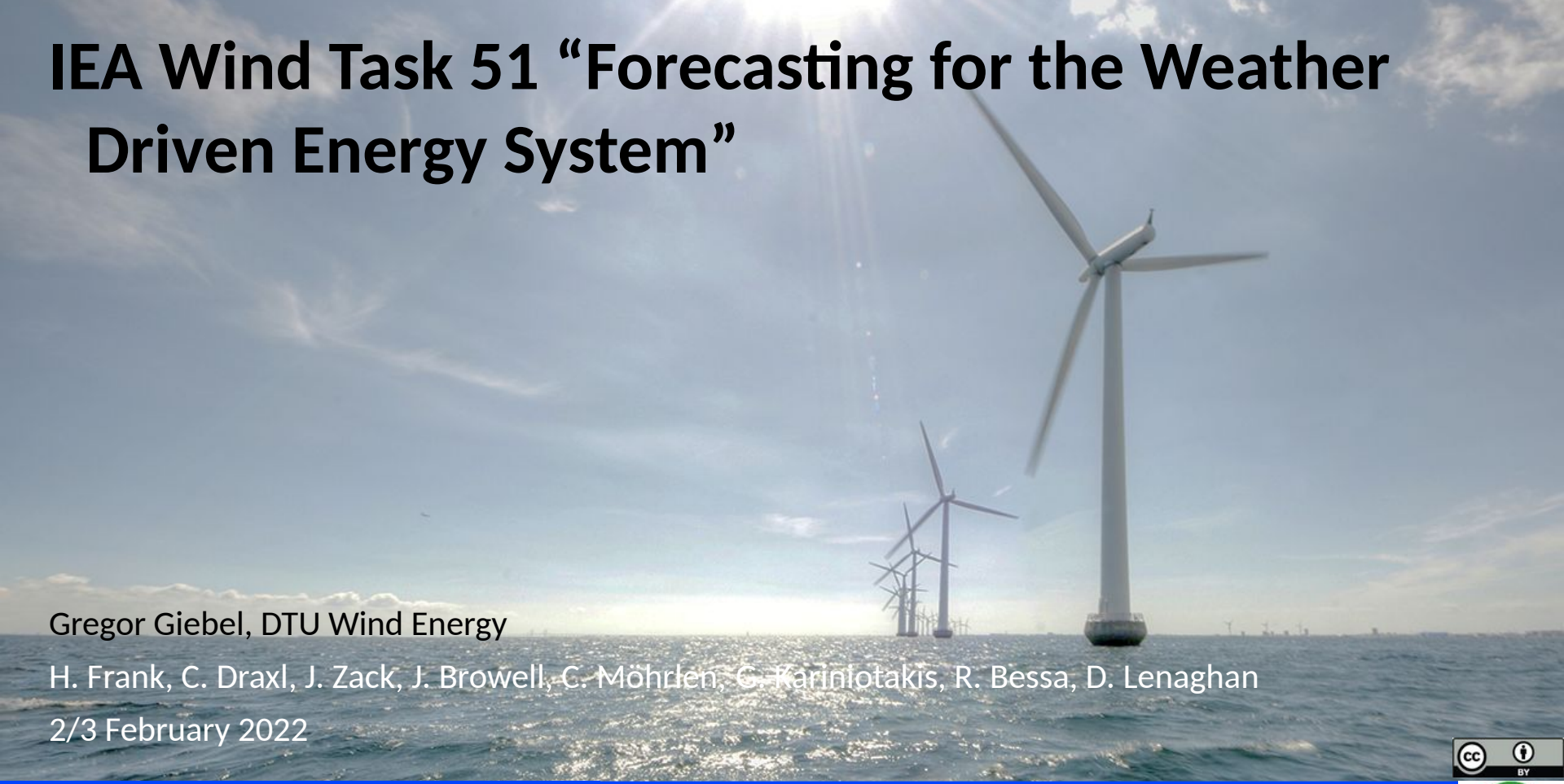
IEA Wind Task 51 “Forecasting for the Weather Driven Energy System”



Gregor Giebel, DTU Wind Energy

H. Frank, C. Draxl, J. Zack, J. Browell, C. Möhrlen, C. Karinlotakis, R. Bessa, D. Lenaghan

2/3 February 2022

Agenda Wed 2 Feb

15:00 *Gregor Giebel, DTU*: Welcome and introduction from the Operating Agent
15:15 *Paul Fleming, NREL*: IEA Wind Task 44 Farm Flow Control
15:30 *David Schlipf, HS Flensburg*: IEA Wind Task 32 Lidar
15:45 *Kristian Petrick, Airborne Wind Europe*: IEA Wind Task 48 Airborne Wind Energy
16:00 *Kaushik Das, DTU*: IEA Wind Task 50 Hybrid Wind Power Plants
16:15 Coffee break
16:20 *Jan Remund, Meteotest*: IEA
PVPS Task 16 Solar Resource for High Penetration and Large Scale Applications
16:35 *(invited)*: The Hydro TCP Annex IX Valuing Hydropower Services
16:50 *Paulo Partidário, DGEG*: The Hydrogen TCP and its connection to Task 51
17:05 *Elina Mäki, VTT*: IEA Bioenergy TCP, Task 44 Flexible Bioenergy and System Integration
17:20 *Roberta Boscolo, WMO*: The WMO Study Group on Integrated Energy Services (SG-ENE)
17:35 Discussion, preparation of the State-of-the-Art and Research Gaps workshop in summer (where, when, how long, structure, who will organise, who to invite)
18:00 Close (10:00 Denver, 01:00 Beijing)

Agenda Thu 3 Feb

15:00 Welcome, summary of yesterday (*Gregor Giebel*)
15:10 Atmospheric physics and modelling (WP1, *Helmut Frank*)
15:20 Airborne Wind Energy Systems (WP1, *Helmut Frank*)
15:30 Seasonal forecasting (WP1, *Caroline Draxl and John Zack*)
15:40 State of the Art for energy system forecasting (WP2, *Gregor Giebel*)
16:10 Coffee Break
16:20 Uncertainty / probabilistic forecasting (WP3, *Jie Yan or Corinna Möhrlen*)
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16:40 Extreme power system events (WP3, *Corinna Möhrlen*)
16:50 Data science and artificial intelligence (WP3, *Ricardo Bessa and George Kariniotakis*)
17:00 Privacy, data markets and sharing (WP3, *Ricardo Bessa*)
17:10 Value of forecasting (WP3, *Janos Hethey*)
15:50 Forecasting for underserved areas (WP2, *Jethro Browell*)
17:20 Forecasting in the design phase (WP3, *John Zack and Jethro Browell*)
16:00 Minute scale forecasting (WP2, *Tuhfe Göçmen*)
17:30 Discussion, AOB
18:00 Close (10:00 Denver, 01:00 Beijing)

International Energy Agency History

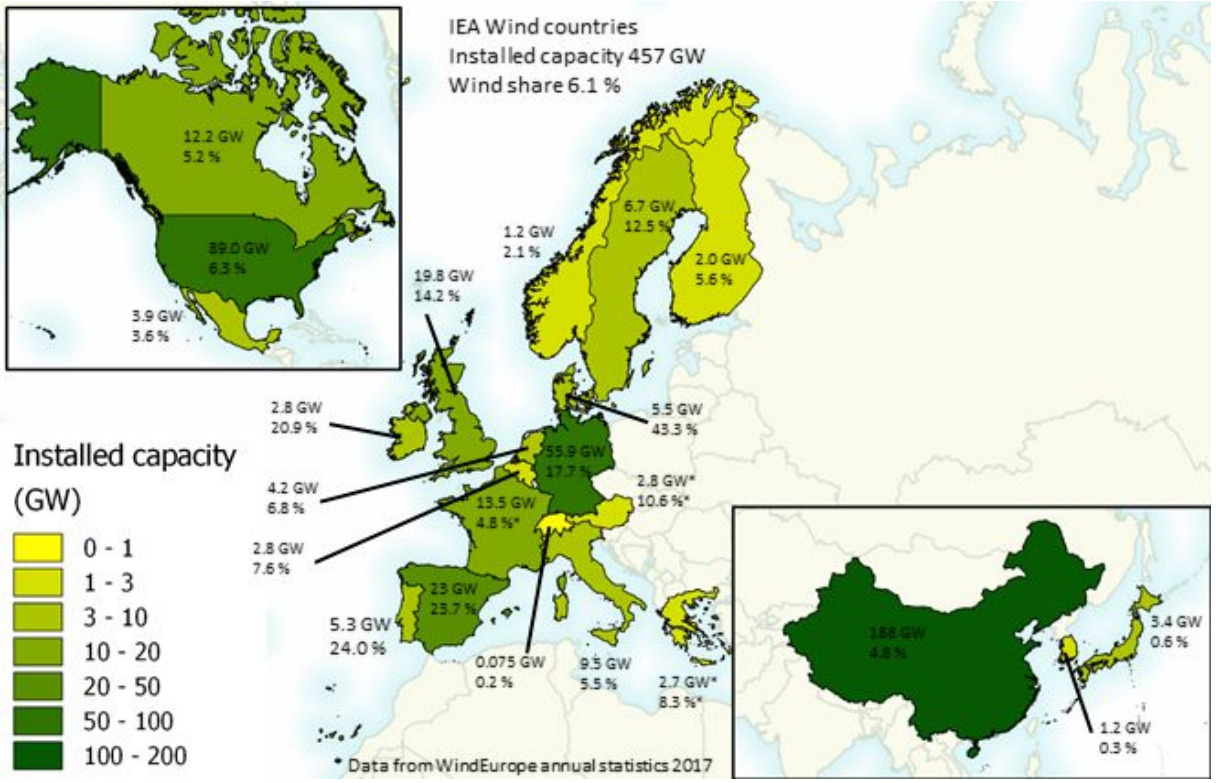
The IEA was founded in 1974 to help countries co-ordinate a collective response to major disruptions in the supply of oil.

Image source: dpa

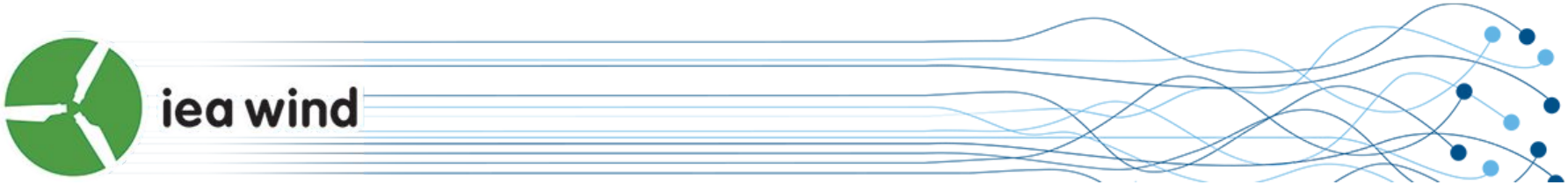
- *Specific Technology Collaboration Programs (in renewable energy):*
- Bioenergy TCP
- Concentrated Solar Power (SolarPACES TCP)
- Geothermal TCP
- Hydrogen TCP
- Hydropower TCP
- Ocean Energy Systems (OES TCP)
- Photovoltaic Power Systems (PVPS TCP)
- Solar Heating and Cooling (SHC TCP)
- Wind Energy Systems (Wind TCP)

See iea.org!

iea Energy Technology Network



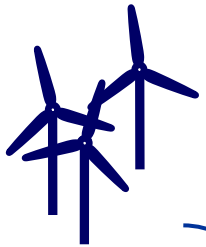
- Task 36 members:
- AT, CN, DE, DK, ES, FI, US



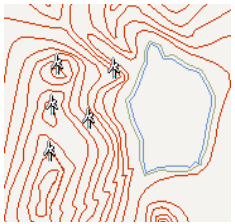
- Task 11 Base Technology Exchange
- Task 19 Wind Energy in Cold Climates
- Task 29 Mexnext III: Analysis of Wind Tunnel Measurements and Improvements of Aerodynamic Models
- Task 30 Offshore Code Comparison Collaboration, Continued, with Correlation (OC5)
- Task 39 Quiet Wind Turbine Technology
- Task 40 Downwind Turbines
- Task 41 Distributed Energy
- Task 42 Wind Turbine Lifetime Extension

- Task 31 WAKEBENCH: Benchmarking Wind Farm Flow Models
- Task 32 LIDAR: Wind Lidar Systems for Wind Energy Deployment
- **Task 36 Forecasting for Wind Energy**
- Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power
- Task 27 Small Wind Turbines in High Turbulence Sites
- Task 37 Wind Energy Systems Engineering
- Task 26 Cost of Wind Energy
- Task 28 Social Acceptance of Wind Energy Project
- Task 34 Working Together to Resolve the Environmental Effects of Wind Energy (WREN)

- See iea-wind.org!

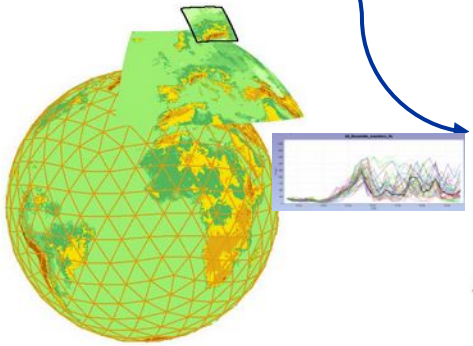


Online data

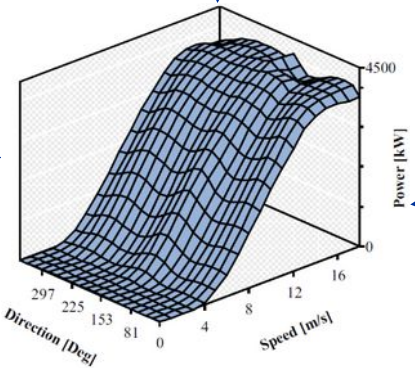


Sometimes:
Orography
Roughness
Wind farm layout

GRID



Numerical Weather Prediction

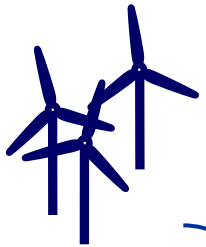


Prediction model

End user

TRADING

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Pittsburgh Post-Gazette, Red Electrica de España.



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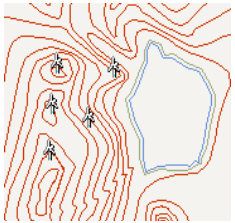

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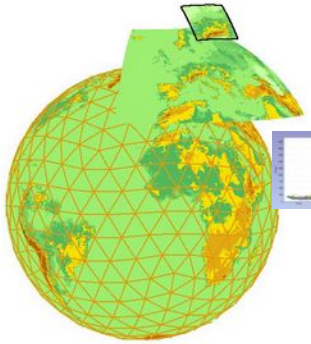
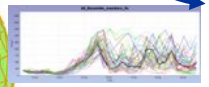
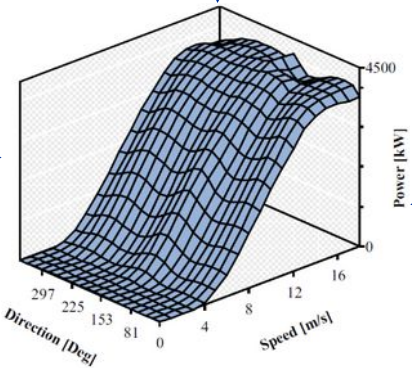
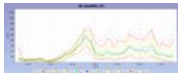


Numerical Weather Prediction





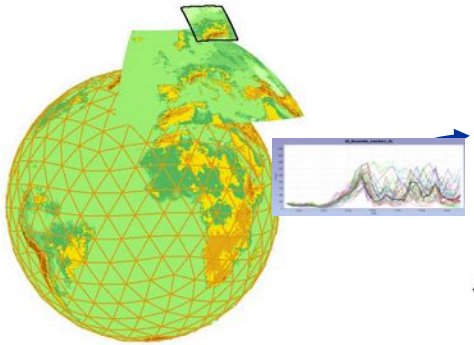
Prediction model



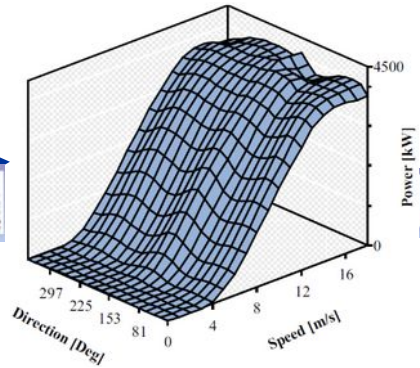
End user

TRADING

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Pittsburgh Post-Gazette, Red Electrica de España.



Numerical Weather Prediction

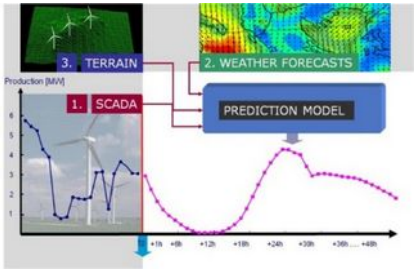


Prediction model

End user

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.

Deterministic approaches
Hybrid approaches

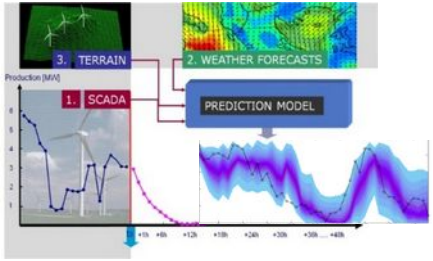


Next generation of tools
Focus on extremes

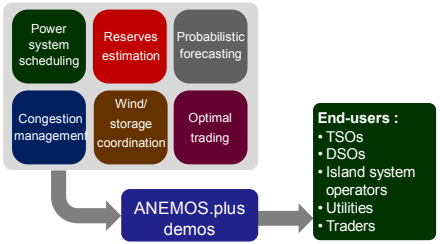
Diversify predicted information

Spatio-temp
Ramp forecasting
Cut-off forecasting
Alarming, risk indices
Link to meteorology etc

1990 | 2002 Anemos | 2008 SafeWind ANEMOS./plus | 2013



Functions considered:



Probabilistic approaches
1st Benchmarking
Towards standardisation
Combined forecasts (multi model/NWPs)

Link forecasts to the application
Power system management/trading
Stochastic optimisation
Demonstration

38

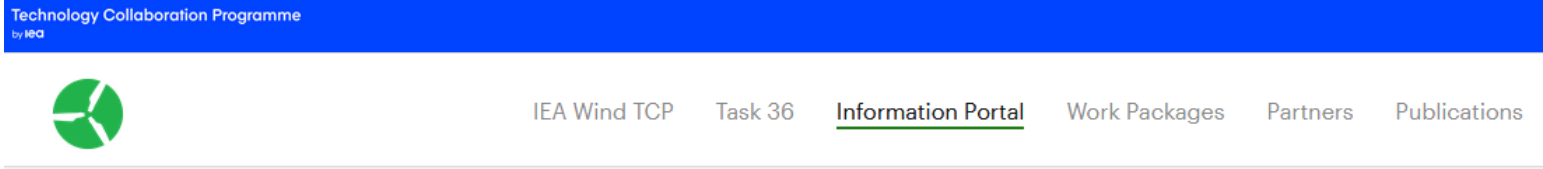
Task Objectives & Expected Results

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
- Meteorologists
- Forecast providers
- End-users and stakeholders

Task Work is divided into 3 work packages:
WP1: Weather Prediction Improvements
WP2: Power and Uncertainty Forecasting
WP3: Optimal Use of Forecasting Solutions

Current Term: 2022-2025



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-36/t36-information-portal/

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.

Wind Power Prediction Project List

This list shows a large number of (mostly publically funded) research projects in short-term forecasting of wind power. The list is incomplete, as the emphasis was a) on current projects, and b) on projects collected from the Task participants. Even so, the list contains research projects from the last two decades worth 46 M€, with 32 M€ public funding, though not all of this can be attributed to forecasting (e.g. the IRP Wind or RAVE projects).

If you have additions or comments, please send them to the Operating Agent, Gregor Giebel.

https://iea-wind.org/task-36/project-list/

Country	Project acronym	Full title	Sponsor	Total / Funded budget	Start – end date	Participants (IEA Task 36 members in bold)
DE	e-TWINS	Verbundvorhaben: e-TWINS ' Ganzheitliche digitale Zwillingstechnologie für das Energiesystem	BMWi (Bundesministerium für Wirtschaft und Energie)	1.96 M€ / 1.96 M€	Jan 2020 – Dec 2022	**ZSW,** TU München Windenergie, Hochschule München, Mesh Engineering
EU	Smart4RES	Next Generation Modelling and Forecasting of Variable Renewable Generation for Large-scale Integration in Energy Systems and Markets	EU Horizon2020	4 M€ / 4 M€	1 Nov 2019 – 30 Apr 2023	**Armines, DTU, INESC TEC, EDP, Meteo-France, emsys, DNV GL,** Whiffle, Dowel, ICCS, HEDNO, DLR

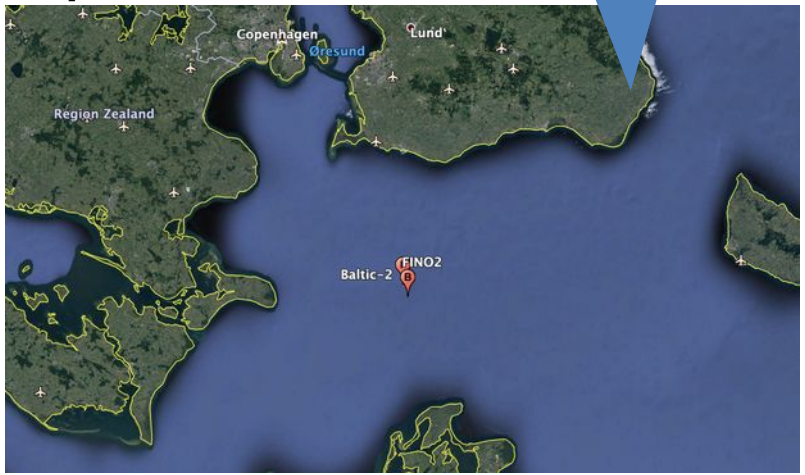
D1.2 NWP Benchmark cases

Started: June 2021

U.S. case

- 1 day in September 2016
- **mountain waves** observed
- observations and model meteorological data available, at 10/5 min resolution
- well documented in the literature, a wealth of information available about the region
- wind farms in the area (but data under an NDA)

European case

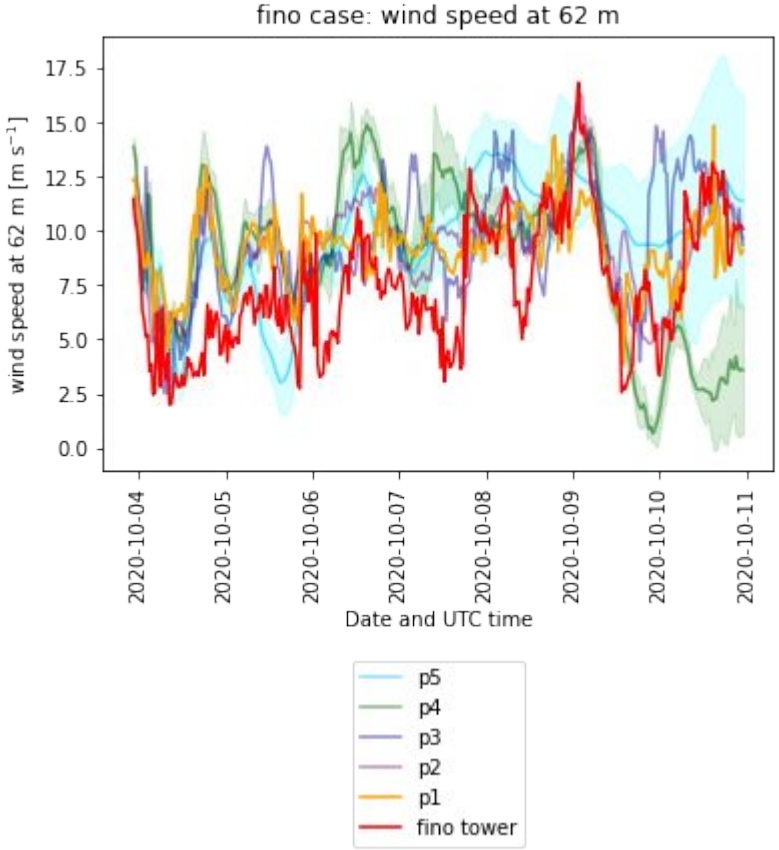


- 1 week in October 2020
- power output available every 15 min, with 100% turbine availability
- corrected nacelle wind measurements averaged over the farm every 15 min
- FINO2 is about 4 km NW of Baltic-2, **offshore**

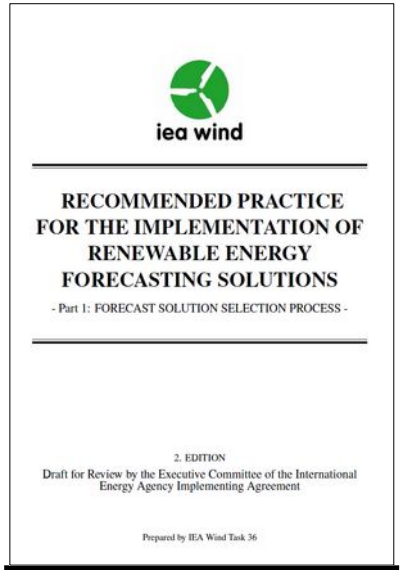
Slide from Caroline Draxl, NREL – please contact IEA.Forecasting.Benchmark@groups.nrel.gov *for participation*

NWP Benchmark analysis updates

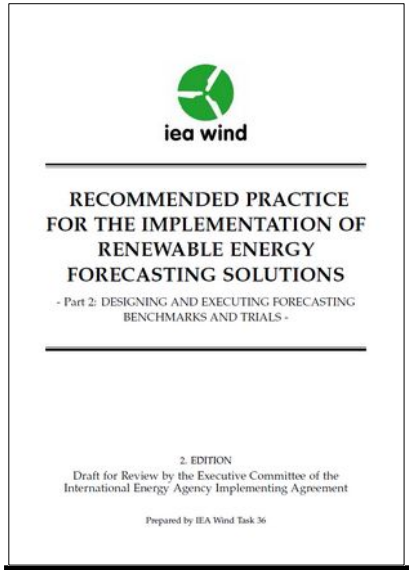
- 5 organizations (2 companies, 3 weather or research) submitted forecasts with a mix of deterministic and ensemble forecasts
- Currently we focus on analyzing the FINO2 met tower/Baltic-2 wind farm case (a week in October 2020), especially on the ramp forecasts. The 7-day period only displays a few ramp events
- Our analysis is anonymous. **We still welcome forecast submissions** to increase the statistical significance of our analysis!
- WE-validate GitHub repo: https://github.com/joejoeyjoseph/WE-Validate - Participants' data are not shared on GitHub at this point



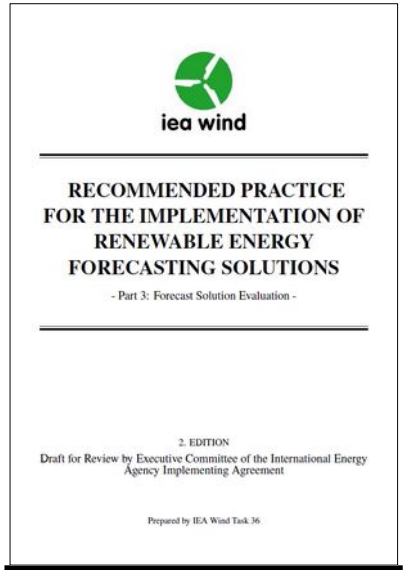
IEA Best Practice Recommendations for the Selection of a Wind Forecasting Solution v2: Set of 4 Documents



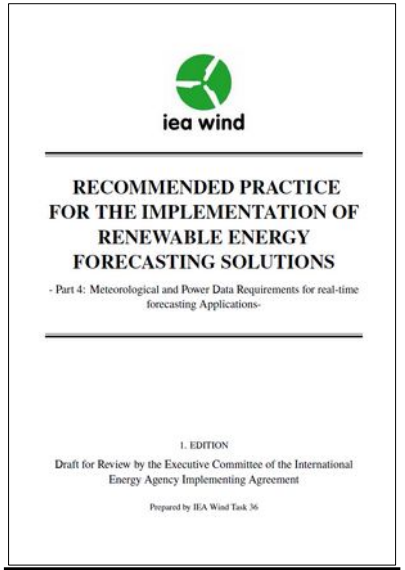
Part 1: Selection of an Optimal Forecast Solution



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

Finalising now - also as book!

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

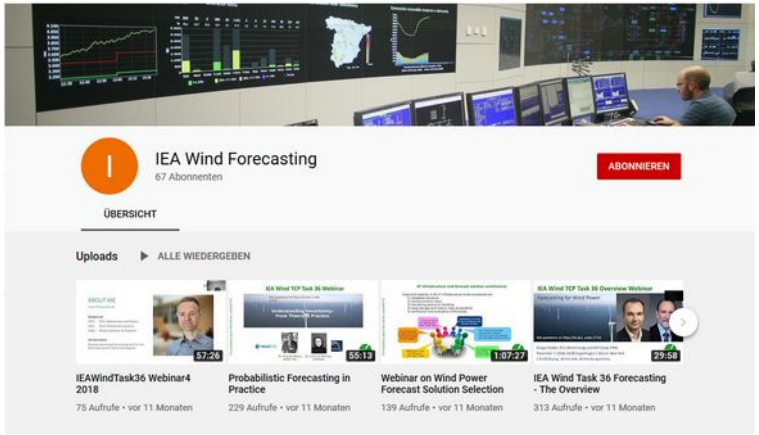
Task 36 Web Presence (Task 51 being worked on)

Website

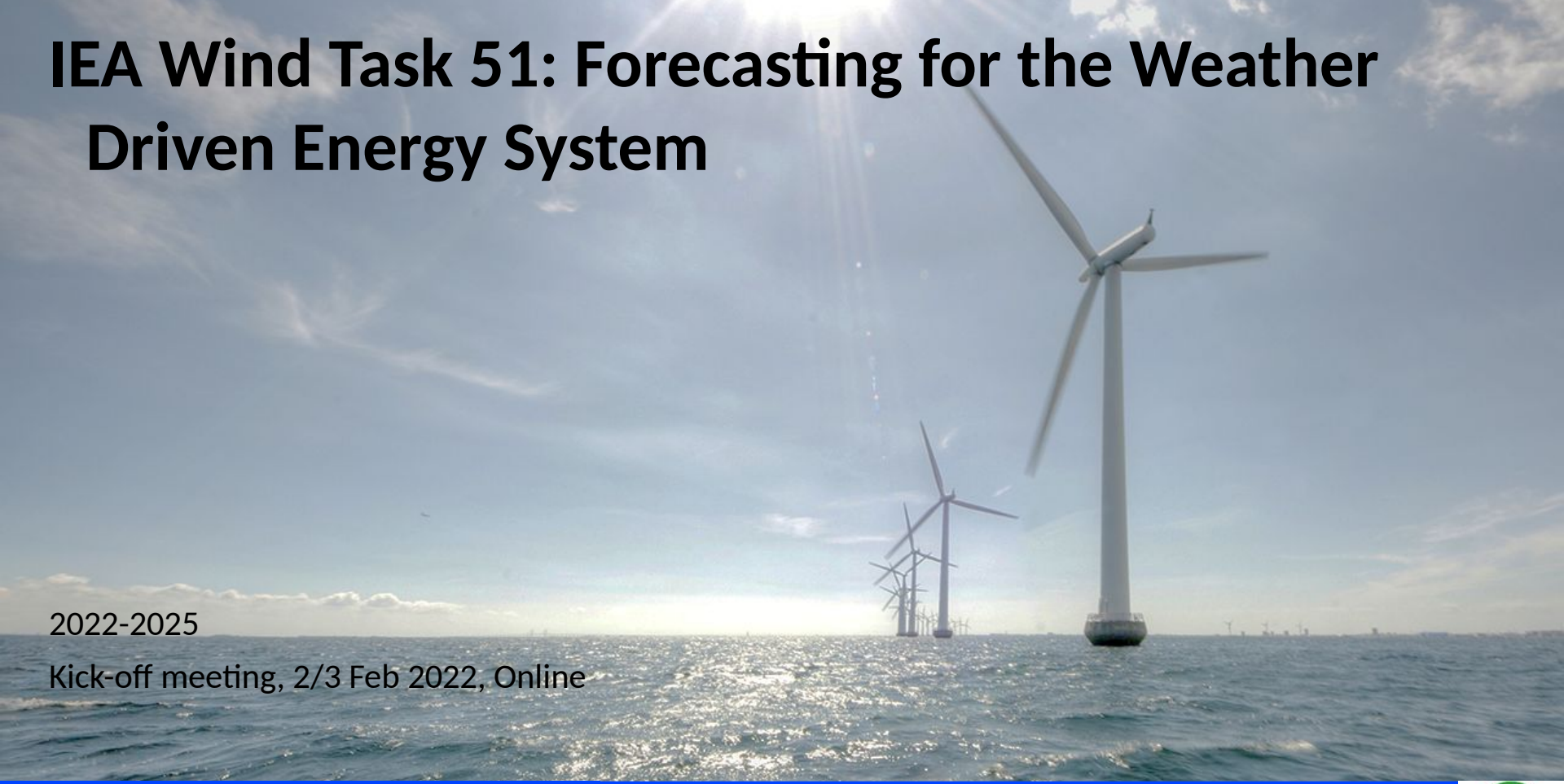
www.ieawindforecasting.dk

YouTube Channel

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



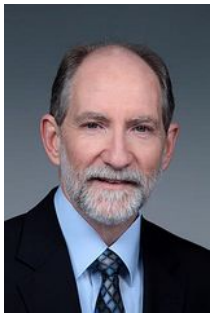
IEA Wind Task 51: Forecasting for the Weather Driven Energy System



2022-2025

Kick-off meeting, 2/3 Feb 2022, Online

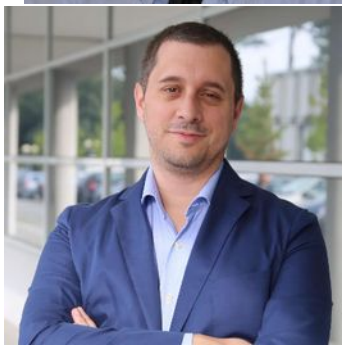
Leadership team changes







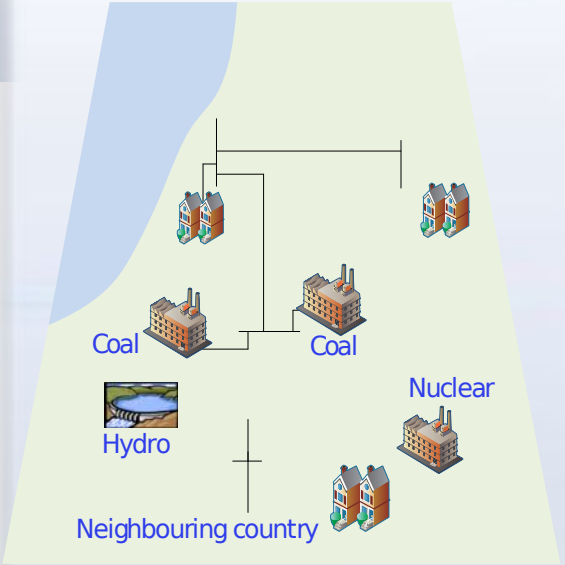


iea wind

From Wind Integration to Energy Systems

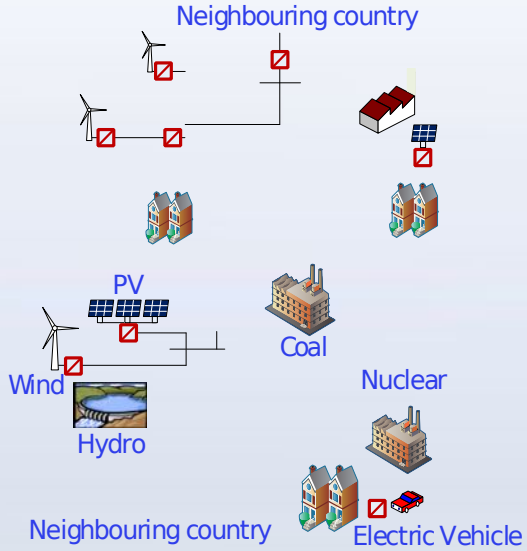
(almost) no RES

Past



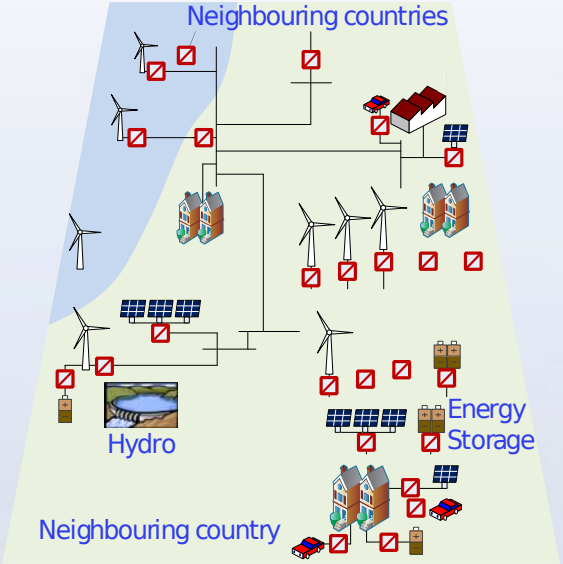
Some RES

Present



100% RES

Future



Forecasting needs: little

All RES seperately

All RES with correct correlations and longer time scales

Slide design: Ömer Göksu and Nicos Cutululis

Next: Forecasting for the Weather Driven Energy System

Preparations for the next phase of forecasting collaboration are ongoing. A recent Task meeting yielded this word cloud.

Strong collaboration with other TCPs.

To start 2022.

Work Streams:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Atmospheric physics and modelling (WP1)				List of experiments and data	D1.1, Ongoing	WMO, PVPS T16
Airborne Wind Energy Systems (WP1)				Presentations on workshops	Part of D2.1	Task 48 Airborne Wind Energy
Seasonal forecasting (WP1)				Workshop / Paper	D1.6 / M19	Hydro TCP, Hydrogen TCP, Biomass TCP
State of the Art for energy system forecasting (WP2)				Workshop / Paper RecPract on Forecast Solution Selection v3	D2.1 / M7, M12 M2.1 / M36	PVPS Task 16, Hydro TCP, Hydrogen TCP, …
Forecasting for underserved areas (WP2)				Public dataset	D2.4 / M24	WMO
Minute scale forecasting (WP2)				Workshop / Paper	D2.5 / M31, M36	Wind Tasks 32 Lidar, 44 Farm Flow Control and 50 Hybrids
Uncertainty / probabilistic forecasting (WP3)				Uncertainty propagation paper with data RecPract v3	D 2.6 / M42 M48	PVPS T16
Decision making under uncertainty (WP3)				Training course Games	M12 M18	
Extreme power system events (WP3)				Workshop	D3.6 / M42	Task 25, ESIG, IEA ISGAN, PVPS T16, G-PST
Data science and artificial intelligence (WP3)				Report	D2.3 / M30	
Privacy, data markets and sharing (WP3)				Workshop / Paper Data format standard	D3.5 / M15	ESIG IEEE WG Energy Forecasting

Agenda Wed 2 Feb

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17:20 *Roberta Boscolo, WMO*: The WMO Study Group on Integrated Energy Services (SG-ENE)
17:35 Discussion, preparation of the State-of-the-Art and Research Gaps workshop in summer (where, when, how long, structure, who will organise, who to invite)
18:00 Close (10:00 Denver, 01:00 Beijing)

Agenda Wed 3 Feb 15:00 Copenhagen (07:00 Denver, 22:00 Beijing)

Going through the work streams one by one. In brackets the currently responsible people for the 10 minutes teaser, but they might get replaced in the meeting.

15:00 Welcome, summary of yesterday (Gregor Giebel)

15:10 Atmospheric physics and modelling (WP1, Helmut Frank)

15:20 Airborne Wind Energy Systems (WP1, Helmut Frank)

15:30 Seasonal forecasting (WP1, Caroline Draxl and John Zack)

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17:00 Privacy, data markets and sharing (WP3, Ricardo Bessa)

17:10 Value of forecasting (WP3, Janos Hethey)

15:50 Forecasting for underserved areas (WP2, Jethro Browell)

17:20 Forecasting in the design phase (WP3, John Zack and Jethro Browell)

16:00 Minute scale forecasting (WP2, Tuhfe Göçmen)

17:30 Discussion, AOB 18:00 Close (10:00 Denver, 01:00 Beijing)

Coffee Break

Please be back at 15:50 UTC!

Work stream Atmospheric Physics

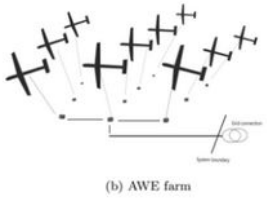
WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Atmospheric physics and modelling (WP1)				List of experiments and data	D1.1, Ongoing	WMO, PVPS T16

Knowing the atmosphere and its developments is the basis for forecasting for all horizons beyond a few hours. Especially with the new emphasis on seasonal forecasting and forecasts for storage management, the weather forecasts are in focus. This work stream spans mostly WP1, where the larger meteorological centres are at home, but crosses over into WP2, where the derived application variables need knowledge of the meteorology.

D 1.1: Online summary of major field studies supportive of wind forecast improvement; list of available data (ongoing)

Image source: NOAA

Work stream Airborne Wind Energy



Work Streams:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Airborne Wind Energy Systems (WP1)				Presentations on workshops	Part of D2.1	Task 48 Airborne Wind Energy

- Novel topic, winds in 300-600m height
- Mapping state of the art on workshop
- Collaboration with Task 48

Image source: Task 48 presentation on IEA Wind ExCo 88, Nov 2021

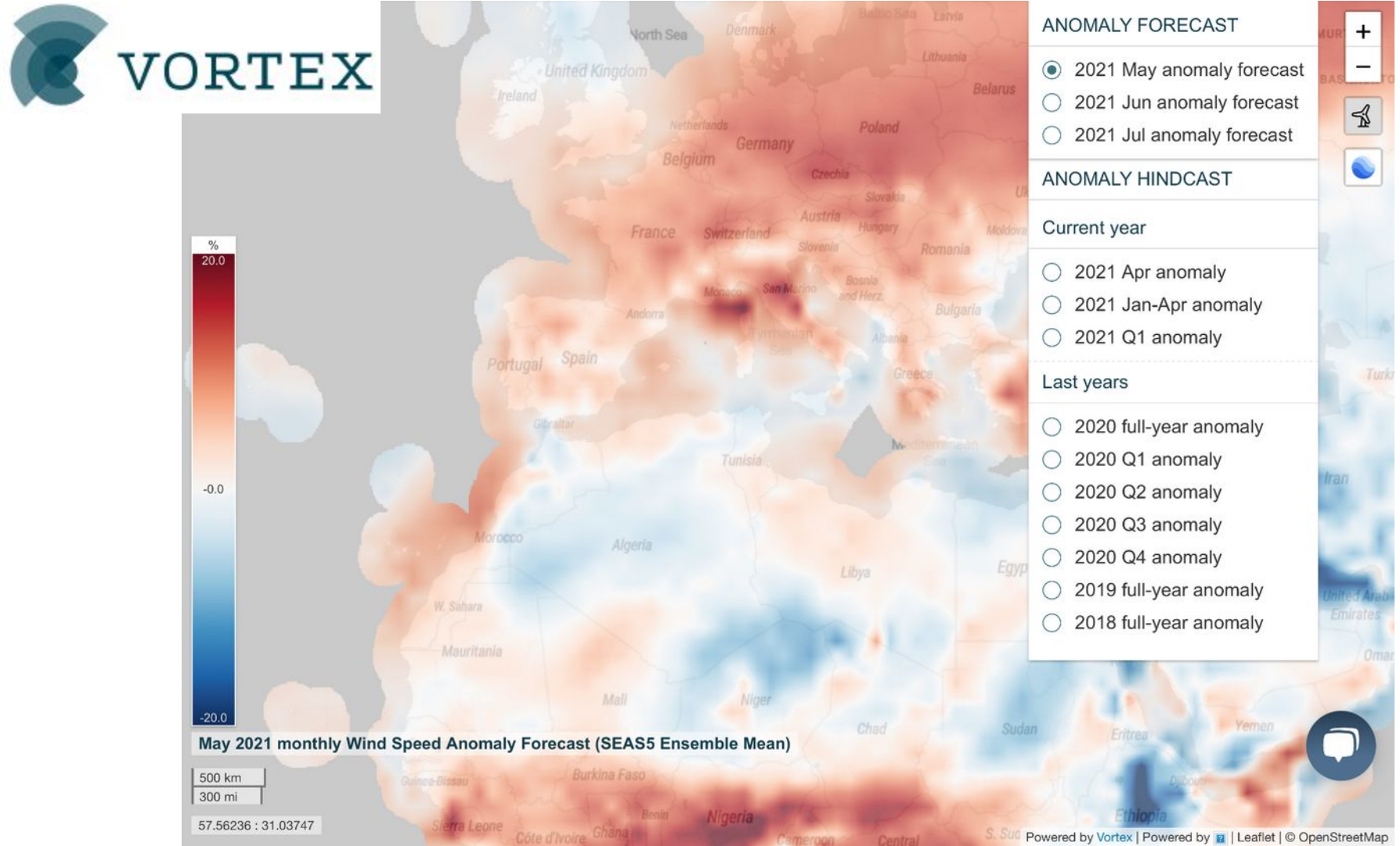
WS Seasonal Forecasting

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Seasonal forecasting (WP1)				Workshop / Paper	D1.5 / M19	Hydro TCP, Hydrogen TCP, Biomass TCP

Seasonal forecasts are growing in importance for the power grid planning, especially, where hydropower, storage and other technologies are involved. This topic is also interlinked to the uncertainty forecasting work stream and will focus on the communication between weather and energy community. Seasonal forecasts are a subset of weather forecasting, and are therefore managed by WP1. WP3 will interlink these communities and serve as a platform to establish new applications for the use of seasonal forecasting in the energy community and the transformation into a carbon free energy system.

D 1.5: Convene workshop and develop paper on seasonal forecasting, emphasizing hydro and storage (M19)

Background image: Vortex FdC


VORTEX
ANOMALY FORECAST
2021 May anomaly forecast
2021 Jun anomaly forecast
2021 Jul anomaly forecast
ANOMALY HINDCAST
Current year
2021 Apr anomaly
2021 Jan-Apr anomaly
2021 Q1 anomaly
Last years
2020 full-year anomaly
2020 Q1 anomaly
2020 Q2 anomaly
2020 Q3 anomaly
2020 Q4 anomaly
2019 full-year anomaly
2018 full-year anomaly
%
20.0
-0.0
-20.0
May 2021 monthly Wind Speed Anomaly Forecast (SEAS5 Ensemble Mean)
500 km
300 mi
57.56236 : 31.03747
Powered by Vortex | Powered by | Leaflet | © OpenStreetMap

WS State of the Art and Research Gaps

WS:	WP1 Weather	**WP2 Power**	WP3 Applications	**Deliverable**	**#, Due**	**Collaboration**
State of the Art for energy system forecasting (WP2)				Workshop / Paper RecPract on Forecast Solution Selection v3	D2.1 / M7, M12 M2.1 / M36	PVPS Task 16, Hydro TCP, Hydrogen TCP, …

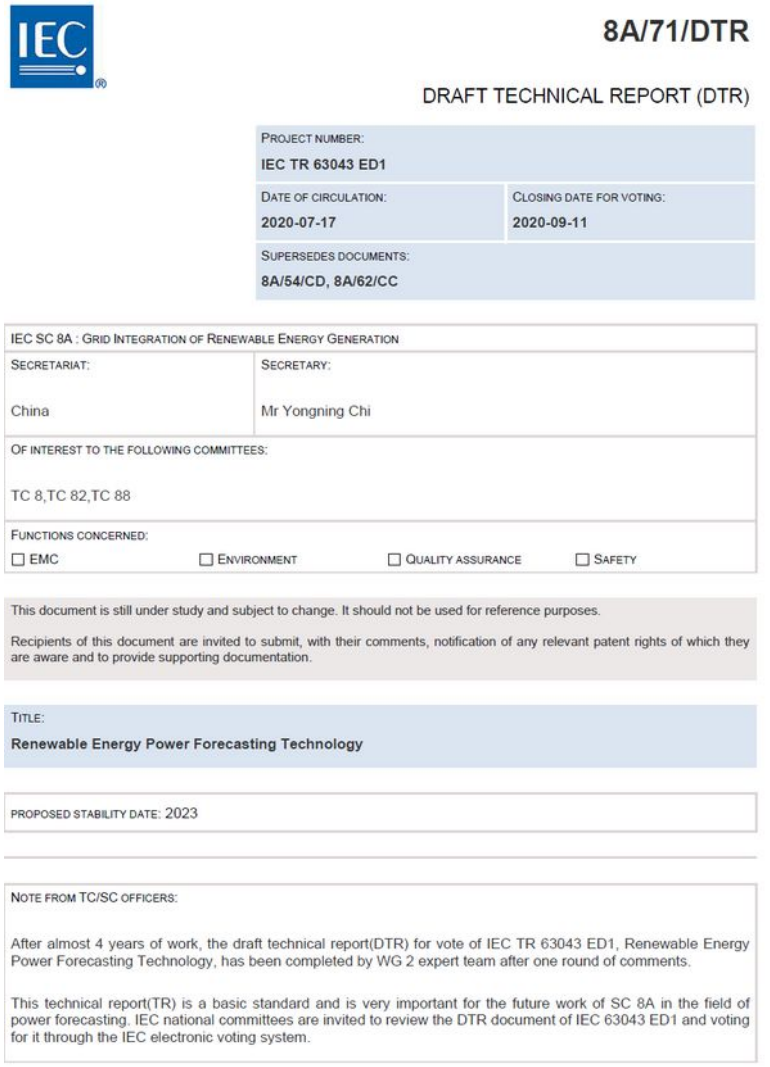
In year 1, the new Task will organise a **workshop** on the state of the art and future research issues in energy forecasting, inviting other TCPs (PVPS Task 16 already has voiced interest). The workshop is modelled after the first workshop in Task 36, which established a baseline and research agenda. The established state-of-the art will be carried forward in the recommended practice guideline for forecasting solution selection and its dissemination to the industry at workshops, webinars, conferences, white papers and a book publications. While every WP contributes to this activity, the conversion to application variables such as power is central here, therefore this WS will be managed by WP2.

D 2.1: Workshop and paper on state-of-the-art and future research issues in the forecasting of weather-dependent energy system variables (M7, M12)

M 2.1: Version 3 of IEA Recommended Practice on Forecast Solution Selection (M36)

Quite recent (2020) text from Sub-Committee 8A Grid Integration of Renewable Energy Generation, Working Group 2 Renewable energy power prediction.

https://webstore.iec.ch/publication/26529



8A/71/DTR

DRAFT TECHNICAL REPORT (DTR)

PROJECT NUMBER:
IEC TR 63043 ED1

DATE OF CIRCULATION: 2020-07-17

CLOSING DATE FOR VOTING: 2020-09-11

SUPERSEDES DOCUMENTS:
8A/54/CD, 8A/62/CC

IEC SC 8A : GRID INTEGRATION OF RENEWABLE ENERGY GENERATION

SECRETARIAT: China

SECRETARY: Mr Yongning Chi

OF INTEREST TO THE FOLLOWING COMMITTEES:
TC 8,TC 82,TC 88

FUNCTIONS CONCERNED:
☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:
Renewable Energy Power Forecasting Technology

PROPOSED STABILITY DATE: 2023

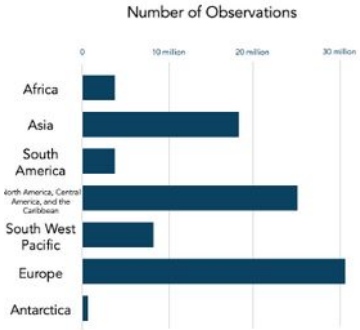
NOTE FROM TC/SC OFFICERS:

After almost 4 years of work, the draft technical report(DTR) for vote of IEC TR 63043 ED1, Renewable Energy Power Forecasting Technology, has been completed by WG 2 expert team after one round of comments.

This technical report(TR) is a basic standard and is very important for the future work of SC 8A in the field of power forecasting. IEC national committees are invited to review the DTR document of IEC 63043 ED1 and voting for it through the IEC electronic voting system.

WS Forecasting for underserved areas

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Forecasting for underserved areas (WP2)				Public dataset	D2.4 / M24	WMO



Forecasting in the established markets like Europe, North America or China has both a long tradition, and a well-established infrastructure. But in sync with the wind industry opening up new markets for the technology, the grid operators and/or market participants need good solutions to deal with the novel influx of power. However, both data availability and possibly market or grid code structures might be quite different in those places. The quality of the forecast needs to be provided by the vendors, which is why this WS is run by WP2. The recommended practices for the implementation of renewable energy forecasting solutions will also serve the under-served markets as valuable guidelines. An adaptation considering the limitations of under-served or emerging countries will be one focus area in collaboration with WP1.

D 2.4: Inventory and web interface of data and tools for forecasting applications in underserved areas. (M24)

WS Minute scale forecasting

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Minute scale forecasting (WP2)				Workshop / Paper	D2.5 / M31, M36	Wind Tasks 32 Lidar, 44 Farm Flow Control and 50 Hybrids, PVPS T16

On the power plant level, forecasts some minutes ahead can be used for battery control in hybrid power plants, in wind farm flow control (it takes minutes for the wind field to pass through a larger wind farm), and sometimes also in market structures like the Australian market, which operates on a 5-min schedule. Advances in minute-scale forecasting have been investigated in phase 2 and will be further developed and communicated to the industry. Since minute scale forecasting mainly uses data driven tools (statistical or machine learning), the WS is administered by WP2, but has connections to WP1 for knowing the wind flow through a farm, and to WP3 with regards to usage of the forecasts. We plan to have a workshop together with the IEA Wind Tasks on Lidar and on Hybrid Power Plants, and possibly others.

D 2.5: Workshop and paper on minute-scale forecasting for hybrid power plants or wind farm control, in conjunction with Task 32 on Lidars, Task 44 on Farm Flow Control and Task 50 on Hybrid Power Plants (M31, M36)

WS Uncertainty / Probabilistic FC / Decision making

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Uncertainty / probabilistic forecasting / decision making under uncertainty (WP3)				Uncertainty propagation paper with data Games RecPract v3 Training course	D 2.6 / M42 M18 M48 M12	PVPS T16

Uncertainty is inherent in the forecasting of weather driven power generation. The preparation of calibrated uncertainty measures is done by the WP2 stakeholders. In WP3, the integration of forecast uncertainty into power grid management, wind power bidding strategies, and storage operation, will be analysed considering the role of humans (and their perception of uncertainty and risk), costs and benefits of end-users. Since this is the research topic needing more attention, WP3 is responsible for this WS. Analysis of critical bottlenecks in forecasting accuracy, as well as validation and value determination, are topics that will be dealt with in interdisciplinary groups and collaborations with associated partners and other WPs. Additionally, a qualitative overview paper of the propagation of uncertainty through the modelling chain was submitted in mid-2021. A natural extension of the work is to use the techniques on real data, to calculate the results and to publish it as a new paper.

D 2.6: Paper on uncertainty propagation in the modelling chain, using quantitative data (M42)

M 2.1: Version 3 of IEA Recom. Practice on Forecast Solution Selection (M36)

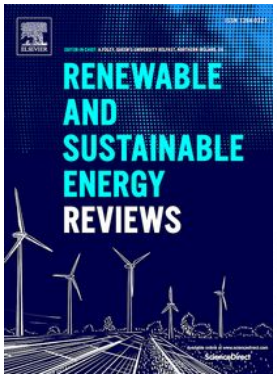
WS Uncertainty / Probabilistic FC / Decision making:

Uncertainty Propagation throughout the model chain with real data

One review paper is submitted and under review. Highlights include:

Jie Yan,Corinna Möhrlen,Tuhfe Göçmen,Mark Kelly,Arne Wessel,Gregor Giebel

- **Uncertainty sources** are defined and described throughout the chain of forecast modelling.
- **Uncertainty mitigation** approaches for each type of uncertainty source **from planning, operation to market phase** are reviewed.
- An example of uncertainty validation is presented and discussed.

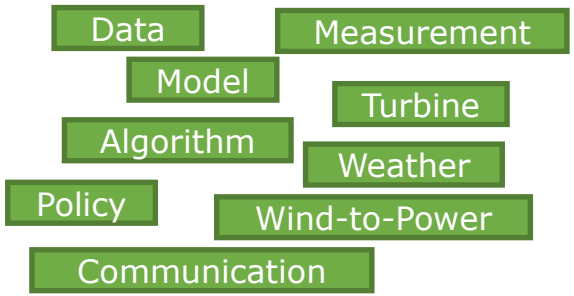


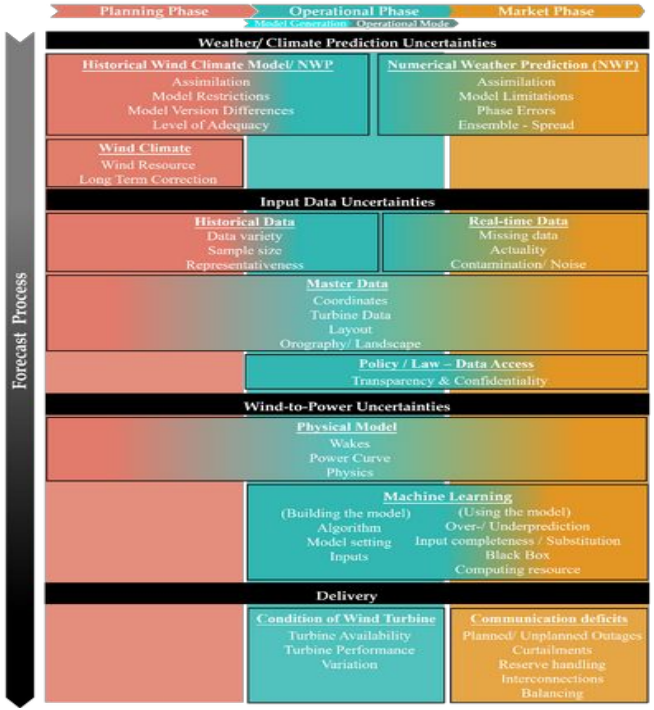

Uncovering wind power forecasting uncertainty origins and development through the whole modelling chain*,**

ARTICLE INFO

ABSTRACT

1. Introduction





iea wind

WS Uncertainty / Probabilistic FC / Decision making:

Uncertainty Propagation throughout the model chain with real data

What we did in 2021

"Dictionary" of Uncertainty

Book
↓
Tool

Our aim in 2021-22

"Calculator" of Uncertainty

- **"dictionary" to learn the sources of uncertainty and how these uncertainties propagate throughout the modelling chain.**
- **"textbook" to guide NWP providers, power forecasters and end users, etc. to implement more rational and targeted uncertainty mitigation strategies.**

Standard Validation Guideline

↓

? "Chain-based" Evaluation Tool

- **"standard test/examination paper" to evaluate a forecast model/system, to know what kinds of uncertainty and how large of these uncertainties.**
- **"exemplary (or general hopefully) public platform" to illustrate the uncertainty chain and to compare different forecast models/systems – for the forecast developers, providers and end-users.**

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WS Uncertainty / Probabilistic FC / Decision making:

Uncertainty Propagation throughout the model chain with real data

Potential collaboration and Results

To do list and expected results:

- **Global standard dataset and validation example (e.g. on Github)**
- **Validation practice (report/paper…)**
- **Platform/Tool develop**
- **…**

Note: extended horizon from seasonal to minute/second-ahead

WP1: Seasonal forecast

WP2: Minute scale forecast

Task 44:
Uncertainty source
Validate by use

Task 32:
Uncertainty source
Standardize the Dataset

Contact:

Jie YAN, North China Electric Power University, yanjie@ncepu.edu.cn

Corinna Möhrlen, WEPROG, com@weprog.com

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WS Uncertainty / Probabilistic FC / Decision making:

Probabilistic Forecast Games and Experiments

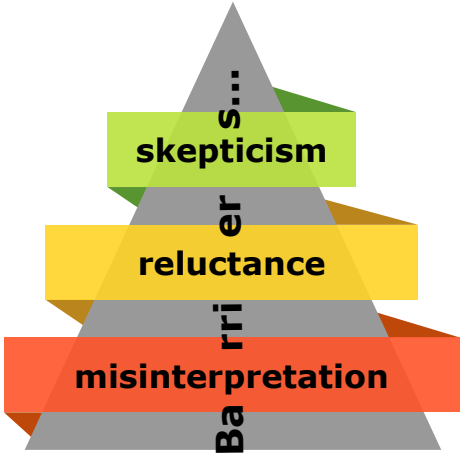
Goals and Objectives of the Initiative

Our aim is:

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

– skepticism – reluctance – misinterpretation –

ii **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**"

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WS Uncertainty / Probabilistic FC / Decision making:

Probabilistic Forecast Games and Experiments

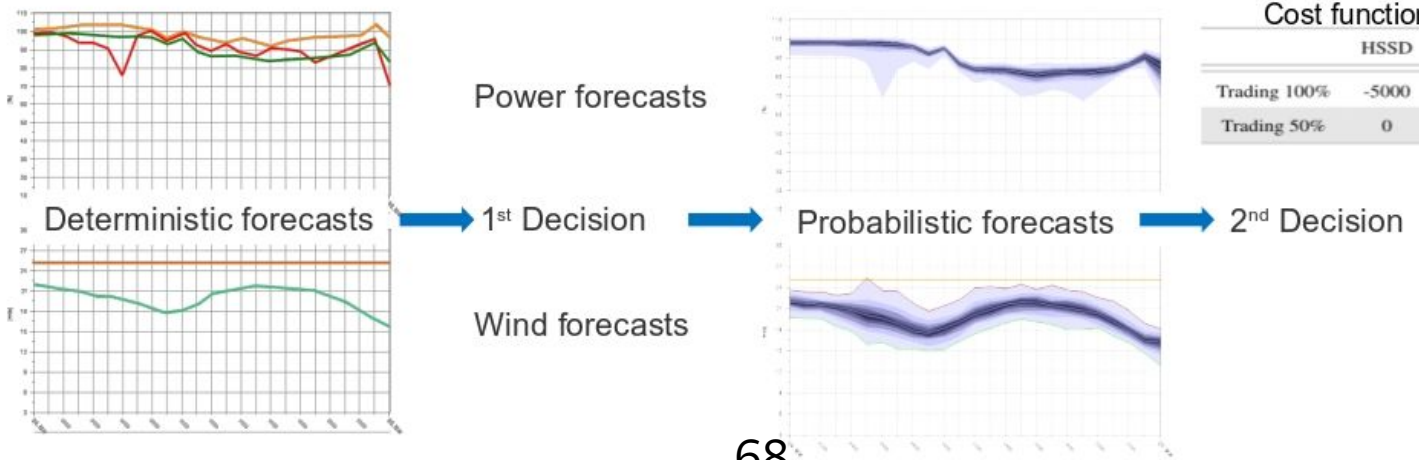
1st Experiment Design (2020)

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 Insititute for Human Development, Hans-Ertl Center of Weather Reseach, Germany
Ensemble Forecasts: **MSEPS 75 Member EPS of WEPROG

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



Cost function

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

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2nd Experiment Design (2021)
Value of probabilistic power forecasts

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

Online: https://meteorology.mpib.dev/wind-power-decisions/about.html **-- Go to "Play again?" to play..**

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

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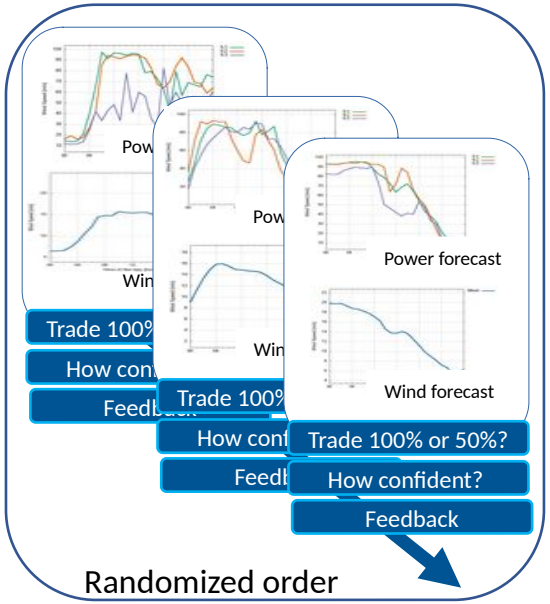
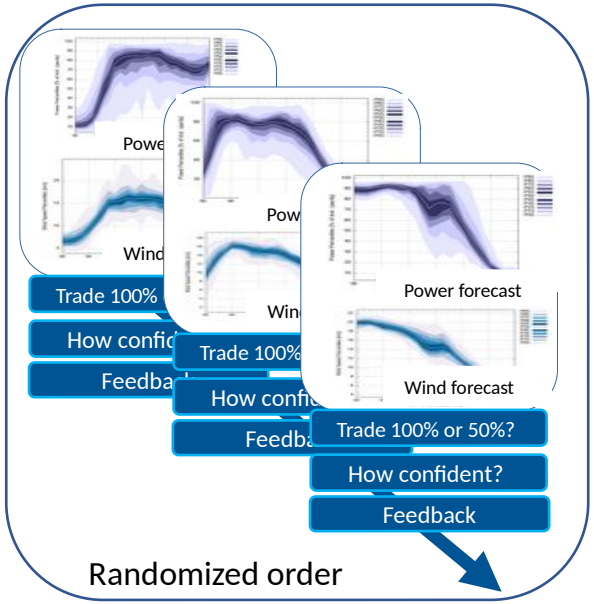
Ensemble Forecasts: **MSEPS 75 Member EPS of WEPROG

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

Each participant →



Blocks randomized ↔



20 decision situations with deterministic forecasts

20 decision situations with probabilistic forecasts

WS Uncertainty / Probabilistic FC / Decision making:

Probabilistic Forecast Games and Experiments

Questions to answer in Task 51

How can probabilistic wind/power forecasts benefit decision making?

Risk communication: **How can we improve risk perception ?**

- Using transparent representations, evidence-based design and evaluation
- Do we have to move from *generation* forecasts to *impact* forecasts ?

Decision support: **How to design decision strategies based on probabilistic information ?**

- What cues need to be provided for interpretation (e.g. highlight critical thresholds)
- How do we put information in perspective (e.g. comparision, typical distribution)
- How can we allow users to develop decision strategies based on realistic experience
- How can we Provide simple and robust heuristics /decision strategies for users

Next steps:

- Evaluate the current running Game/Experiment --→ please share the link** !!!
- Design a new experiment for the Summer Workshop
  - use results from experiment 1 and 2 to see, whether there are unanswered questions
  - what other questions should we investigate ???

**Online: https://meteorology.mpib.dev/wind-power-decisions/about.html -- Go to "Play again?" to play..

WS Uncertainty / Probabilistic FC / Decision making:

Extreme Power Events

In February 2021, an extreme winter storm event caused a **massive electricity generation failure in the state of Texas,** which resulted in a **loss of power for more than 4.5 million homes**. ... bringing attention to the energy system crisis and its potential causes. While much press has been dedicated to identifying the entities and individuals potentially at fault, **determining exact causes and accurately assigning responsibility for an event this complex requires expert input and opinion**…..

Texas Outage Sheds Light On 'Unreliability' ...
According to the Austin American-Statesman, the Texas **power supply relies chiefly on natural-gas** plants. Those supplied 40% of the grid to the Lone-Star State while the second-largest source was of power was wind at 23%....

Reliability

Resilience

What does that mean for forecasting in the future with 80% … 100% renewables on the grid ?

Do we have to move from *generation* forecasts to *impact* forecasts ?

Do we not have to think wind + solar together with demand ?

Do we not have to collaborate and think all (CO_2-free) generation together ?

Need of broiad collaboration….

IEA Bioenergy Task

IEA HybridTask

IEA PVPS Task

WMO SG-ENE

iea wind

WS Extreme Power System Events

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Extreme power system events (WP3)				Workshop	D3.6 / M42	Task 25, ESIG, IEA ISGAN, PVPS T16, G-PST

Weather extremes are a threat to the power system, not only due to destruction of hardware, but also due to inadequate unit commitment, grid planning and available generation units. The challenges are broad and reach into the power markets, where extreme prices can be caused by extreme weather events. Knowledge and exchange of information on how to forecast extremes and mitigate effects from such extremes are topics that need attention in the next phase. While there is a strong weather dependency in this WS, the work will be structured according to the needs of the end users, and therefore administered by WP3.

D 3.6: Convene workshop on extreme power system events (M42)

WS Data Science and Artificial Intelligence

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Data science and artificial intelligence (WP3)				Report	D2.3 / M30	

Data-driven decision-making under risk and uncertainty is being augmented with advances in data science (e.g., deep learning with heterogeneous data sources) and artificial intelligence (e.g., reinforcement learning for optimization) techniques. WP3 will administer the WS and will collect success cases of application in the forecasting and decision-making domain of wind power forecasting, and study different paradigms for integrating uncertainty, data science and AI, such as: human-in-the-loop decision making, digital twins for decision support, interactive machine learning, etc. Finally, trust and security of data-driven methods will be a topic of analysis, in particularly considering industry requirements for integrating new technologies in their business processes. For meteorologists, the numerical weather prediction models change faster than the climate. How can the local adaption or some kind of AI adapt to this without running a new and old model in parallel for a long time? To shorten this parallel time would free up some effort to be used somewhere else.

D 2.3: Report and conference papers on techniques to optimize the use of data science/AI tools for the forecasting of energy-application variables (M30)

WS Privacy, Data Markets and Sharing

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Privacy, data markets and sharing (WP3)				Workshop / Paper Data format standard	D3.5 / M15	ESIG, IEEE WG Energy Forecasting

The transformation of the energy system towards a carbon free generation, and the EU strategy for Common European data spaces that will ensure that more data becomes available for use in the economy and society, requires new policies for data sharing (monetary and non-monetary incentives) and privacy, but also developments of regulatory frameworks and data market designs. This will cover different use cases, such as forecasting and operation & maintenance of wind power plants, where data sharing across the energy value chain can bring benefits for multiple stakeholders (e.g., improved predictability, reduced O&M costs, improvement of turbine component reliability, etc.). The Task also develops its own API, to become a common open-source framework, standardised across vendors, and looks into other data transfer issues.

D 3.5: Summary of use cases, such as forecasting and operation & maintenance of wind power plants to show benefits of data sharing across the energy value chain (M15)

WS Value of Forecasting

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Value of forecasting (WP3)				Paper	D 3.4 / M33	

Without value for the end users, there wouldn't be a market for forecasts. The incremental value of increase accuracy is though much harder to assess. The value proposition is though quite country and market specific. Therefore, we will analyse different market structures w.r.t. to the regulatory framework, the amount of renewable power in the system (i.e. whether it is a price taker or price maker), the possibilities for gaming and the implications of gaming for the system.

D.3.4: Documentation and communication of the assessment of the value of probabilistic forecasts in selected markets, bidding strategies (M24)

WS Forecasting in the Design Phase

WS:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Forecasting in the design phase (WP3)						Task 50 (hybrids), PV T16, hydrogen TCP

An assessment of the expected forecasting accuracy for a given site was already investigated for a single case. However, since then it has been quiet. The new Task will analyse the tradeoffs between normal siting of the turbines, and the forecast capability type.

Summary Forecasting for the Weather Driven Energy System

- Relaunch of Task 36
- Framework conditions changed since first phase of Task 36: RES is not small addition to system, but IS the system; sector coupling to transport, heat, X…
- Has new challenges for new forecast horizons (seasonal forecasting…)
- Needs strong **collaboration with related TCPs** (solar, hydro, hydrogen, …) and related Tasks (Integration, Lidar, Farm Flow Control, Hybrids, …)
- Data markets coming into focus

www.IEAWindForecasting.dk

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