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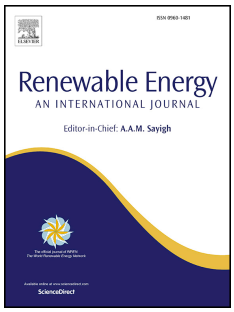

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Jannis Tautz-Weinert, Nurseda Y. Yürüşen, Julio J. Melero, Simon J. Watson

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Sensitivity study of a wind farm maintenance decision - a performance and revenue analysis

Jannis Tautz-Weinert[*a, b], Nurseda Y. Yürüşen[* a, b], Julio J. Melero[§a], Simon J. Watson[c]

[a]*CIRCE-Universidad de Zaragoza, C/ Mariano Esquillor 15, 50018, Zaragoza, Spain*

[b]*CREST, Loughborough University, Holywell Park, Loughborough, LE113TU, UK*

[c]*DUWIND, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, Netherlands*

[*]Shared first authorship - the authors contributed equally to this work.
[§]Corresponding author: melero@unizar.es

Abstract

Commercial operation and maintenance of wind farms always involves trying to find the most cost-effective solution from various possible options. In this paper, a maintenance action within a Spanish wind farm was studied, whereby a blade replacement was required to prevent catastrophic failure. The conducted replacement was accompanied by an underperformance resolved in a later blade re-pitching. We analyse the decision taken in terms of the power performance and net present value from the cash flow resulting from the energy sales. The impact of the timing of the maintenance is discussed in various what-if scenarios. The sensitivity to environmental causes of underperformance is compared by varying the duration of blade icing and comparing the performance in different wind directions. Country dynamics and subsidy impacts are hypothetically evaluated for the prevailing electricity market conditions as if the turbine were operating in either Spain, Netherlands or the UK. The findings highlight the uncertainty in power performance and the importance of maintenance accuracy. It is shown that the decision-making of operators should not only consider the seasonality of the wind resource, but also the seasonality in electricity markets.

Keywords: Wind turbine, Operation and Maintenance (O&M), Power curve, Electricity markets, Net present value, Icing

1. Introduction

There has been a significant amount of research into the financial feasibility of wind farm installations. Application of various evaluation frameworks has showed e.g. that the feasibility is strongly influenced by capacity factor and electricity market price fluctuation, whereas the nominal power and inflation rate were found as only slightly influential on the payback period of an investment [1]. Further studies have discussed the importance of the wind resource, turbine selection, farm layout and country policies [2, 3, 4].

With increasing importance of operation and maintenance (O&M) costs, sensitivity studies to maintenance policies have gained more attention. Wind farm maintenance simulation and optimisation tools have been developed and results have showed that turbine availability was sensitive to the shift length of the service team and failure rates of components [5, 6, 7]. Repair time, inspection timing and inspection accuracy were found to be strongly affecting whether corrective, preventive or predictive maintenance strategies were most effective [8, 9, 10, 11]. Kerres *et al.* [12] state that corrective maintenance is the most cost-effective strategy for the components of the drive train. Leigh and Dunnet [13] show that periodical replacements of subsystems significantly decrease the number of required corrective maintenance visits. A maintenance decision is also highly dependent on the environment, since environmental variables are significantly correlated with failure occurrences [14] and accessibility is also dependent on the weather [15]. Most research on optimising wind farm maintenance focused on generic strategies, however the complexity of real maintenance decisions and their financial consequences have not gained much attention.

To analyse the impact of maintenance decisions, the wind turbine performance has to be evaluated. The common way of addressing the performance, is by deriving a power curve using 0.5 m/s bins of the wind speed and calculating mean values of the power production for each bin [16]. Improving the method of bins by accounting for the non-linear power vs wind speed relationship and deriving multiple curves for different direction sectors has been discussed [17]. Other work compared different