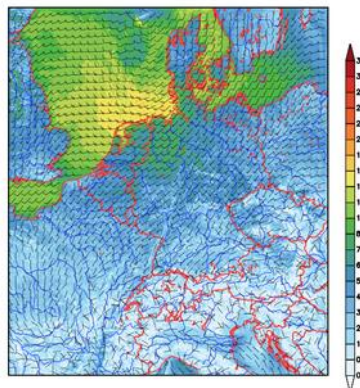
iea wind



Collaboration with Airborne Wind Task 48

DWD: data assimilation with 150-300m masts started

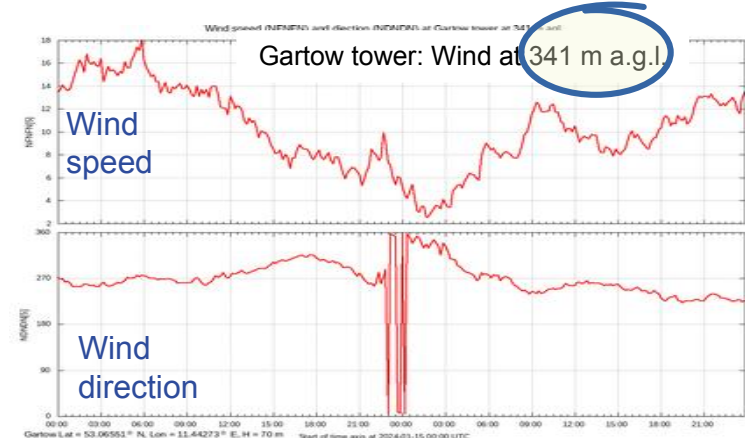
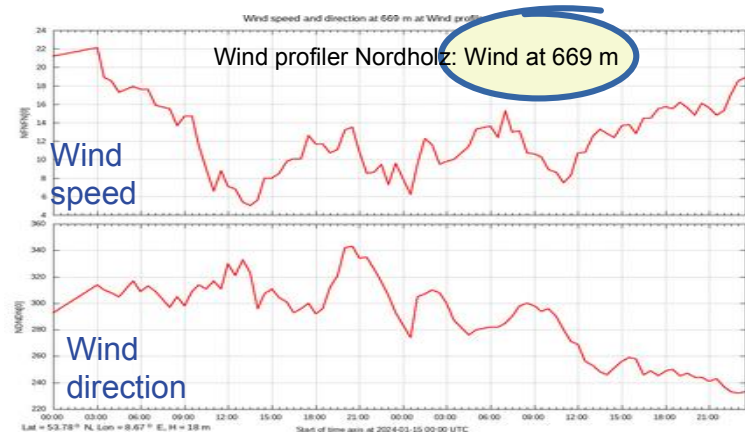
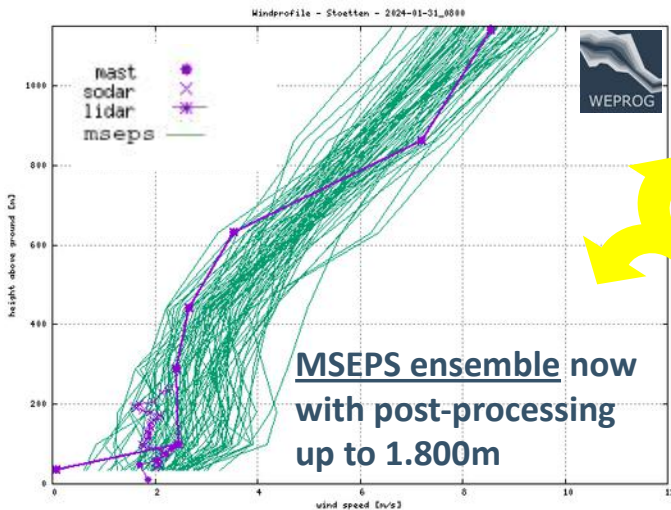
Start time: 02.11.2022 00:00 UTC  
Forecast time: 02.11.2022 08:00 UTC  
[M in 10 m [m/s] (shaded)



ICON-DE model now in 15min resolution every hour

Private and public weather forecast services prepare for phase 4-6

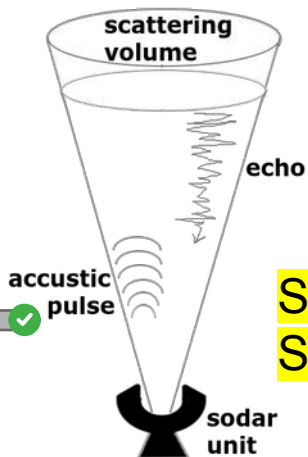
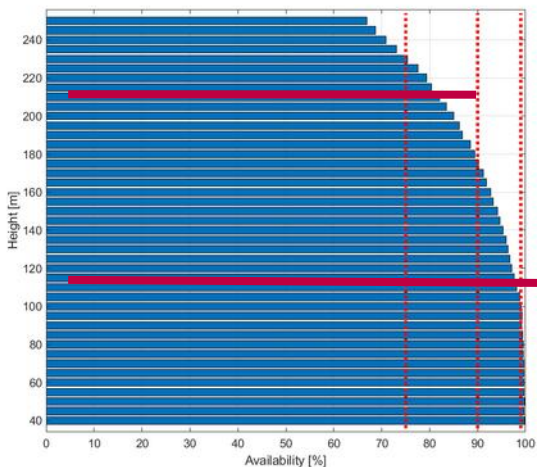
MSEPS ensemble now with post-processing up to 1.800m



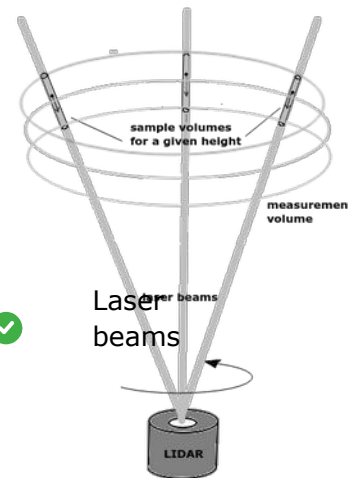
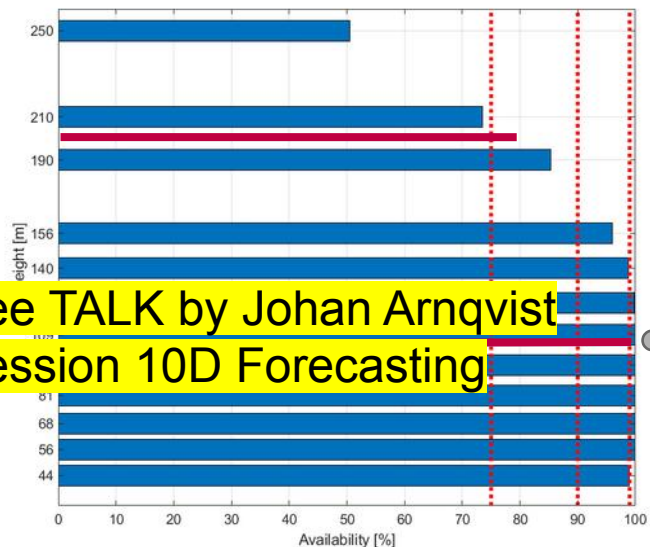
# Need for more Signal-processing Research

- ✔ Remote sensing device's volume based measurement with height is of advantage
- ✘ Availability of "trustworthy" data from remote sensing devices deteriorate with height...

## SODAR



## LIDAR



See TALK by Johan Arnqvist  
Session 10D Forecasting

--> The aim of signal processing research is to **enhance availability & trustworthiness**  
... and **make instruments fit-for-purpose**



# Example 1: Meaning of a “holistic” view:

## Uncertainty Propagation throughout the entire model chain

The publication served to

- 1) Define
- 2) describe
- 3) review

throughout the chain of forecast modelling:

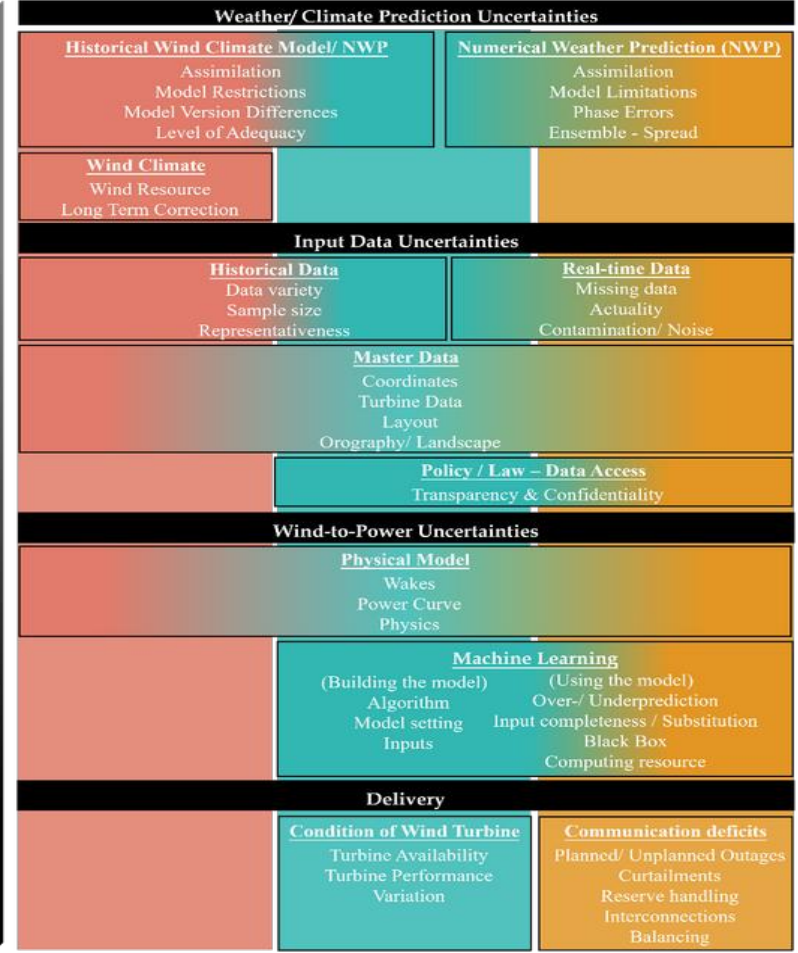
- **Uncertainty sources**
- **Uncertainty mitigation** approaches
- **Uncertainty validation** approaches

for each type of uncertainty source from

**planning phase → operation phase → market phase**



Forecast Process



Uncovering wind power forecasting uncertainty origins and development through the whole modelling chain\*\*  
 in Year: 2020; Authors: Minkler, Tish Glavin, Vick Kelly, ...; Journal: Renewable Energy

**ARTICLE INFO:**  
 Article title: Uncovering wind power forecasting uncertainty origins and development through the whole modelling chain  
 Authors: Minkler, Tish Glavin, Vick Kelly, ...  
 Journal: Renewable Energy  
 Volume: 158  
 Pages: 1115-1127  
 DOI: 10.1016/j.renene.2020.07.042

**ABSTRACT:**  
 Wind power forecasting (WPF) is a critical component of the wind energy supply chain. It is essential for the wind energy industry to understand the origins and development of WPF uncertainty to improve forecasting accuracy and reliability. This paper presents a holistic view of WPF uncertainty, covering the entire modelling chain from the planning phase to the market phase. The study identifies the main sources of uncertainty and their propagation throughout the modelling chain. The results show that the largest sources of uncertainty are related to the input data and the physical model. The study also identifies the main mitigation and validation approaches for each type of uncertainty source. The results of this study can be used to improve WPF accuracy and reliability, and to optimize the wind energy supply chain.

**1. Introduction**  
 High penetration of wind power has been recognized globally as one of the most important features of current and future sustainable power systems. The recent advancement and maturity of the wind power generation capacity technology... (text continues)

OpenAccess Download:  
<https://www.sciencedirect.com/science/article/pii/S136403212004221>

# Workstream Uncertainty :

Uncertainty Propagation throughout the model chain with real data

## PHASE I

2022-2023

tool 1

tool 2

R-verify tool

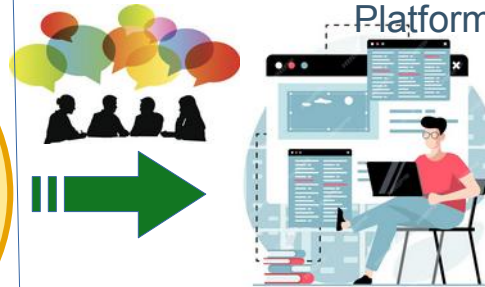
tool 3

Uncertainty Quantification with test data sets according to 2022 UQ publication\*

## PHASE II

2024-2025

Online Verification Platform



Discussion & testing of verification platform



## PHASE III

2025...

Publication



Discussion & writing of publication with most suitable test cases

\* Uncovering wind power forecasting uncertainty sources and their propagation through the whole modelling chain

<https://www.sciencedirect.com/science/article/pii/S1364032122004221>



# Validation & Verification code examples



IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions

Wind Energy Engineering

2023, Pages 321-322



Examples developed within the IEA Wind Task 36 and Task 51:

## WE-validate

Available on GitHub: <https://github.com/joejoeyjoseph/i-validate/>

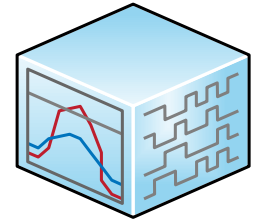
Use Case: Demo Jupyter Notebook (U.S. Mountain Wave case):

[https://nbviewer.jupyter.org/github/joejoeyjoseph/i-validate/blob/main/notebooks/demo\\_notebook.ipynb](https://nbviewer.jupyter.org/github/joejoeyjoseph/i-validate/blob/main/notebooks/demo_notebook.ipynb)

Existing metrics: RMSE, cRMSE, mean bias, mean absolute error

Existing plots: time series, histogram, scatter plot

Appendix G - Validation and verification code examples



~~WE-validate-prob~~ – R-package for probabilistic verification

**Renamed on Github: evalprob4cast**

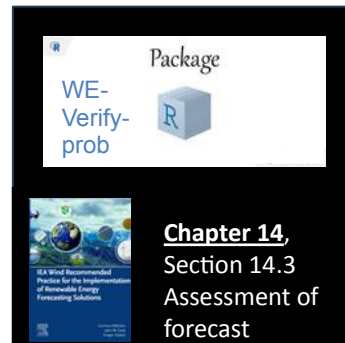
Existing metrics: CRPS, Brier Score, ROC curve, Histograms,

Reliability Diagram, Contingency table

Existing plots: time series, histograms, ROC curve, CRPS

Available on GitHub: <https://github.com/jbrowell/evalprob4cast>

Publication: <https://doi.org/10.48550/arXiv.2504.03544>



# Challenges for Energy Forecasting



iee-dataport.org/competitions/hybrid-energy-forecasting-and-trading-competition

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## Competition

Archived Competition

### Hybrid Energy Forecasting and Trading Competition



Submission Dates: 02/19/2024 to 05/18/2024

Citation Author(s): Jethro Browell (University of Glasgow)  
Sebastian Haglund (rebase.energy)  
Henrik Kalvegren (rebase.energy)  
Edoardo Simioni (Ørsted)  
Ricardo Bessa (INESC TEC)  
Yi Wang (University of Hong Kong)  
Dennis van der Meer (Ørsted)

Submitted by: Jethro Browell

Last updated: Sun, 04/27/2025 - 12:23

DOI: 10.21227/5hn0-8091

Links: Ørsted  
rebase.energy  
rebase Slack - Ask questions here  
Getting Started Example (GitHub)  
API Online Documentation

21896 views  
6525 downloads

Categories: Machine Learning  
Power and Energy  
Weather  
Financial

Keywords: Energy Forecasting, energy trading

ACCESS DATASET | CITE | SHARE/EMBED

#### ABSTRACT

Forecasting production from wind and solar power plants, and making effective decisions under forecast uncertainty, are essential capabilities in low-carbon energy systems. This competition invites participants to develop state-of-the-art forecasting and energy trading techniques to accelerate the global transition to net-zero and to win a share of \$21,000 in prize money. It aims to bridge the gap between academic and industry practice, introduce energy forecasting challenges to new communities, and promote energy analytics and data science education.

#### COMPETITION DATASET FILES

- dwd\_icon\_eu\_20200920\_20231027.zip (Size: 314.58 MB)
- ncep\_gfs\_20200920\_20231027.zip (Size: 329.16 MB)

<https://iee-dataport.org/competitions/hybrid-energy-forecasting-and-trading-competition>



# Extreme Power System Events

April 28, 2025  
Iberia blackout



## Resilience of the power system has many faces

- impact changes with penetration levels > 30% of Renewables
- Can forecasts mitigate impact?
- Grid resilience must now be treated as an economic imperative

## Definition of Extremes are dependent on impact

- How can we cooperate on critical conditions ?
- What time-scales do we need for mitigation strategies across disciplines?
- ....

## Collaboration across disciplines

- Multi-disciplinary task requires multi-disciplinary task force group
- Meteorologists
- Energy Meteorologists
- Grid operators and Power Engineers
- Traders and Markets
- Policy Makers
- Governments



A banner image for the IEA Wind Task 51 Workshop. It is divided into three diagonal sections: a snowy landscape with a house on the left, a storm with a lightning bolt in the center, and a sunset over a field with trees on the right. The IEA Wind logo is in the top right corner.

IEA Wind Task 51 Workshop  
Forecasting Extremes in the Power System



## NEWS

[iea-wind.org/task51](https://iea-wind.org/task51)



DWD, Offenbach/Frankfurt, Germany  
30<sup>th</sup> September - 1<sup>st</sup> October 2025

<https://iea-wind.org/2025/02/14/iea-wind-task-51-workshop-on-extremes-in-the-power-system/>

### Agenda topics:

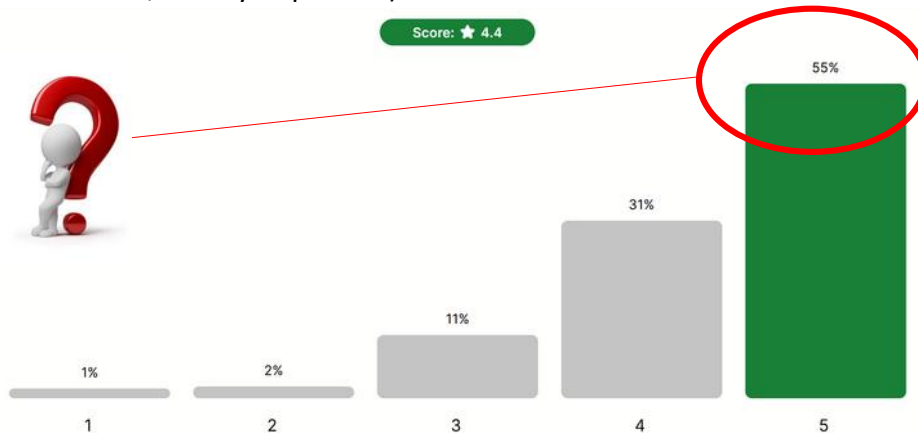
- **Definition and associated differences of extremes in meteorology and the power system**
- **Forecasting tools to mitigate Extremes in the power system**
- **AI and Cybersecurity in Extreme situations**

# Where are the gaps ... ?

Questions posed to 120 participants in an IEA Wind Task 51 workshop in Vienna in 2024

How do you deal with uncertainty in weather forecasts at the moment?

AI makes forecasting easier and faster. If you (would) get high-resolution forecasts from AI – how important is **uncertainty** and transparency ?  
(1=not at all, 5=very important)



## “Probabilistic Forecasting Games & Experiments” initiative: *2<sup>nd</sup> Experiment Evaluation*

Results that are worth looking into...

### Participant scores

- ~80% of participants did not reach a score > “all-safe”
- ~42% reached a score > “chance level” < “all-safe”
- ~17% reach exactly “all safe” - only 1% played safe!
- ~40% had a score < “chance level”

Strategy	Payoff
Risky	0
All Safe	27.000
Chance level	13.750
Gods eye	55.000

### Take away:

Teaching, use-cases and industry recommendations are necessary for the industry to deal with weather uncertainty impacting the energy transision!



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# Where are the gaps ... ?

Question posed to 60 participants in an *IEA Wind Task 51 Workshop Forecasting for Extremes in the Power System* at the German Weather Service last week ...

What is the most important application for you (related to power system extremes) that you would like AI to help with?



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# Where are the gaps ... ?

Question posed to 60 participants in an *IEA Wind Task 51 Workshop Forecasting for Extremes in the Power System* at the German Weather Service last week ...

What comes to your mind, when you think about forecast uncertainty in energy markets?



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

Poll result at a task meeting in **2021** when preparing for the next phase of the task yielded this word cloud ...

What are the most important topics to cover in the next phase of the task ?



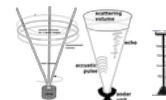


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# IEA Wind Task 51 Work distribution – new phase 2 ....

## 9 workstreams

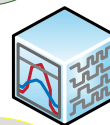
Work Streams:	WP1 Weather	WP2 Power	WP3 Applications
Atmospheric physics and modelling (WP1)	★		
Airborne Wind Energy Systems (WP1)	★		
		★	
Minute scale forecasting (WP2)		★	
Uncertainty quantification and forecast evaluation (WP2)			★
Decision making in integrated forecasting (WP2)			★
Data policies, markets and sharing (WP3)			★
Forecasting challenges and extreme power system events (WP3)			★



Modelling & data assimilation



workshops



Verification Platform



Publications

Collaboration

WMO, PVPS T16

Task 48 Airborne Wind Energy

Hydro TCP, Hydrogen TCP, Biomass TCP, WEMC

Wind Tasks 32 Lidar, 44 Farm Flow Control and 50 Hybrids

PVPS T16, WMO

PVPS T16, ESIG

ESIG  
IEEE WG Energy Forecasting

Task 25, ESIG, IEA ISGAN, PVPS T16, G-PST



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# Collaboration Needs & Research

## Take Aways:

Which tools are necessary to tackle uncertainties & Extremes in systems with high penetration of renewable energy?



Accuracy vs. Impact

>50+% RES in power grids in a changing climate

Common Definitions  
weather conditions & power system

**HOWTO deal with ...**

visibility & operability

DSO ↔ TSO  
Forecaster

Data quality requirements  
to tackle challenges in power system



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## Task 51 – “Forecasting for the weather-driven Energy System”

[iea-wind.org/task51](http://iea-wind.org/task51)

Get in touch with us...

See also following dissemination slides ...

### Operating Agent & Task Managers:

presenting

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[com@weprog.com](mailto:com@weprog.com)

The IEA Wind TCP agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.



# Task 51 Web Presence

Website

<https://iea-wind.org/task51>



Forecasting for the Weather Driven Energy System – Improving the value of renewable energy forecasts to the wind industry

The Task 51, under the *IEA Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind)* focuses on improving the value of renewable energy forecasts.

There are three distinct areas of challenge in forecasting wind power. The first area is in the continuing effort to improve the representation of physical processes in weather forecast models through both new high performance initializations and tailored parameterizations. The second area is the heterogeneity of the forecasters and end users, the full understanding of the uncertainties throughout the modelling chain and the incorporation of novel data into power forecasting algorithms. A third area is representation, communication, and use of these uncertainties to industry in forms that readily support decision-making in plant operations and electricity markets.

This Task will focus on facilitating communication and collaborations among international research groups engaged in the improvement of the accuracy and applicability of forecast models and their utility for the stakeholders in the wind industry, in the power sector and in the energy system.

This Task has the following specific objectives:

- To establish an active, open forum for sharing knowledge among the participants, related IEA Wind Tasks and other related TCPs through workshops, dissemination and communication measures
- To establish and communicate standards and frameworks for the operation and evaluation of forecast model performance
- To identify paths to increased application and utility of forecast information to the task stakeholders
- To advance the knowledge in the underlying atmospheric physics, in the mathematical models converting the transforming atmospheric quantities to energy system application variables, in the modelling of the uncertainty and in the applications and decision-making
- To identify most promising areas for new research to improve the quality and utility of forecasts
- To provide guidelines for the implementation of optimal forecasting solutions

 YouTube Channel

<https://www.youtube.com/c/IEAWindForecasting>



Webinar  
Weather-AI



IEAWindForecasting <https://youtu.be/t6H7diavQdg>

# Handouts

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

<https://iea-wind.org/task51/task51-publications/task51-posters-and-handouts/>

**IEA Wind Task 36**  
Forecasting for Wind Power

**FORECASTING FOR YOU**

**Setup**

Wind power forecasts have been used operationally for over 25 years. Despite this fact, there are still several possibilities to improve the forecasts, both from the weather prediction side and from the usage of the forecasts.

The IEA Wind Task is divided in three work packages. Firstly, a collaboration on the improvement of the scientific basis for the wind predictions themselves. This includes numerical weather prediction model physics, but also widely distributed information on accessible datasets. Secondly, we deal with the conversion to power and losses affecting the forecast vendors. Thirdly, we will be engaging real users aiming at dissemination of the best practice in the usage of wind power predictions. The Task is currently in its second phase, 2020-2022.

**Results of phase 1 (2016-2018)**

We developed an **information panel**, with links to data, projects and knowledge useful for wind power forecasting. This could be a list of full assets useful for online validation of NWP models, a list of field campaigns with open data for model verification, or a selection of benchmarks for forecasts with established data sources and existing reference frameworks.

A major result was the **IEA Wind Recommended Practice (RP) on Forecast Solution Selection**, detailing on the necessary steps to get the best solution for the individual use case. The RP starts with the initial deliberations which might or might not end up with the decision to do a forecast trial. The second document shows how to conduct such a trial in order to yield accurate and usable results for both the end user and the participating vendor. The trial part shows how to evaluate the trial to get 3 significant, 2) representative and 3) reliable results.

For **probabilistic forecasts**, we published two papers with an overview (for a broader readability) and one with a long list of specific use cases (more technically oriented). We also classified methods for uncertainty forecasting and tried to establish a common vocabulary. We also mapped the current use of probabilistic forecasts through a questionnaire.

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**Task Overview**

**Impact**

The Task sends out news a few times a year, is present on conferences and meetings, and has its own YouTube channel. There, standalone video transmissions of the public sessions, we also had a **webinars** of half an hour talks plus audience questions use the major results of phase 1. The fourth one was an additional one on Forecast use in Denmark.

The Task members also try to get an **enhance relationships** between weather prediction providers and vendors, and between vendors and end users. One activity for the current phase of the Task (2020-2022) is a book into **standardization** of data, to make data exchange more fluid across the industry. Another activity is to **estimate the value of better forecasting**.

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**Collaboration**

Currently, some 750 people from 12 countries are collaborating on forecasts. There are meetings every half year, often in combination with relevant conferences. We also have special sessions of conferences for outreach, and usually an **informing poster**. If you are interested to collaborate, or just to be informed about new results, please contact George Gohari.

**Solution**

The recommended **Forecasting for Wind Power** solution is based on the IEA Wind Task 36. The solution is based on the IEA Wind Task 36. The solution is based on the IEA Wind Task 36.

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**IEA Wind Task 36**  
Forecasting for Wind Power

**Understanding Uncertainty: The difficult move from a deterministic to a probabilistic world**

**Challenge**

Uncertainty forecasts are a mix of a information meeting the requirements for the industry to meet forecasts. The differentiation of forecasts is making the weather prediction more of an information product from a data and not a data product. The information is not a data product, but a data product. The information is not a data product, but a data product.

**Background**

Understanding the benefits and the path, when employing probabilistic forecasts, requires clear communication that is accessible, broad, practical and understandable for power generation and end users.

**Solution**

The main challenge of the IEA Wind Task 36 is to develop a solution for the industry to meet forecasts. The solution is based on the IEA Wind Task 36. The solution is based on the IEA Wind Task 36.

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**Forecast Solution Selection**

**Benchmarks and Trials**

The process of selecting a forecast solution involves several steps. The process is based on the IEA Wind Task 36. The process is based on the IEA Wind Task 36.

**Where to get the guideline**

The guideline is available for download from the IEA Wind Task 36 website. The guideline is available for download from the IEA Wind Task 36 website.

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## Forecast Solution Selection

**IEA Wind Task 36**  
Forecasting for Wind Power

**RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS**

**Forecast Solution Selection**

The process of selecting a forecast solution involves several steps. The process is based on the IEA Wind Task 36. The process is based on the IEA Wind Task 36.

**Solution**

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## Uncertainty and Probabilistic Forecasting

**IEA Wind Task 36**  
Forecasting for Wind Power

**Understanding Uncertainty: The difficult move from a deterministic to a probabilistic world**

**Challenge**

Uncertainty forecasts are a mix of a information meeting the requirements for the industry to meet forecasts. The differentiation of forecasts is making the weather prediction more of an information product from a data and not a data product. The information is not a data product, but a data product.

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Editors: Corinna Möhrle, John W. Zack, and Gregor Giebel

<https://www.elsevier.com/books/iea-wind-recommended-practice-for-the-implementation-of-renewable-energy-forecasting-solutions/mohrlen/978-0-443-18681-3>

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IEA Wind Task 51 Information

iea-wind.org → Task 51 → Publications → [Recommended Practice](#)

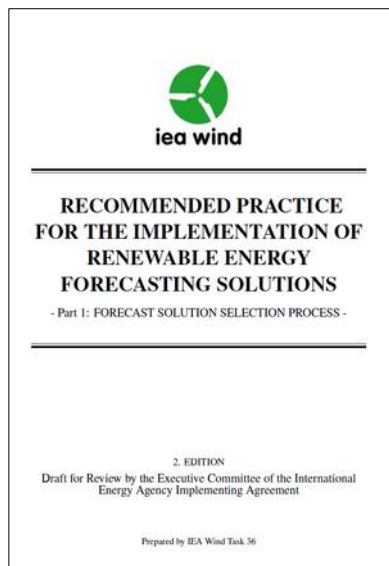


## IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions

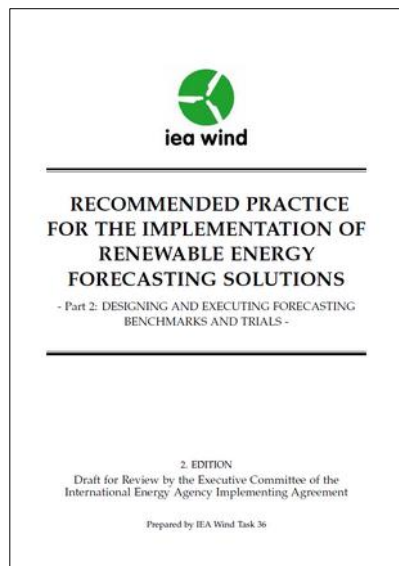


Corinna Möhrle  
John W. Zack  
Gregor Giebel

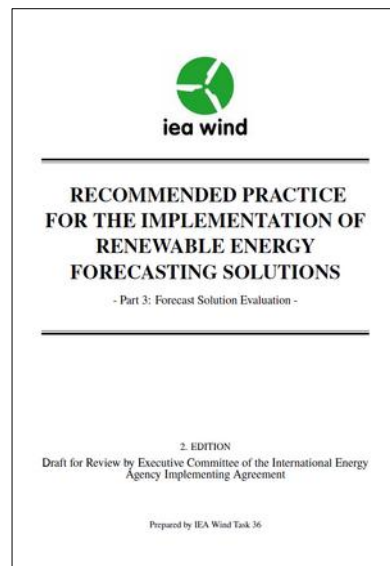
# IEA Best Practice Recommendations for the Selection of a Wind Forecasting Solution v2: Set of 4 Documents



Part 1: Selection of an Optimal Forecast Solution



Part 2: Design and Execution of Benchmarks and Trials



Part 3: Evaluation of Forecasts and Forecast Solutions



Part 4: Data Requirements for Real-time Applications

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Introduction: <https://www.youtube.com/watch?v=XVO37hLE03M>



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# Validation & Verification code examples

Examples developed within the IEA Wind Task 36 and Task 51:

See: <https://iea-wind.org/task51/task51-publications/task51-recommended-practices/>

## evalprob4cast (book: WE-validate-prob)

An R-package for evaluation of ensembles as probabilistic forecasts or event forecasts

Available on GitHub: <https://github.com/jbrowell/evalprob4cast>

Publication: <https://doi.org/10.48550/arXiv.2504.03544>

Existing metrics: CRPS, Brier Score, ROC curve, Histograms, Reliability Diagram, Contingency table

Graphics: time series, histograms, ROC curve, CRPS

## WE-validate

Software package **for Wind Energy Validation**

Available on GitHub: <https://github.com/joejoeyjoseph/WE-Validate>

Publication: <https://www.sciencedirect.com/science/article/pii/S0960148122014707>

Use Case: Demo Jupyter Notebook (U.S. Mountain Wave case):

[https://nbviewer.jupyter.org/github/joejoeyjoseph/i-validate/blob/main/notebooks/demo\\_notebook.ipynb](https://nbviewer.jupyter.org/github/joejoeyjoseph/i-validate/blob/main/notebooks/demo_notebook.ipynb)

Existing metrics: RMSE, cRMSE, mean bias, mean absolute error

Existing plots: time series, histogram, scatter plot

See also our workshops & conference page:

<https://iea-wind.org/task51/task51-publications/task51-workshops-and-special-sessions/>



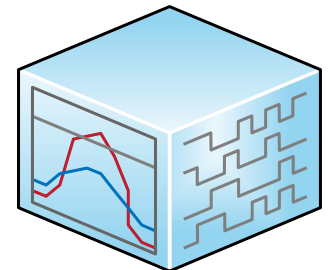
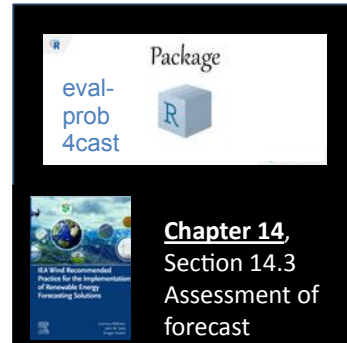
IEA Wind Recommended Practice for the  
Implementation of Renewable Energy  
Forecasting Solutions

Wind Energy Engineering

2023, Pages 321-322



## Appendix G - Validation and verification code examples





# Information Portal

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The Task 51 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-51/t51-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.

## Decision making under uncertainty

Forecast Game	Short Description	Link
		<a href="#">Forecast Game</a> (choose "Play the Game" at top menu)
	IEA Wind Task 36/51 and MPH for Human Development have released a forecast game at the European Meteorological Society Annual Conference 2021.	<a href="#">Forecast Game Results</a>
	The game investigates how ensemble forecasts showing forecast uncertainty can improve our ability to make informed decisions, also when the weather conditions are complex or extreme.	Links to additional material: <a href="#">WV2022: City Note Presentation</a>
<b>Wind Power Trading decisions for a Wind Park in complex terrain</b>	In the experimental game, the player is asked to make trading decisions for a wind farm in complex terrain in a number of situations based on deterministic and probabilistic power and wind forecasts.	AMS 2022: <a href="#">Presentation</a> Electric-City 2021: <a href="#">Paper</a> & <a href="#">award winning Poster</a> EMS 2021: <a href="#">Presentation</a>
		IEA Task 36 Webinar <a href="#">Youtube</a> & <a href="#">Presentation</a>
		<a href="#">Forecast Game</a> (offline version to come soon)
		<a href="#">Forecast Game Results</a>
<b>Wind Power Trading decisions for an Offshore Wind Park</b>	The game investigates how useful different forecasts are for wind power trading decisions in a simplified way in the game, the player is asked to make trading decisions for an offshore wind farm in the Nordsees in a number of situations based on deterministic and probabilistic power and wind forecasts.	<a href="#">IEA Wind Task 36 Youtube channel at time: 3:03:00</a> <a href="#">Presentation Download</a>
		Publications: <a href="#">Meteorology, 2022</a> <a href="#">Int Phys Conf Series</a> <a href="#">2021</a>
	In the game the player is managing a water supply reservoir!	<a href="#">Forecast Game</a>
	Purpose of the Game is to train with forecast information and improve decision making.	License conditions
<b>Call for Water Game</b>	The player is newly appointed water manager for a	Creative Commons <a href="#">CC</a>

	In the game the player is managing a water supply reservoir!	<a href="#">Forecast Game</a>
<b>Call for Water Game</b>	Purpose of the Game is to train with forecast information and improve decision-making.	License conditions: Creative Commons <a href="#">CC</a> <a href="#">BY-NC-ND/4.0</a>
	The player is newly appointed water manager for a reservoir that serves water users for a town and is responsible to secure sufficient water for the town at a specific time.	
	The game is played in two rounds of 5 years each.	<a href="#">Forecast Game</a>
<b>HEPEX Forecast Game</b> "Pathways to running a flood forecasting centre: an adventure game"	The game simulates the responsibilities of a water management centre in charge of protecting a city against floods.	<a href="#">A blog post on the game was published in the Intenex review website</a>
	The game is investigating what kind of information is needed and how many days in advance the forecast information is good enough to make a decision that could save lives and money.	Reference: Arnal et al (EGU 2017 abstract)
<b>Feuerwache (only available in German)</b>	The game's aim is to well users understand and are able to make use of the uncertainty of weather forecasts	<a href="#">Forecast Game</a>
	The task of the game is to decide on 16 days, whether or not to request more firefighters for the next 21 hours to handle additional missions in predicted storm events.	

### Offline Games

HEPEX Forecast Games		
<b>Water Management Game</b>	The game experiment focuses on risk-based decision-making in water management using probabilistic forecasts of inflows to a reservoir	Download: <a href="#">English</a> , <a href="#">German</a> Reference: <a href="#">Couchman et al., 2019</a> HEPEX blog <a href="#">post</a>
<b>Peak Box Game</b>	The "Peak Box" game supports interpretation and verification of operational ensemble peak-flow forecasts, proposed by Zappa and colleagues, and encourages discussions of the use of ensemble predictions in operational hydrology.	Download: <a href="#">Peak Box Game</a> Reference: <a href="#">Zappa et al., 2013</a> <a href="#">HEPEX blog post</a>
	The Peak-Box defines the "best estimate" of a flood event's timing and magnitude by framing the discharge peaks of all members of an ensemble forecast and taking their median in timing and magnitude.	

## Table and collection of forecasting Games:

iea-wind.org/taks 51

→ Workstreams → Decision Making under Uncertainty

<https://iea-wind.org/task51/taks51-work-streams/ws-decision-making-under-uncertainty/>

# Research projects

<https://iea-wind.org/task-51/project-list/>

Here are some ongoing and finished projects towards short-term prediction of wind power throughout the last two decades. In total, the public (and partly private) spending on this list exceeds 150 million euro.

Country	Project acronym	Full title	Sponsor	Total / Funded budget	Start – end date	Participants incl. those from IEA Task 36/51
DE	WindStore	Optimized system integration of offshore wind energy through intelligent linking of various forecast concepts and forward-looking management of distributed cascade storage systems.	BMWK (German Federal Ministry for Economics and Climate Protection)	1.76 M€ / 1.47 M€	Jan 2024 – Dec 2026	Fraunhofer IEE, DLR, 4Cast, SETrade, WEPROG, EnBW, Stadtwerke Hassfurt und Wunsiedel
BE	BeFORECAST	Wake-effect included offshore wind power forecasting for smooth operation of the Belgian electricity grid based on advanced data handling and sensor technology, including airborne systems.	Energy Transition Funds of the Federal Public Service Economy of the Belgian Federal Government	3.25 M€ / 2.74 M€	Nov 23 – Oct 25	von Karman Institute for Fluid Dynamics, Vrije Universiteit Brussel, KU Leuven, 3E, SABCA, Royal Meteorological Institute of Belgium
UK		Multi-variate forecasting for wind power integration in electricity markets	Shell/ETP Scotland	90k€/120k€	Oct 22 – Mar26	University of Glasgow, Jethro Browell