PO.012

IREC wind energy indexes: macro indicators for performance monitoring over time

A case study on 200 wind farms

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Abstract

Generally speaking, wind energy indexes allow to quantify the wind resource available that can be harnessed by a wind farm on elapsed periods. Their main purposes regarding operating wind farms are to assess their actual long-term production capacity based on production data (i.e. operational long-term P50) and to highlight if the production capacity (i.e. the performance) has remained stable or on the contrary has been changing over time.

Wind energy indexes constitute macro indicators which allow to get a quick overview of the evolution of the production capacity of a portfolio and thus of its value over time.

The analysis of the accuracy of the so-called IREC Indexes[1] for production monitoring was carried within the frame of this study, based on the production data of 200 wind farms (166 in France and 34 elsewhere in the world).

It results from this analysis that when the quality of operational data (especially monthly availability rates) is satisfactory, the production predicted from IREC energy indexes can be associated to an uncertainty level below ±5%.

Objectives

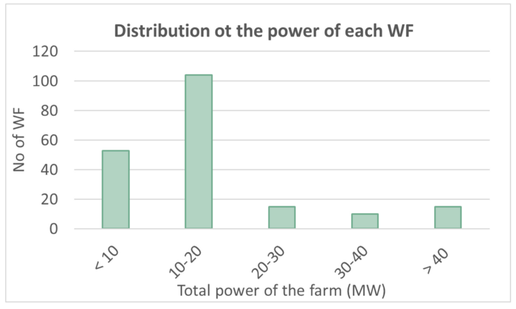
The aim of the analysis carried out was to get a robust statistical analysis leading to:

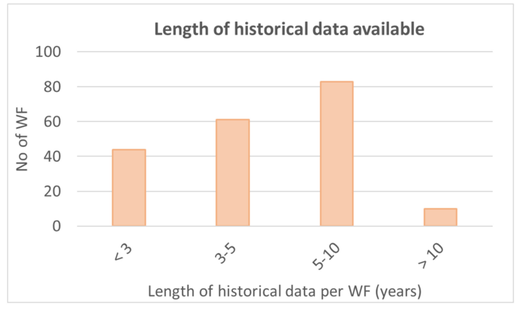
- The distribution of the correlation level between wind energy indexes and actual production data,
- The part of wind farms for which a drift of performance could be highlighted thanks to energy indexes,
- The variability of the deviation observed between the predicted productions issued from the energy indexes and actual production data (over 1-month to 12-month periods).

Thus this study aims at quantifying the accuracy level that can be expected from wind energy indexes (based on IREC Index database) for the production monitoring over time.

Sample and Methods

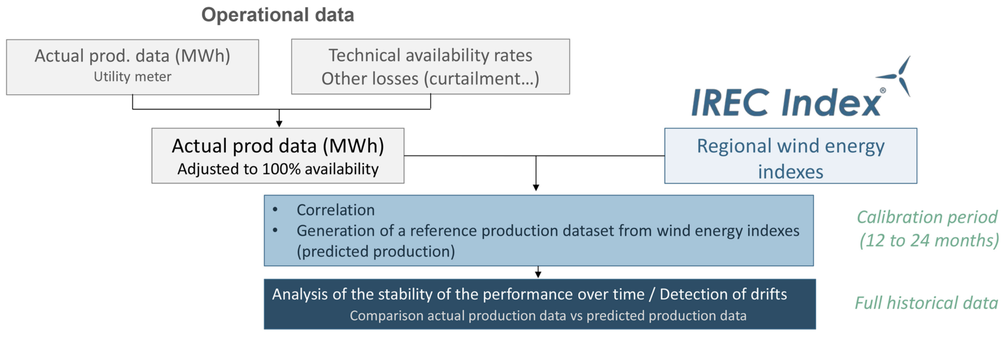
The production data of 200 wind farms (>3.5 GW) were analysed in the framework of this study: 166 in France and 34 in other countries (Germany, Sweden, Finland, Austria, Italia, Portugal, Greece, Romania, Brazil, Caribbean islands, Mauritius). The considered wind farms should have at least 2 years of operating data to be considered in this study. The graphs below represent the distribution of the power of each considered wind farm and the length of the historical data available:





Production data of each wind farm were adjusted to 100% availability and corrected from curtailment losses (as far as the information available allowed it), before being correlated to IREC Indexes. It should be noted that all losses should be taken into account (failures, grid issues, icing, bat stops…). IREC wind energy indexes, generated by Eoltech and mainly based on ERA5 wind data, were established for each considered wind farm. The distribution of the correlation levels obtained on the calibration period are presented in the results section.

The first 12 or 24 months of operation were considered as a calibration period, aiming at setting the transfer function to get the predicted production data from IREC Indexes. This predicted production was then considered as a reference production, representative of the turbines production with no drift over time (performance comparable to the one over the calibration period). The deviation between the predicted production and the actual production adjusted to 100% availability was analysed over the entire historical data available.



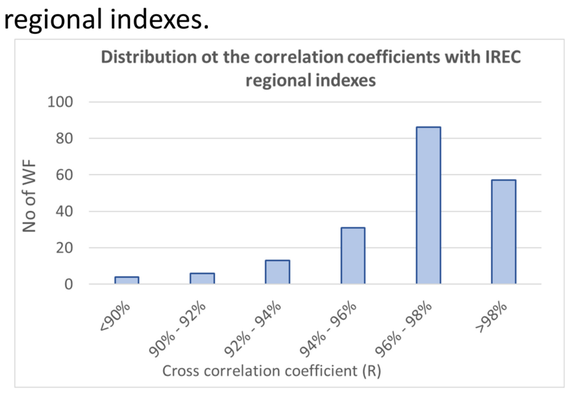
If availability rates are consistent in time (method of calculation and types of downtimes taken into account), the deviation between the actual production and the predicted production (reference production issued from IREC Indexes) should reflect an evolution of the production capacity of the wind farm (i.e. its performance) such as:

- Change in operating conditions (implantation of a new curtailment strategy, power curve upgrade…),
- Change in the turbines environment (additional wake effect losses due to the commissioning of a wind farm in the surroundings),
- Other performance drift (degradation over time due to components ageing…).

Results

❖ Correlation coefficients (calibration period)

The graph below displays the distribution of the correlation coefficients R between the actual production (corrected from availability issues, i.e. adjusted to 100% availability), and IREC regional indexes.



The following points can be highlighted:

- R > 98% for almost 1/3 of the wind farms and > 97% for more than half of the farms
- R < 90% for only 4 wind farms out of 200. Uncertainties on availability rates are significant for these wind farms and 2 are located in quite complex terrain
- Lowest R values are often observed for areas with local wind regimes.

❖ Analysis of performance stability (analysis on the full historical data)

Deviations between the actual production and the reference production deduced from IREC Indexes were established over the entire historical period for each wind farm on different cumulated periods (1 month, 3 months, 6 months, 9 months and 12 months).

The analysis of these deviations over time allowed to point out wind farms which performance has changed over time.

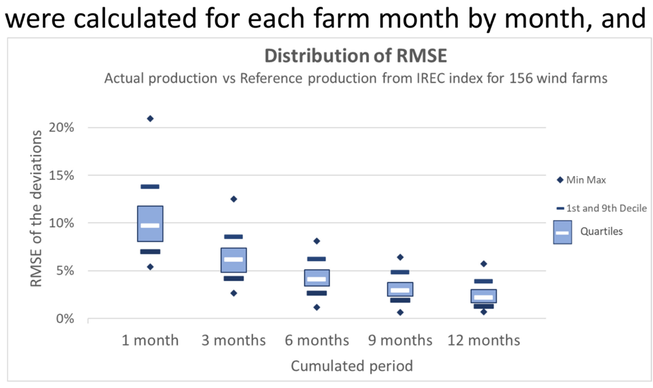
Most deviations could be explained by a change in operating conditions (commissioning of a new farm in the surroundings leading to additional wake effects, implementation of a curtailment..), in such cases the analysis allowed to quantify the average annual production loss actually experienced by the farms. In several cases no explanation could be found, so the deviation could reflect a performance drift not expected by the owner.

We should also note that a deviation can highlight a disruption of consistency in availability rates (method of calculation or type of downtimes taken into account). In such case, it is not possible to conclude about the farms performance stability.

In order to determine the uncertainty that can be expected from IREC Indexes, wind farms presenting drifts in performance (identified reason or not) or in availability rates consistency were discarded. In the end, 156 farms were kept for the analysis.

Root Mean Square Errors (RMSE) of the deviations between the predicted production issued from IREC Index and the actual production were calculated for each farm month by month, and on cumulated periods (3 to 12 months).

Distribution of RMSE values observed for the different wind farms are presented on the graph against on different cumulated periods. It appears clearly that the deviations decrease significantly while cumulating periods: on 12-month periods, the maximum RMSE observed for a wind farm is up to 5.7%, and it does not exceed 4% for 90% of the wind farms (9th decile).



Similar analyses were made depending on the correlation level observed with the indexes and they showed that the RMSE are lower for higher correlation levels. These observations allowed to assess uncertainty levels expected from IREC Indexes dependent on the correlation level with actual production data.

Conclusions

This analysis allowed to estimated the level of uncertainty expected from IREC indexes:

Correlation level with actual production R	1 month	3 months	6 months	9 months	12 months
> 98 %	± 12.0 %	± 7.0 %	± 5.0 %	± 4.0 %	± 3.0 %
96 % - 98 %	± 13.0 %	± 8.0 %	± 6.0 %	± 5.0 %	± 4.0 %
94 % - 96 %	± 14.0 %	± 9.0 %	± 7.0 %	± 5.5 %	± 4.5 %
< 94%	± 16.0 %	± 11.0 %	± 8.0 %	± 6.0 %	± 5.0 %

These values allow to set global thresholds for the detection of performance drifts although some nuances can be found case-by-case. Thus, a deviation of performance from 3 % to 5 % (depending on the correlation level with production data) can be highlighted using wind energy indexes. The uncertainty month by month remains quite high as a regional index cannot replace on-site wind measurement and cannot fit the wind farm specificities (layout, specific exposure on given sectors…).

As a reminder, availability rates should be consistent over the entire period analysed (method of calculation and type of downtimes taken into account), otherwise it could lead to a deviation that could be attributable to the wind farm performance by mistake.

Thus, the use of wind energy indexes represents a robust and accurate approach for production follow-up, aiming at quickly checking the stability of the value of a portfolio or conversely identifying performance drifts over time.

References

1. IREC Indexes : worldwide wind energy indexes mainly based on ERA5 wind data. More details on the dedicated online platform www.irecindex.com.

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