

Abstract

The aim of this study is to estimate the impact on production of curtailment strategies linked to environmental constraints and their evolution over time for almost 200 wind farms in France. Only acoustic and bat curtailment strategies were considered in this study as they represent the most encountered curtailment strategies for wind farms in France.

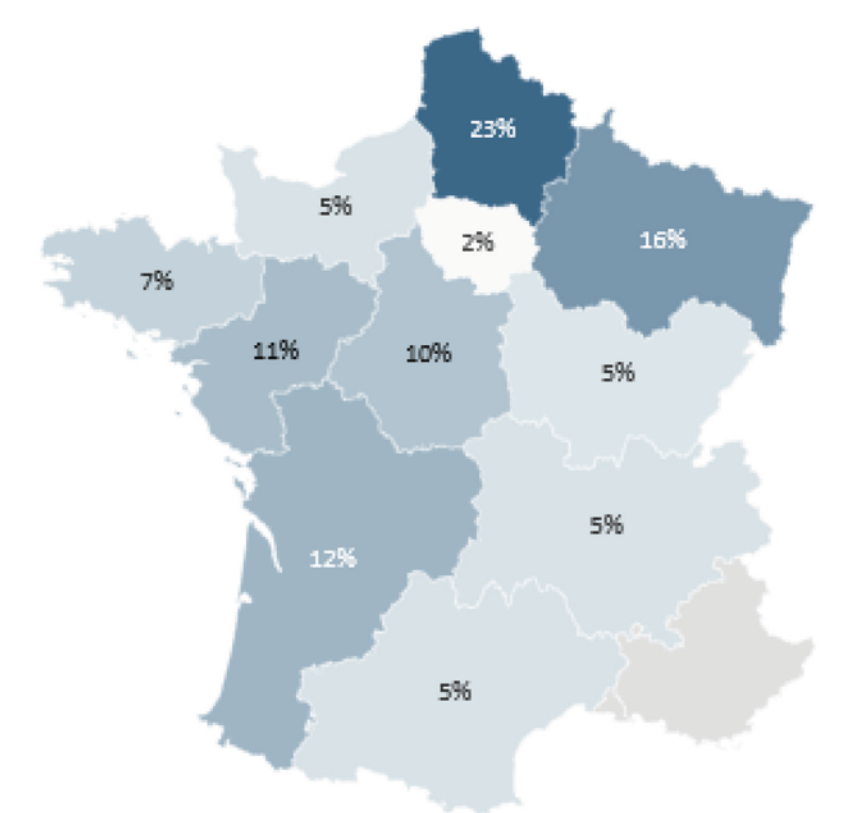
Through a statistical analysis, both the presence of such strategies throughout the years and the evolution of the impacts on the production of the wind farms, have been observed.

The results of this study have confirmed that not only these strategies are more and more frequent in France but their impacts on production per wind farm have evolved over time in different ways and can be significant. Hence, these curtailment strategies and their optimization are becoming key points of the project during the development phase.

Method

The impact on production of bat and acoustic curtailment strategies were estimated for almost 200 wind farms in France, some already in operating and other still at the development stage from 2015 until 2022.

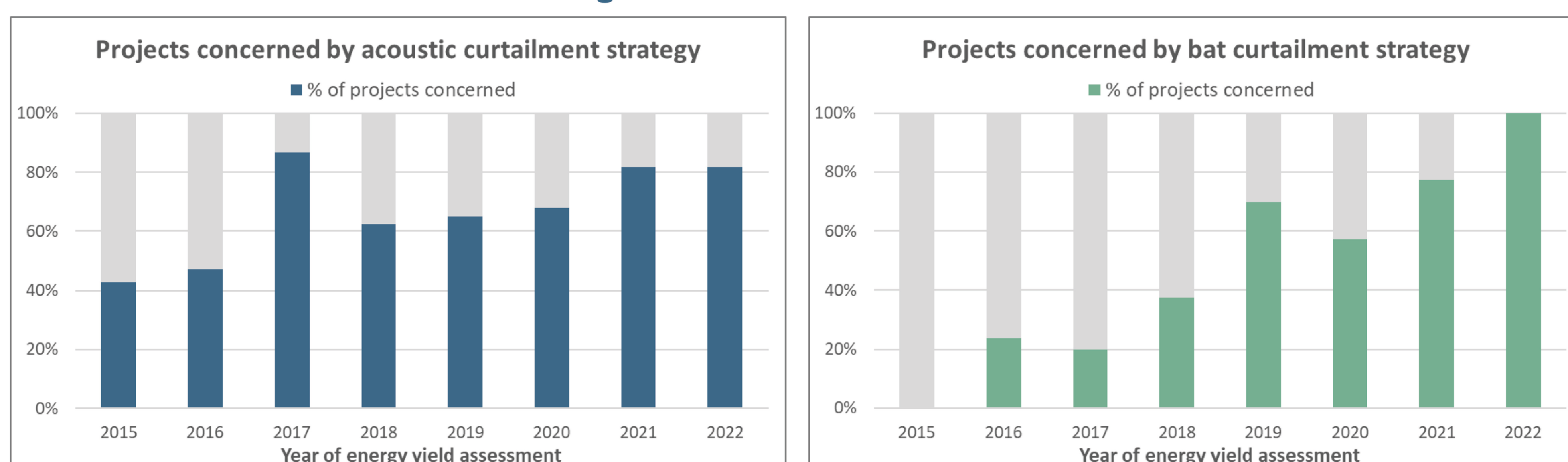
For this purpose, for each project, hourly wind data from ERA5 reanalyses were adjusted on the wind resource expected on site at hub height and converted into production time series based on the turbine type considered for the project. Production losses were estimated by comparing the resulting long-term production calculated with and without considering the constraints of curtailment (reduced modes and/or stops).



Results

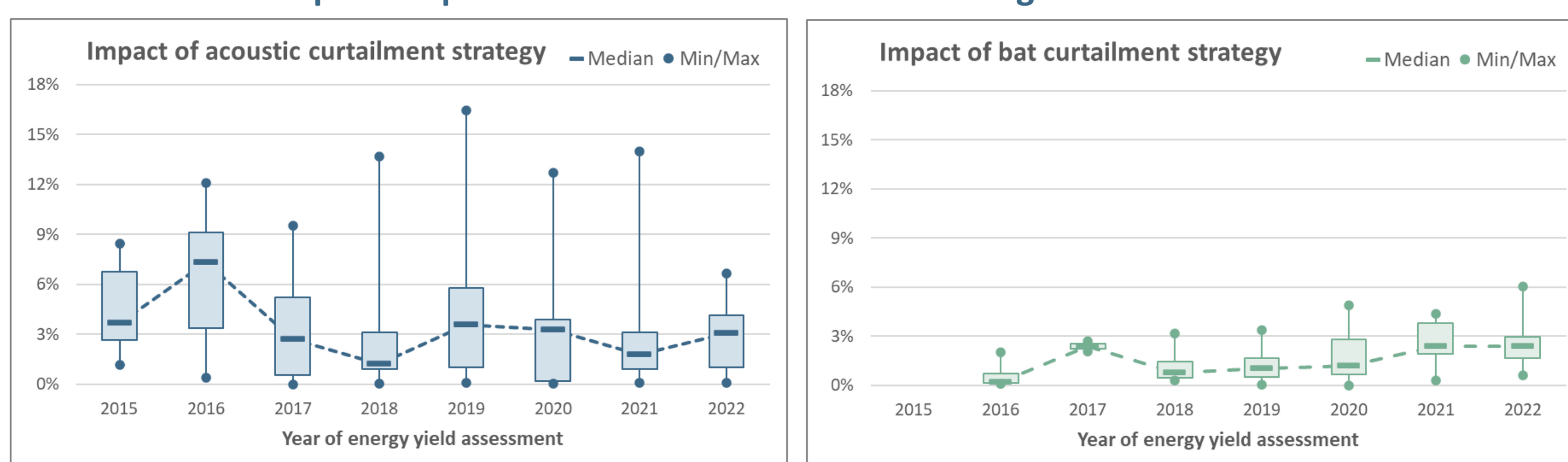
The figures below present the evolution of the frequency of the acoustic and bat curtailment strategies in the energy yield assessments as well as the evolution in time of their impacts on production.

Occurrence of the curtailment strategies over time



The results indicate that both curtailment strategies are more and more present in energy yield assessments. In 2022, more than 80 % of the projects were concerned by an acoustic and/or a bat curtailment strategy whereas in 2016, there were less than 50 % of the projects that were concerned by acoustic curtailment strategies and less than 30 % concerned by bat curtailment strategies.

Evolution of the impact on production of the curtailment strategies over time



The following figures show that:

- The impact on production of the acoustic curtailment strategy varies significantly from one wind farm to another and there is a global decreasing tendency of this impact.
- The impact on production of the bat curtailment strategy rarely exceeds 5 % today but there is a slight increasing tendency of this impact.

Over the past 2-3 years the median impacts on production of both acoustic and bat curtailment strategies are relatively stable: 2.8 % for the acoustic curtailment and 2.3% for the bat curtailment.

Conclusions

This study indicates that the presence of curtailment strategies in energy yield assessments have significantly increased in the past 8 years. Regarding the impact on production of these two curtailment strategies, there is a slight decrease of the impact on production of the acoustic strategies that can probably be explained by the evolution of the wind turbine technology (serrated trailing edge etc.) whereas the bat curtailment strategies have a higher impact which can probably be explained by the tightening of the constraints. Over the past 3 years, the impact on production of each curtailment strategy was estimated at 2.3% for bats and 2.8% for acoustic, which implies that the optimization of these curtailment strategies is becoming a key point of the project during the development phase.

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