PO.006

Actual impact of icing on wind farms production

A case study on over 300 wind farms operating in France and Germany

Marion Jude

Eoltech

Abstract

To date, production losses due to icing and assumed in the energy yield assessment carried out at the pre-construction phase are theoretical values mostly based on regional meteorological data. However, the uncertainty on icing losses is linked not only to the complexity of the meteorological phenomenon itself but also to the actual behaviour of the turbines subject to this phenomenon (i.e. strategies implemented by the manufacturers).

The objective of this study is to get a better understanding of these uncertainties by conducting a feedback study on actual production losses due to icing and recorded on more than 300 operating wind farms located in France and in Germany. Indeed, this large sample has enabled to get an average loss and a dispersion rate within several areas.

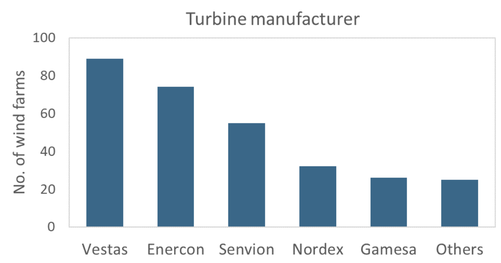
An analysis of the dependence of losses on geographic location and on wind farms characteristics was carried out in details in order to get a better understanding of the estimation of icing losses for projects under development.

Sample

8 owners/operators have participated in the study providing the icing losses experienced yearly by their wind farms in operation in France and in Germany. The focus was made on the past two years 2022 and 2023 in order to include recent wind farms and to consider the largest possible sample.

The sample is made of 302 wind farms distributed as follows:

Owners / Operators	8
No. of wind farms	302
France - half North	211
France - half South	55
Germany	36
No. of turbines	> 2000
Total power	4.3 GW

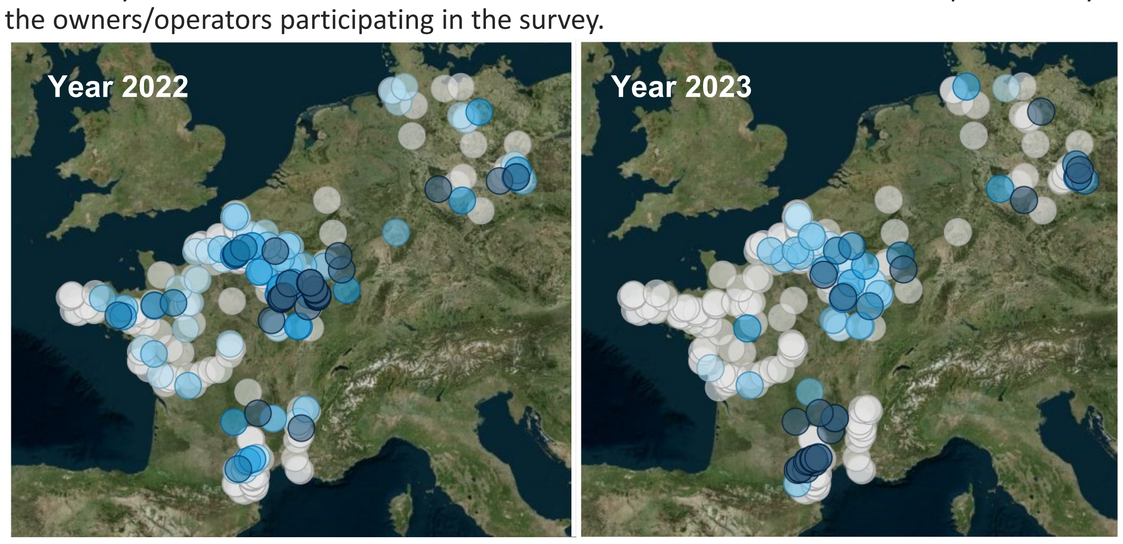


For France, the sample is quite representative of the total power actually installed in the country.

Results

Global results on 2022 and 2023

The figures below display the annual icing losses experienced by the wind farms for calendar years 2022 and 2023. It should be reminded that the losses were provided by the owners/operators participating in the survey.



An analysis of meteorological data based on ERA5 reanalyses has shown that for most studied areas icing occurrences were higher in 2022 than on the long-term average (i.e., colder year), whereas in 2023 icing occurrences were lower (i.e., warmer year). This observation is coherent with operational data: no icing experienced for numerous farms in 2023 and lower losses in 2023 than in 2022 except for specific locations such as mountainous areas in Southern France.

The analysis of meteorological data have shown that considering the average of both years can be considered as almost representative of the long-term in terms of icing conditions for most studied regions. A different assumption was made for a few areas, north of Niedersachsen in Germany for instance, where 2022 and 2023 have experienced more icing conditions than the long-term average.

Synthesis of the results

An analysis was carried out on each year and the sample was broken down into sub-areas a priori consistent in terms of meteorological conditions. Within each area, the median and the standard deviation of the icing losses was analysed for each year separately. Sub-areas were gathered into larger areas when they provided similar results on each considered year.

The map below presents a synthesis of the results, providing **the median icing loss experienced on the sample** within the different areas as well as **the dispersion encountered between the different farms.** These results correspond to an average of both analysed years, considered to be quite representative of long-term conditions.

Analysis of results dispersion

A focus was made on two areas of Northeastern France (Region 1: Aisne, Ardennes, Aube, Marne, Yonne, part of Somme and Region 2: Meuse, Moselle, Côte-d'Or – surrounded in orange on the map against) where a significant part of the farms in the sample can be found.

Within each area, a breakdown was made depending on the turbine manufacturer. The focus was made on year 2022, with higher icing frequencies than 2023 (and also more than the average expected losses). The main results of the analysis are as follows:

Icing losses year 2022 - Region 1			
Turbine manufacturer	No. WF	Median	Standard Deviation
All	94	0.4 %	0.9 %
A	26	0.3 %	0.6 %
B	24	0.4 %	0.4 %
C	16	1.1 %	0.6 %
D	13	0.1 %	0.5 %
Others	15	0.0 %	1.8 %

Icing losses year 2022 - Region 2			
Turbine manufacturer	No. WF	Median	Standard Deviation
All	26	1.0 %	1.2 %
A	6	0.0 %	0.0 %
B	13	2.3 %	0.7 %
C	0	na	na
D	2	2.9 %	0.9 %
Others	5	0.0 %	0.0 %

The previous table shows that within a region, icing losses are dependent on the turbine manufacturer (different median values). However, when considering each turbine manufacturer separately, a quite significant dispersion of the results remains. This leads to consider that icing losses are also dependent on the turbine type and settings but could also be dependent on the operator's estimation of the losses. It should be noted that the presence and the type of any ice detection system or anti-icing system was unknown for most farms, which is likely to have also an impact on the dispersion of the results.

Conclusion

The analysis of icing losses experienced over the past two years by 302 operating farms in France and in Germany has enabled to estimate the most likely losses in several areas with high density of wind turbines in France and in Germany.

However, it should be noted that as soon as icing conditions are met, there is a quite significant dispersion of icing losses between farms, depending on the turbine manufacturer, but not only. The more icing losses were observed within a region, the more dispersion of the results was found. This study offers first assessment of the risk of production losses estimation due to icing.

Wind EUROPE TECHNOLOGY WORKSHOP 2024 10-11 JUNE DUBLIN

windeurope.org/tech2024

#WindTech24

Watch this presentation

Download the poster

PO006