INTERMITTENCY REDUCTION: WIND TIME-SERIES ANALYSIS.

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Overview

As the world moves towards sustainable energy development along with energy price increasing due to the impact of Russian invasion on Ukraine, the use of wind energy (WE) is expanding. France aims to achieve 33.2 GW of installed capacity by 2028. However, intermittent wind energy production presents challenges to energy balancing and demand satisfaction. In this research we investigate complementary wind energy production as a solution to intermittency reduction. Therefore, we identify these complementary locations by analyzing wind time-series (TS), assessing their capability to cover inelastic electricity demand and to evaluate the improvement that can be made with respect to supply from alternative resources (i.e., electricity supply from spot market).

Methods

In this study, a twostep method is applied: first, complementary wind locations in France are identified with best scoring method. Different classifiers were used for the wind time series, including "Dynamic Time Warping" and "Shape Based Distance".

Subsequently, hourly wind power production is simulated for two potential wind locations from the most dissimilar clusters. Thus, investigating its contribution in demand satisfaction and potential improvement when compared to non-complementary production. Ultimately, a first scenario will be established where wind energy output is only produced in one location and a second one where same installed capacity is distributed on two complementary locations. For each scenario, electricity demand satisfaction and intermittency measures are estimated.

- Scenario 1: wind generation is not complementary; it is produced in one windpark location (windpark 1);
- Scenario 2: wind generation is complementary; it is produced in two different windparks belonging to dissimilar clusters (windpark 1 and 2).

Results

The selected method is a Shape Based Distance (SBD), more particularly k-Shape method since it preserves data avoiding its alteration over time. Ten clusters are then obtained, where some of them show intra-distance dissimilarity, namely cluster 1 and 6 being most dissimilar with 4 and 10 respectively. Fig. 1 displays individuals from these clusters.

The previous technical part provides potential complementary locations that are assessed in both scenarios, i.e., non-complementary wind generation scenario and complementary one. Economic evaluation shows that in scenario 2, complementary wind power generation improves demand satisfaction by about 60% to 76%. Moreover, production availability increases by about 66% to 88% and variability coefficient decreases from 86% in scenario 1 to 62% in scenario 2.

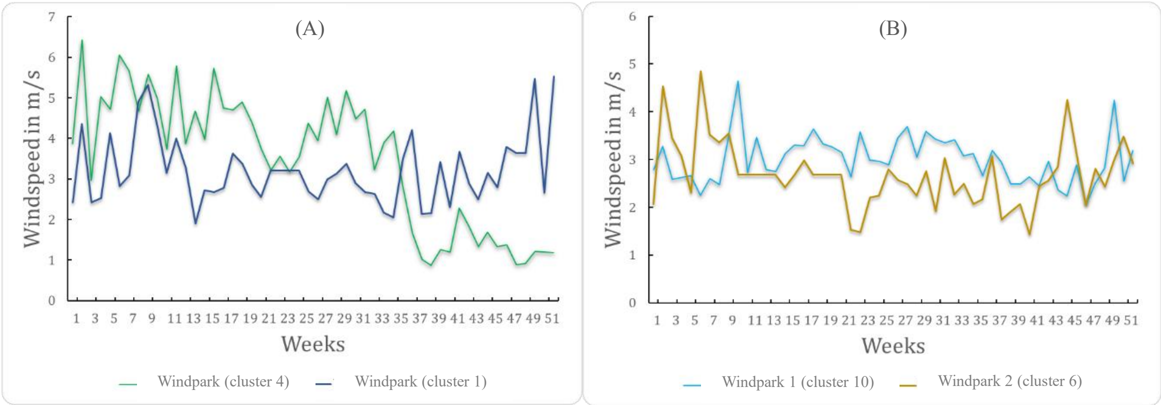

Fig. 1: Potential wind locations selected from most dissimilar clusters. *Each location corresponds to a wind measurement station at 10 m height. Fig.1(A) shows individuals from cluster 1 and 4 that have a negative correlation (i.e., dissimilar), while Fig.2 (B) shows dissimilar individuals from cluster 6 and 10 which were used in the economic evaluation. For wind electricity output calculations, windspeeds are extrapolated to wind turbine hub height using power law.*

Conclusions

With an evolving strained energy context due to Russian invasion on Ukraine, wind energy is a part of the solution to get energy independence. While wind energy complementarity is often studied on continental scale, this research shows that this solution can be further more addressed on a national scale, thus providing a smart planning for future installed wind capacities.

Indeed, results show that complementary wind energy production allows a better electricity demand satisfaction and reduces intermittency by improving output stability, i.e., production availability increasing and variability decreasing. Furthermore, hourly data analysis provides more precision in estimating economic value of complementary windparks, as it takes into consideration intraday fluctuations.

In this application, economic evaluation is applied on a local scale. Future research might be carried on a regional aggregated level in France to study a wider effect of this solution. Additionally, sensitivity analysis that includes grid limits and different windspeeds potential is recommended.

References

Schindler, Dirk; Schmidt-Rohr, Sophia; Jung, Christopher (2021) On the spatiotemporal complementarity of the European onshore wind resource. In: Energy Conversion and Management, vol. 237, p. 114098. DOI: 10.1016/j.enconman.2021.114098.

Aghabozorgi, Saeed; Seyed Shirkhorshidi, Ali; Ying Wah, Teh (2015) Time-series clustering – A decade review. In: Information Systems, vol. 53, p. 16–38. DOI: 10.1016/j.is.2015.04.007.

Paparrizos, John; Gravano, Luis (2017) Fast and Accurate Time-Series Clustering. In: ACM Transactions on Database Systems, vol. 42, n° 2, p. 1–49. DOI: 10.1145/3044711.

Gualtieri, Giovanni; Secci, Sauro (2012) Methods to extrapolate wind resource to the turbine hub height based on power law: A 1-h wind speed vs. Weibull distribution extrapolation comparison. In: Renewable Energy, vol. 43, p. 183–200. DOI: 10.1016/j.renene.2011.12.022.

Gao, Yang; Ma, Shaoxiu; Wang, Tao; Miao, Changhong; Yang, Fan (2022) Distributed onshore wind farm siting using intelligent optimization algorithm based on spatial and temporal variability of wind energy. In: Energy, vol. 258, p. 124816. DOI: 10.1016/j.energy.2022.124816.