IEA Wind Task 51: Minute and Seasonal Forecasting Workshops for the Weather Driven Energy System

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IEA Wind Task 51
Minute and Seasonal Forecasting Workshops for the Weather Driven Energy System

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As the world's fastest-growing technology, **Artificial Intelligence** (AI) is rapidly shaping industries such as Energy and Meteorology. To help address stakeholders' concerns about the impacts of increasingly incorporating AI and Machine Learning into weather and power prediction models, the International Energy Agency's (IEA) Wind Task 51 "Forecasting for the Weather Driven Energy System" invites you to a webinar in Deep Learning for Weather-Based Power Prediction. In this Webinar we will **bring together the Energy Meteorology and Machine Learning / Deep Learning (ML/DL)** communities to showcase the latest advancements in ML/DL for weather prediction. This event also provides an opportunity to discuss **future directions for the integration of these new generation models in the Energy systems**.

Watch it on https://youtu.be/t6H7diavQdg.

Thursday, January 11, 2024	
15:30 – 16:25	Welcome and Keynote by Mariana Clare, ECMWF - Welcome by webinar organizers Sukanta Basu and Joana Mendes (5 min) - Keynote presentation "The rise of data-driven weather forecasting" (40 min) - Q&A (10 min)
16:25 – 16:30	Comfort break
16:30 – 17:05	Greg Hakim, University of Washington, Seattle - Dynamical Tests of a Deep-Learning Weather Prediction Model (25 min) - Q&A (10 min)
17:05 – 17:40	Joel Oskarsson, Linköping University - Neural Weather Prediction for Limited Area Modeling (25 min) - Q&A (10 min)
17:40 – 18:15	Florian Achermann, ETH and JUA.ai - A Research Collaboration between ETH Zurich and Jua: Ultra High Resolution Wind Forecasts (25 min) - Q&A (10 min)
18:15 – 18:30	Open discussion and close - Facilitated discussion around the topics presented (13 min) - Concluding remarks and close (2 min)

Learning:

- The models are already quite accurate.
  ECMWF was one of the first to try, and will add AIFS to its suite of models soon, also as part of the ensemble system. ECMWF packages the models for ease of use: https://github.com/ecmwf-lab/ai-models
- The models are easy to work with.
  E.g., Greg Hakim could download the models, do some experiments and write a paper in a few months.
- Some of the models at least seem to get the physics right.
  Greg Hakim did some experiments with a number of the models. None have explicit physics, but seem to build a good picture anyway.
- The models develop fast.
  Where in conventional NWP models, a model cycle can be years, new AI WP models come every few months, and bring significant improvement.
- Huge ensembles (>1000 members) get possible, probabilistic forecasting is coming.
  Once trained, the running time of e.g. a global 1-km resolution model for 48 hours is 20 seconds, plus 20 minutes for data i/o.
- Currently for global models, though LAMs are coming; not (yet?) for LES or climate
- Start from analysis, or measurements?
  Currently, all models start from a "proper" NWP analysis, e.g. from ECMWF IFS. But there is significant work underway to start the models from measurements alone.
- How to keep outliers under control?

Largest global discussion forum for renewables forecasting

2024: public Workshop on Minute Scale Forecasting, April 10/11, Risø (DK)

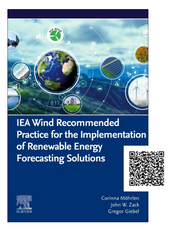
Recent workshops on State of the Art, Seasonal Forecasting and AI Weather Prediction on YouTube "IEAWindForecasting"

To come in 2025:

Public Workshop "Extreme power system events", Boulder (USA) (~April)

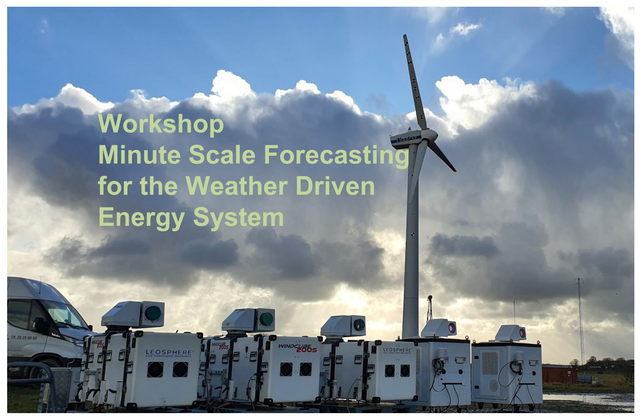
Work Streams:	WP1 Weather	WP2 Power	WP3 Applications	Deliverable	#, Due	Collaboration
Atmospheric physics and modelling (WP1)	★			List of experiments and data	D1.1, Ongoing	WMO, PVPS T16
Airborne Wind Energy Systems (WP1)	★			Presentations on workshops	Part of D2.1	Task 48 Airborne Wind Energy
Seasonal forecasting (WP1)	★			**Workshop** / Paper	D1.6 / M19= May 2023, Reading	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= Sept '22, Dublin M2.1 / M36	PVPS Task 16, Hydro TCP, Hydrogen TCP, …
Minute scale forecasting (WP2)		★		Workshop / Paper	D2.5 / M31, M36 = **April 2024, Risø**	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= **Spring 2025, Boulder**	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
Value of forecasting (WP3)		★	★	Paper	D 3.4 / M33	

- 11 work streams
- **Collaboration** with other IEA Wind Tasks (Lidar, Hybrid Power Plants, Wind Farm Flow Control, Large-Scale Integration, Distributed Wind, Airborne Wind, …) and other IEA TCPs (PVPS, Biomass, Hydrogen, Hydro, …) as well as WMO
- Also collaborating with IEC SC8A WG2 Forecasting of Renewable Power, developing standards for input data and evaluation protocols for renewable generation forecasts
- Built on IEA Wind Recommended Practice



- Error evaluation frameworks:
  - WE-validate (Juniper package)
  - WE-validate_prob (R package)
  - Forecast Arbiter (formerly Solar Arbiter, now also for wind, load and net load)
  - NCEPU Evaluation and Uncertainty Quantification Framework

For collaboration in the Task or just for the newsletter, **please contact the Operating Agent, Gregor Giebel (grgi@dtu.dk).**
Current member countries are
AT, CN, DE, DK, ES, FR, IE, NL, PT, SE, UK and US.



Forecasts of wind and clouds are important inputs for the control and value of renewable power plants. The forecasts on a time resolution of minutes or seconds are typically data driven, looking at upstream plants, all-sky images of clouds or direct measurements of wind by lidars. Therefore, to facilitate the dissemination of information about minute scale forecasting products, skill, applications, issues, and best practices to members of the electric energy community, we invited to a Minute-Scale Forecasting workshop with the goal of

- gathering information about methods used to produce the forecasts
- current state-of-the-art skill and uncertainty in forecasting for variables on high temporal resolution
- current and planned research activities intended to improve the current level of skill
- types of public and private sector operational forecasting products
- the range of minute scale applications in the energy community and the quantified or perceived value obtained from those applications
- the sensitivity of user's application performance to variations in forecast skill
- the unmet minute-scale forecasting-related needs or desires of the energy user community.

The workshop took place as the collaboration of the International Energy Agency's (IEA) Wind Task 51, entitled "Forecasting for the Weather Driven Energy System", IEA Wind Task 52 Lidars, IEA Wind Task 50 Hybrid Power Plants, IEA Wind Task 44 Wind Farm Flow Control and IEA Photovoltaic Power Systems Programme (PVPS) Task 16 Solar Resource. The venue was Risø, Denmark. Some 70+ people attended in person, another 20 followed online.

Day 1's opening session was a **keynote session**, detailing out the use case by Energinet, and showing the methods for solar and wind forecasting based on measurement data. The **second session** was about All Sky Imager networks, and the use of the resulting data. The **third session** detailed out applications, including from Eirgrid and Svenska Kraftnät, the Irish and Swedish Transmission System Operators. An **open space session** then collected input from the participants regarding barriers for use and implementation, AI, quality control of the measurements and a comparison of wind and solar forecasts. On ***day 2***, the data driven wind and solar forecasts were discussed in more detail.

Lessons learned from the Minute-scale workshop

- ***Two aspects of Minute-scale:***

1. Forecasts for the next minutes ahead
2. Forecasting in time-scales of minutes

- The first (1) is done with data-driven or hybrid algorithms such as:
  - **Data-driven**: Machine Learning, dynamic graph ML, neural networks such as GNN, feature engineering, generator models, graph convolutional long-short-term memory models etc.
  - ***Hybrid***: can include heterogenous data sources from satellite or NWP images improve predictions, use cloud-scale dependent autoregressive advection or deep learning radiative transfer emulators, Kalman filters
- ***Observational data sources are:***
  - WIND: scanning LIDARs with scanning heads, or sonic anemometers and sodars for wind applications
  - SOLAR: ASI (all sky imaging, fish-eye cameras pointed at the sky) and satellite observations
- ***Learnings from recent research:***
  - Feature engineering methods need "engineering" in the sense of knowing the atmosphere and its development to be useful
  - High-resolution NWP with high-time resolution of the order 5-10min are enabling NWP models to be used for minute-scale forecasting
  - AI weather forecasting system 3D-CNN is mapping relationship between global analysis and local (wind/solar) measurements and aims to replace the modelling process of traditional NWP scales with local measurements
- ***Evaluation methods:***
  - Data Scientist and Physicists/Meteorologist evaluate forecast skill and value different
  - Data-driven and NWP-driven methods model/predict different space and time scales of features and this needs to be considered in the comparison process
- ***End-users and applications:***
  - O&M Wind has changed focus away from scanning LIDARS due to costs since last workshop in 2018 to data-driven methods with near-by measurements
  - System operators are seeing the need for
    - balancing the grid
    - ramping reserves
  - Traders:
    - balancing
    - ancillary services

www.IEA-Wind.org/task51/