Report 2022

Task 51

Photo: M_MUC1968 /Getty Images-Canva.

Forecasting for the Weather-Driven Energy System

Author *Gregor Giebel, Technical University of Denmark (DTU), Wind and Energy Systems, Denmark.*

A decade ago, the idea of "wind integration" discussed how to integrate 10% or more of wind in an otherwise unchanged power system.

A decade from now, wind and solar will be the backbone of the system, at least in some areas of the world at some times. Task 51, "Forecasting for the Weather-Driven Energy System", reaches out to other Tasks and TCPs to discuss and improve forecasting for all aspects of the Weather Driven Energy System. It aims to improve forecast performance from the minute scale to a seasonal scale and increase the value obtained from the forecasts by improving their usage. The work is organised across three work packages (Atmospheric Physics, Conversion to User Variables, End Use) and spans 13 work streams, such as minute scale forecasting, seasonal forecasting, data sharing, and the value of forecasting and extreme power

system events.

In 2022, the Task released version 2 of the IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions as an open book, which can be bought as a printed book and also downloaded chapter-wise for free. Additionally, Task 51 started the new phase with a workshop on the state-of-the-art and research gaps in Dublin in September.

Industry collaborates with the Task in two ways. Firstly, as providers of the forecasts (mostly taking the results from weather predictions run by national weather institutes, but sometimes by creating their own). Secondly, as end users, such as operating a renewable generation facility, trading power, or running a power system.

Introduction

While its predecessor, Task 36, had the title "Forecasting for Wind Energy", Task 51 is trying to break up the TCP silos as "Forecasting for the Weather Driven Energy System". This means collaborating more closely within the Wind TCP (e.g., Task 25 Large Scale Integration, Task 44 Wind Farm Flow Control, Task 48 Airborne Wind Energy, Task 50 Hybrid Power Plants and Task 53 Lidars) and the broader renewables realm. We have established a collaboration with IEA PVPS Task 16, "Solar Resources for High Penetration and Large-Scale Applications", for solar forecasts and will organise a joint workshop on minute-scale forecasting in 2024. Task 51 also had guests from IEA Hydro Annex IX, "Valuing Hydropower Services", at our recent workshop on seasonal forecasting. Furthermore, we established a collaboration with the WMO (World Meteorological Organisation) Study Group on Integrated Energy Services and IEC (International Electrotechnical Commission) Sub-Committee 8A Working Group 2 on Forecasting Renewable Energy Power.

The work is aligned along three work packages, partitioned according to stakeholders (meteorologists, forecast vendors and end users). Academics populate all three work packages. The participant list is some 300 people, which makes Task 51 notionally the largest global discussion group on forecasting issues. The topical activities are designed across those as work streams. The 13 work streams span meteorology, data, uncertainty, decision-making, several specialised time horizons, and the value of forecasting.

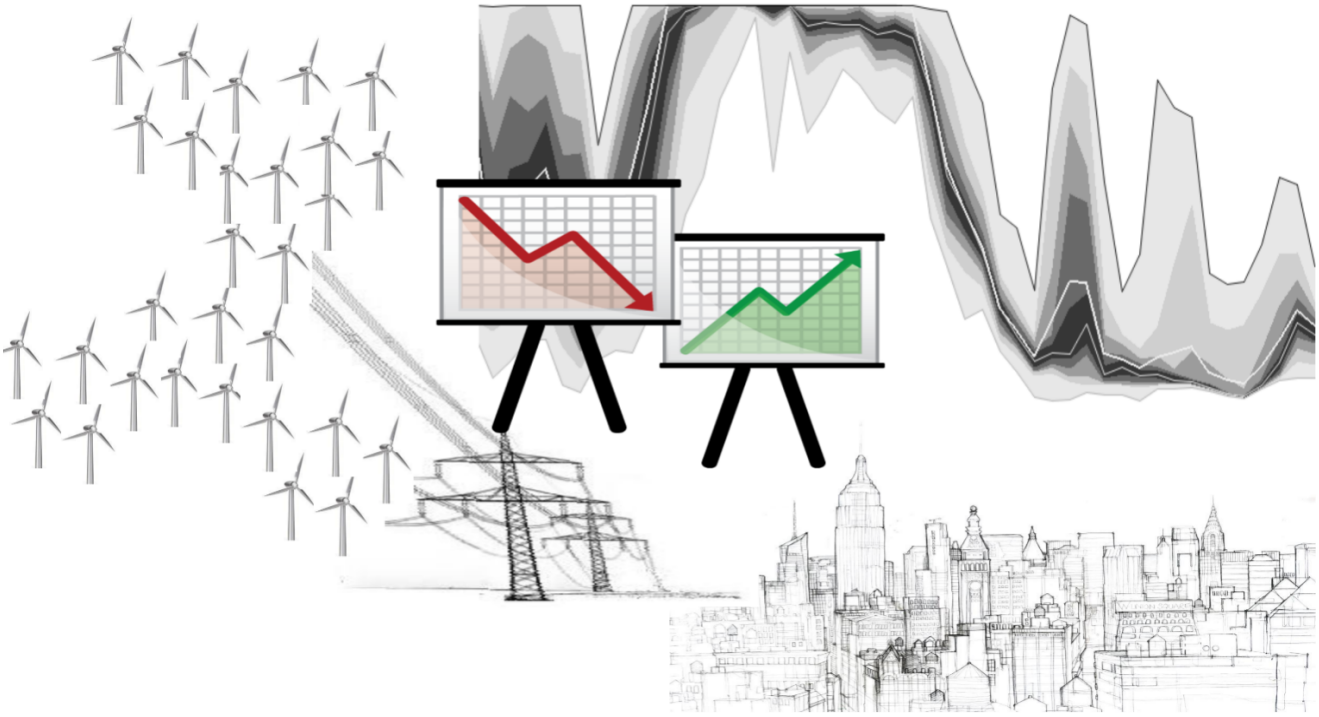

Figure 1: Wind Power Forecasting for Grid Integration. *Source: Corinna Möhrlen, WEPROG.*

Table 1. Contries Participating in Task 51. The Netherlands and Sweden will join in 2023.

COUNTRY/SPONSOR	INSTITUTION(S)
Austria	Geosphere Austria
CWEA	China Electric Power Research Institute; China Meteorological Administration; Envision; North China Electric Power University; Xinjiang Goldwind; Zhejiang Windey
Denmark	Technical University of Denmark (DTU); Denmarks Meteorological Institute; DNV; ENFOR; WEPROG; ConWX; Ea Energianalyse
Germany	Deutscher Wetterdienst; Fraunhofer Institute for Energy Economics and Energy System Technology; Enercon; ForWind; Zentrum für Sonnenenergie und Wasserstoff-Forschung; WindForS; EWC; 4cast; Stuttgart University; DLR Vernetzte Energiesysteme; MPI Bildungsforschung; enercast, Overspeed; Uni. Tübingen
France	MINES ParisTech; MeteoSwift; MetEolien; Electricité de France; Compagnie Nationale du Rhône; Engie Green; Réseau de transport d'électricité
Finland	VTT Technical Research Centre of Finland; FMI
Ireland	Technological University of Dublin; University College Dublin
Portugal	INESC TEC; Laboratorio Nacional de Energia e Geologia
Spain	Iberdrola Renovables; Electricidade do Portugal Renovaveis; Red Electrica de España; Scirocco; Vortex FDC
United Kingdom	UK National Grid ESO; Glasgow University; Reading University; Strathclyde University
United States	Pacific Northwest National Laboratory; National Renewable Energy Laboratory; National Oceanic and Atmospheric Administration; National Centre for Atmospheric Research; Electric Power Research Institute; ERCOT; SUNY Albany; MESO, Inc

Progress and Achievements

To initiate the new phase of the Forecasting Task, a public workshop was held in Dublin on the 12th and 13th of September 2022. Around 40 people attended in person, with another 20 following the proceedings online. The entire workshop is now available on the Task's YouTube channel [1]. The talks and discussions spanned from meteorological modelling to the end use in power systems and trading, from the minute scale to seasonal time scales. Additionally, it discussed data and AI for forecasting and had two open space sessions to work out the forecasting needs for the coming years.

NREL conducted a meteorological benchmark exercise as one of the last activities of Task 36 and reported the findings in a paper in 2022 [2]. The meteorological benchmark was based on the data and the verification and validation work developed under the Second Wind Forecast Improvement Project. For the validation, an open-source Python framework was established, WE-Validate. One sodar in the North-Western U.S. with a strong case of mountain waves was used, as well as data from an offshore wind farm and the FINO 2 mast in the Baltic Sea. Developing the correct and robust metrics for evaluation, including ramp evaluation, was a particular focus.

A significant effort during 2022 was publishing the review on uncertainty propagation through the modelling chain [3]. The paper presents a qualitative view of the uncertainty sources in wind power forecasting, from the input data to the outputs, and shows how those uncertainties propagate through the modelling chain. The paper distinguishes between the planning phase, operational phase, and market phase. It is demonstrated that mitigation of uncertainties should be addressed in every modelling step. A standardised uncertainty validation practice is also recommended.

Another paper reviewed multivariate forecasting for wind and solar [4], emphasising the reconciliation of forecasts across several spatial and temporal aggregation levels. The

review also discussed how to combine probabilistic forecasts and evaluate them in line with the business aims of the forecast users.

Finally, the effort of games to motivate the use of probabilistic forecasts was also documented in a paper [5]. 105 participants from academia and industry participated in a simplified decision-making game based on wind generation shut-down events. The same events were played with deterministic and probabilistic forecasts. 70% of participants got better results based on the probabilistic forecasts.

Highlight(s)

The major highlight of 2022 was the publication of the IEA Wind Recommended Practice (RP) for the Implementation of Renewable Energy Forecasting Solutions as an open book [6]. The RP is intended to be a practical guide to selecting optimal renewable energy forecast solutions. It consists of four parts. Part 1 addresses the process of choosing an optimal forecasting solution for specific applications. Here, it is intended to provide guidance for the design of an economically viable process that will maximise the probability of obtaining an optimal forecast solution for a user's applications. Part 2 provides guidance for the design and execution of representative benchmarks or trials. Part 3 provides guidance on the evaluation of forecasts. Part 4 is designed to provide background information on meteorological instrumentation and their recommended setup, maintenance, and quality control to facilitate real-time data flow from generation facilities for optimal input into forecast production processes.

There is considerable evidence that for many applications, the optimal forecast solutions are often not used. Therefore, some of the potential forecast value is not realised. The primary factors that contribute to this are (1) the specification of the wrong forecast objectives in the solution selection process, (2) the use of poorly designed or executed trials of candidate solutions, (3) the use of performance metrics that are not well-aligned with the application objectives and (4) issues with the quality, representativeness and timeliness of the data from the forecast target facilities that is provided as input to the forecast production process.

Outcomes and Significance

Task 51 Forecasting is the largest global forum to discuss issues with renewable power forecasting. The Task has prepared a recommended practice on forecast choice and evaluation and will continue to update that. The Task also started to create open software libraries for data exchange and evaluation of forecasts, helping the industry employ commercial forecasts more smoothly and get the best value from the forecasts they already employ.
Task 51 also had extensive dissemination efforts at several conferences, such as WindEurope's Annual Event, EGU, ICEM, the Wind Integration Workshop, and the Hybrid Power System Workshop, among others.

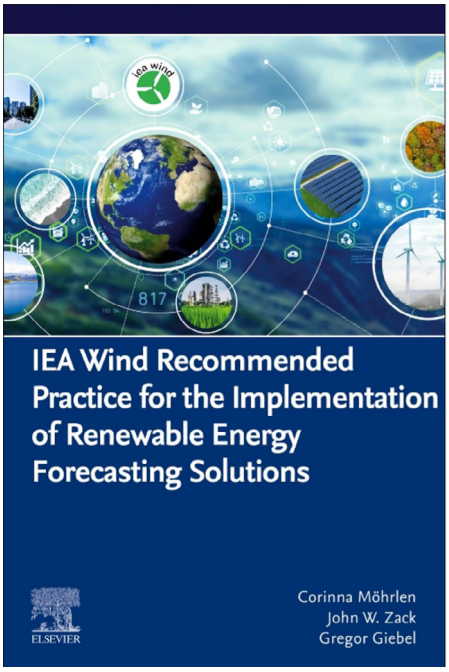

Figure 2: The IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions has come out as a book in Elsevier, with open-access chapter downloads and reprinted with permission from Elsevier.

Next Steps

Task 51 organised an open workshop on seasonal forecasting for the Weather Driven Energy System in Reading, UK, on the 17th and 18th of May 2023. The workshop is on the Task's YouTube channel, and the results will be written as a paper. Additionally, the information portal on the website will be kept up to date, the work streams will be discussing their separate deliverables and the Minute-Scale Forecasting workshop is planned for 2024 in collaboration with Tasks 44, 50, 52 and IEA PVPS Task 16. Additionally, we are organising a webinar on pure machine learning to drive weather prediction for Autumn 2023.

References

[1] EA Wind Forecasting. (n.d.). YouTube. https://www.youtube.com/c/IEAWindForecasting

[2] Joseph C. Y. Lee, Caroline Draxl, Larry K. Berg (2022): Evaluating wind speed and power forecasts for wind-energy applications using an open-source and systematic validation framework, Renewable Energy, 200, 457-475. https://doi.org/10.1016/j.renene.2022.09.111

[3] Jie Yan, Corinna Möhrlen, Tuhfe Göçmen, Mark Kelly, Arne Wessel, Gregor Giebel (2022): Uncovering wind power forecasting uncertainty sources and their propagation through the whole modelling chain. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2022.112519

[4] Mikkel L. Sørensen, Peter Nystrup, Mathias B. Bjerregård, Jan K. Møller, Peder Bacher, Henrik Madsen (2022): Recent developments in multivariate wind and solar power forecasting. WIREs Energy and Environment. https://doi.org/10.1002/wene.465

[5] Möhrlen, C., Bessa, R. J., & Fleischhut, N. (2022): A decision-making experiment under wind power forecast uncertainty. Meteorological Applications, 29(3), e2077. https://doi.org/10.1002/met.2077

[6] Möhrlen, C., J. Zack, G. Giebel (2022): IEA Wind Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions. ISBN: 978-0-443-18681-3. *Academic Press*. https://www.sciencedirect.com/book/9780443186813/iea-wind-recommended-practice-for-the-implementation-of-renewable-energy-forecasting-solutions

Task Contact

Gregor Giebel,
Technical University of Denmark (DTU), Wind and Energy Systems, Denmark.
Caroline Draxl,
National Renewable Energy Laboratory, United States.

Emails:
grgi@dtu.dk
caroline.draxl@nrel.gov

Website:
https://iea-wind.org/task51/