Next Generation Forecasting Solutions for Wind Energy – Results from the Smart4RES Project

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PO.117

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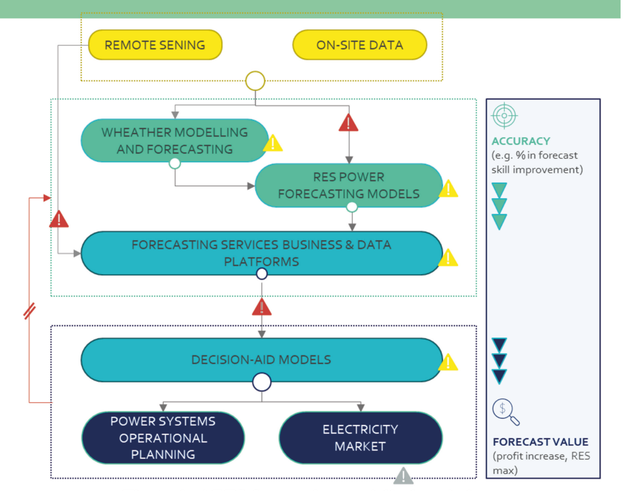
Abstract

Forecasting renewable energy (RES) production, **a few minutes to days ahead**, is a quite mature technology. The majority of actors (grid operators, aggregators, traders...) use today operational forecasting tools and services to optimize their decisions related to wind power integration in power systems and electricity markets. Despite that maturity, uncertainty in forecasts remans high **and end users continuously request higher accuracy**. The **H2020 Smart4RES project** was initiated in 2019 to develop next generation forecasting solutions with increased forecasting performance and also innovative approaches to leverage the value (technical or economic) of forecasts by considering the whole model chain from weather forecasting to end-use applications. Here we present a selection of highlight final results both regarding forecasting and also the optimal use of forecasts.



The typical RES forecasting model/value chain

Objective – A transformation of the forecasting technology

Gaps & bottlenecks		Developed solutions & Impacts	
REDUCED KNOWLEDGE OF THE PHYSICAL SYSTEM	• Weather forecasting is an essential input but not always tailored to energy applications.	• Ultra/high resolution modeling of weather conditions • Weather forecasts adapted to the energy sector • Modelling based on multiple sources of data	HIGHER MODELLING ACCURACY
VULNERABILITY	• Not 100% reliable data (i.e. communication faults). • Possible corruption of data and models from cyberattacks or other malicious factors.	• Solutions that permit operators to take optimal decisions under situations with lacking information	RESILIENCE
COMPLEXITY	• High dependability of RES prediction models on specific data sources. • Due to multiple modelling steps, the resulting decisions lack interpretability especially in situations with high uncertainties/extremes	• Convergence of the technology through seamless solutions • Joint forecasting and optimisation prescriptive approach • Reduce information for human operators	SIMPLICITY
UNCERTAINTIES	• High uncertainties not always understood by operators • Optimisation tools remain deterministic in business practices	• Reduce uncertainties through better predictions • Optimisation tools to manage uncertainties	ROBUSTNESS
SUBOPTIMALITY	▪ Potential value of the available data not fully extracted. Data not shared due to confidentiality or privacy constraints. Forecasting models are seen as stand alone without considering the application they are used and the value they bring.	• Value-oriented vs accuracy-oriented forecasting • Privacy/confidentiality preserving data sharing & optimisation • Prescriptive analytics	VALUE MAXIMISATION

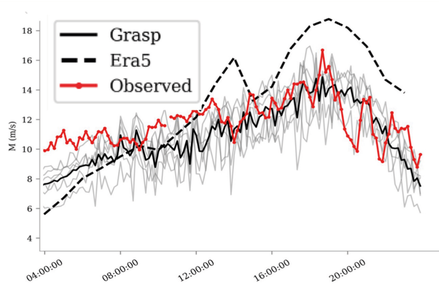
Examples of highlight results

Predicted local wind speeds via Large Eddy Simulation

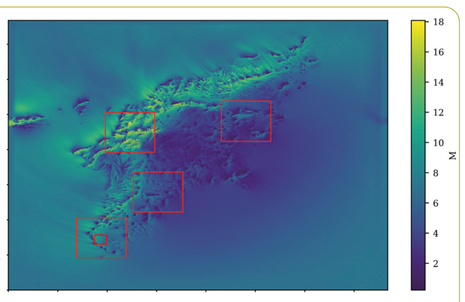
Method: A **Large Eddy Simulation** has been developed to predict local wind speeds, reproducing spatio-temporal patterns of variability and modelling complex terrain

A nested LES forecast for islands : Outer domain ~ 200m resolution, 4 inner domains on farms: ~ 40m

Results: Realistic variability of the LES compared to the smooth signal from NWP (dashed line). The RMSE is at least as good as the underlying NWP model.



Wind speed simulation at wind farm level

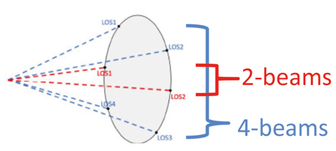


LES domain on Rhodes (Whiffle)

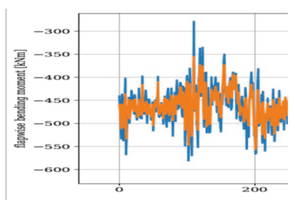
Seconds-ahead wind turbine forecasting with LIDAR

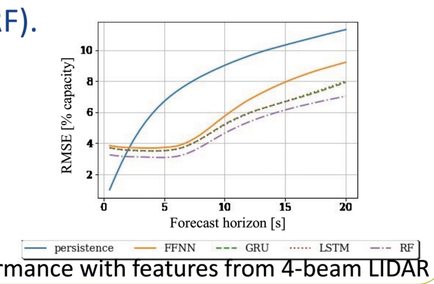
Method. Time series from LIDAR serve as explanatory variables of a forecasting tool for wind turbine power and moment forecasting.

Results. Lidar measurements provide a **predictive spatio-temporal information of incoming wind** that beats recent past information of the turbine when used in Machine Learning for horizons above 2-4s. **4-beams LIDAR** features enable to **increase forecasting performance of active power.** ML models with good ability to treat highly correlated features work best e.g. here Random Forest (RF).



Windar Photonics, processed into explanatory variables



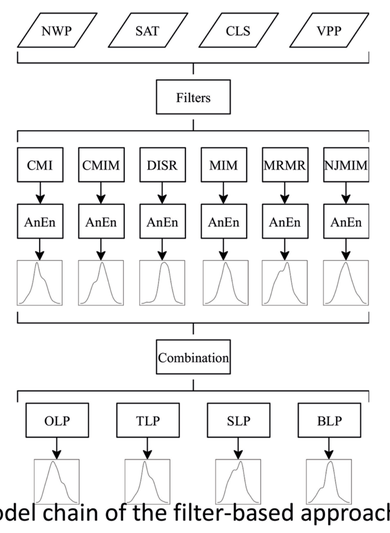


Wind power forecasting performance with features from 4-beam LIDAR

Filter-based seamless renewable forecasting

Method. Filters automatically select and weigh explanatory variables that are relevant for **multiple forecasting horizons**. The obtained analog probabilistic forecasts are **combined** by linear/non-linear methods to mitigate the uncertainty caused by feature selection.

Result. The filters **reduce computational effort** and decrease CRPS by 16% on average compared to a vanilla analog model, when tested on the 15min to 6h ahead forecasting of Wind+PV production.



Model chain of the filter-based approach

Acknowledgement

This work was carried out in the frame of the European project Smart4RES (No 864337) supported by the H2020 Framework Program

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