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

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Third Destination Earth User eXchange
15-16 October, 2024
Darmstadt, Germany

IEA Wind Task 51 Workshop Results

In order to facilitate energy stakeholder's growing interest in sub-seasonal to seasonal (S2S) forecasting information in their application, the IEA Wind Task 51 organised a workshop to disseminate information about S2S forecasting products, skill, applications, issues, and best practices to members of the electric energy community.
The S2S forecasting workshop covered topics on:

- methods used to produce S2S forecasts
- current and planned research activities to improve skill
- types of public and private sector operational S2S forecasting products
- the range of S2S applications in the energy community
- the quantified or perceived value obtained from those applications
- the sensitivity of user's application performance to variations in skill
- the S2S-forecasting-related needs or desires of energy user community

Lessons Learned:

- Infomation is available: met centers generate many products (e.g. DWD, Copernicus. ECMWF, UK MetOffice, NOAA, etc.)
  - climatic predictions, ensemble predictions, traffic lights inclusive skills
  - user workshops and newsletters
- Requirement for more user engagement: user request are unspecific and require adaptation to general data collections, users ask for ease of use (see e.g. free climate data tool of WEMC "Teal Tool")

Past: observation analysis for planning task in energy community
Future: Maintenance, Energy Management Investment planning need monthly, seasonal and climatic outlooks

Webinar now available in our YouTube channel
https://youtu.be/t6H7diavQdg

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.

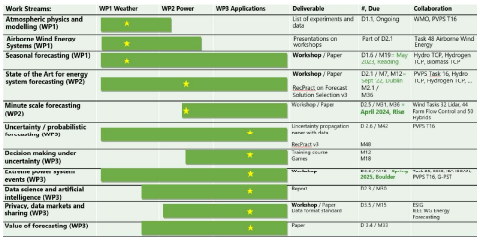
In this Webinar we brought together the **Energy Meteorology and Machine Learning / Deep Learning (ML/DL) communities** to showcase the latest advancements in ML/DL for weather prediction.

Some Lessons Learned from the webinar:

- The models start to show skill
  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.
- The models are accessible to the Public
  Greg Hakim did some experiments with a number of the models and found it easy do sensitivity studies.
- The models develop fast
  At present there is a lot of focus and resources put into these models, and new AI WP models come every few months, and bring significant improvement.
- Huge ensembles (>1000 members) are on the horizon
  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.
- Start from analysis, or measurements?
  Currently, all models start from a "proper" NWP analysis, e.g. from NCEP GFS, ECMWF IFS, etc. But there is work underway to start the models from measurements alone.
- How to keep outliers under control?
  There is not much information about how to get outliers under control, how to quality check observations available yet.

Largest global discussion forum for renewable energy forecasting

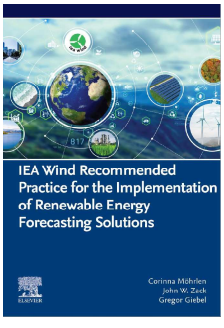
Wind and solar are no longer mere additions to the grid, in the future they *are* the grid. They are weather dependent, therefore the entire power and energy system needs to be handled according to the weather. **IEA Wind Task 51 "Forecasting for the Weather Driven Energy System"** takes a broad approach for all sources, and some mitigation options, of the naturally occurring variability. The Task first phase is from 2022 - 2025.
The work packages reflect the modelling chain: meteorology (WP1), power conversion (WP2) and application of the forecasts (WP3). Below that we have established 11work streams that reach across areas and are run in collaboration with many other IEA Wind Tasks, IEA Technology Collaboration Programmes (PVPS), the WMO Energy Group and the IEC SC8A Grid Integration for Renewable Energy.



The current Work Program:

- 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
- Collaboration with IEC SC8A WG2 Forecasting of Renewable Energy, on developing the **first standard for real-time forecasting** built on IEA Wind Recommended Practice for:
  - input and observational data handling
  - data quality control
  - evaluation methods and protocols
  - ...
- **Use-case studies** and **Evaluation framework** development and OpenAccess Publication:
  - 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

Our first IEA Wind Recommended Practice guideline now includes solar forecasting and how to effectively gather and utilize meteorological data from wind and solar farm locations.
The guideline makes recommendations for how to select and maintain optimal forecasting solutions; it is written both from an end-user and vendor perspective. The main message is to carefully analyze your needs before planning for or evaluating a forecasting solution.



The OpenAccess Recommended Practice guideline is purchasable as paperback book and available for download by Elsevier– for both see QR code

For collaboration/information with the Task or to receive our newsletter**, please contact the Task Managers**
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Current member countries are
AT, CN, DE, DK, ES, FR, IE, NL, PT, SE, UK and US.

IEA Wind Task 51Workshops Results

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 or sodars. 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 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
- sensitivity of user's application performance to variations in 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.

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 auto-regressive 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 measurements and aims to replace the modelling process of NWP 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 from scanning LIDARS due to costs since last workshop(2018) to data-driven methods with near-by measurements
- System operators are seeing the need for
  - balancing the grid and ramping reserves
- Traders are seeing the need for :
  - Balancing and ancillary services

www.iea-wind.org/task51