Extreme Power System Events, Results from a Recent Workshop of IEA Wind Task 51 Forecasting

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IEA Wind Task 51 'Forecasting for the Weather Driven Energy System' is currently the largest group of stakeholders in renewable power forecasting. The Task members collaborate on issues ranging from how to achieve better wind forecasts to how to choose a forecast system and how to deal with decision making under forecast uncertainty.

Electric grid systems that want to operate with a high penetration of weather-driven renewable generation need an interdisciplinary forecasting approach in order to optimize the system economics, reliability and resilience. While anchored in IEA Wind, Task 51 activities to maximize forecasting performance and demonstrate the value of forecasting for a weather-driven energy system, spans a much wider scope, also encompassing PV, hydro, biomass, hydrogen, storage and other IEA Technology Collaboration Programmes (TCPs). The three existing Work Packages (WPs) on numerical weather prediction (NWP) Improvements (WP1), Power and Uncertainty Forecasting (WP2) and optimal use of Forecasting Solutions (WP3), are complemented by eleven work streams in a matrix structure.

The three work packages span **three distinct areas of challenge** in forecasting for the weather driven energy system. The **first area** is the continuing effort to improve and enhance weather forecast input for the energy community. This is done by working on different time horizons from minute-scale to seasonable forecasting, as well as the representation of physical processes in weather forecast models through both new high performance initializations and tailored parameterizations. The **second area** deals with the conversion methods from wind to power, the full understanding of the uncertainties throughout the modelling chain and the incorporation of novel data into power forecasting algorithms. The **third area's objective** is the representation, communication, and use of forecasts and its inherent uncertainties to the industry in forms that readily provide support in decision-making at plant level, grid system operations and electricity markets.
Task 51 focuses 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.

The three WPs therefore also reflect the stakeholders: WP1 is mainly aimed at meteorologists, providing the weather forecast basis for the power forecasts. In WP2, the forecast service vendors are the main stakeholders, while the end users populate WP3. Since many of the activities span several groups, we established work streams perpendicular to the WPs. Some examples are the Atmospheric physics and modelling, Seasonal forecasting, and Minute-scale forecasting, Decision making under uncertainty (including uncertainty quantification), Extreme power system events, Data Science, Privacy, Data markets and sharing, and Value of forecasting.

The most recent activity of Task 51 was a Workshop on Extreme Power System Events (1-2 April 2025 in Boulder (CO), USA). Previous workshops were on the State of the Art in Dublin, 2022, on Seasonal Forecasting in Reading, 2023, and on Minute Scale Forecasting together with the solar counterpart in Risø, 2024, and an online workshop on AI Weather Prediction, also 2024. Additionally, the probabilistic verification package "evalprob4forcast" associated with the IEA Wind Recommended Practice on Forecast Solution Selection, has been launched and use-case examples have been added to make it easy to be adopted by the industry. The Recommended Practice together with the PVPS Handbook developed by the IEA PVPS Task 16 additionally serves as a blueprint for an international standard development, focussing on error measures and data quality, that is being developed in cooperation with the International Electrotechnical Commission's (IEC) Scientific Committee on Grid integration of Renewable energy workgroup on Renewable energy power forecasting (SC8A WG2).

The Extreme Events workshop dealt with topics ranging from extreme weather (hurricanes, tornadoes, flooding, drought etc) to non-critical weather conditions that can generate critical power system implications (e.g. Dunkelflaute, volcano disruptions, solar eclipses, unexpected cold or warm periods, etc.). In a session on extremes in the power system at our workshop in Dublin in 2023, a mapping of weather-related and non-weather related influences on the power sector, including items like availability of cooling water for nuclear power plants, waterways for coal transport under low water conditions in rivers, or the influence of weather on EV charging. Also the influence of large events such as Olympic games or cyberattacks have been collected and their impact discussed. In Boulder, we also look into predictability of those events, potential impacts, and solutions for mitigation. Additionally, we look into AI risks and benefits in extremes, and dealing with uncertainty in extreme events. The interactive sessions provided valuable input to a common understanding of the issues.

The presentation will report on progress in Phase I (2022-2025), on the major outcomes of the Extremes workshop. It will summarise other relevant results and provide an outlook into the next Phase II (2026-2029).

For collaboration, please contact the author (grgi@dtu.dk) and see the website at www.iea-wind.org/task51/.