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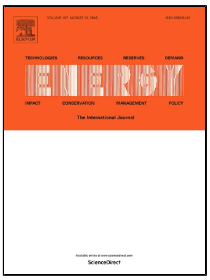

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Gustavo S. Böhme, Eliane A. Fadigas, André L.V. Gimenes, Carlos E.M. Tassinari

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Wake Effect Measurement in Complex Terrain - A Case Study in Brazilian Wind Farms

Gustavo S. Böhme[1], Eliane A. Fadigas, André L. V. Gimenes, Carlos E. M. Tassinari
Department of Electrical Engineering, University of São Paulo, Av. Prof. Luciano Gualberto, trav. 3,158; CEP 05508-970 São Paulo, SP, Brazil.

Abstract

This study measured the wake effect in a Brazilian onshore windfarm with 38 turbines located in complex terrain. The proposed methodology calculated the wind deficit in 3 different metmasts, by comparing the measurement periods in free-of-wake condition to measurement periods under wake effect. Uncertainties due to wind variability and seasonality effects have been avoided by performing MCP (Measure Correlate Predict) procedures making use of a fourth metmast in free-of-wake condition during the entire concurrent period. This methodology is free of uncertainties from Nacelle anemometry, power curve measurements and micrositing models' spatial extrapolation.

The calculation of the wind deficits was performed per sector, confirming the adherence of the resulting wake effect to the turbine layout configuration. Higher wind deficits were identified in the sectors were turbines under operation are present in the upwind direction. The results were combined to the power curves from the turbines closest to the metmasts, using the data from the turbine supplier's technical specification. This allowed the identification of the respective power deficit due to the wake effect in these locations.

The calculated wind- and power deficits were compared to the results of wake models used by two large international wind farms site assessment consultants (Coupled Eddy Viscosity and PARK), commonly accepted by banks for the financing of wind farms in Brazil. The results indicated that both models underestimate the effects in all 3 analyzed locations, with differences between the calculated and modeled power deficits higher than the respective uncertainties provided by both consultants.

The two main limitations of this analysis lie in the restriction of the wake effect measurement to the metmasts locations, and in that the results are respective to the terrain conditions of the analyzed wind farm. However, this study indicates that commonly used wake models need to be further developed and calibrated for onshore wind farms. The literature shows that wake models developments are frequently directed to offshore wind farms, where wake effects play a significant role. Onshore wind farms are less studied, even though the global installed capacity greatly surpasses that of the offshore wind farms.

Brazil has by the end of 2017 already 12.8 GW of installed capacity of wind power plants, and this number continues to increase steadily. With the continuous concentration of operating wind farms in regions of higher wind resource and transmission infrastructure, wake effects play a significant role in the sector. Bibliography shows that commonly used wake models tend to underestimate the energy losses due to this effect in offshore wind farms, making it important to study it also in onshore wind farms in complex terrain, which is the case of most Brazilian wind farms.

Keywords: wind energy, wake effect, wind farm performance.

[1] Corresponding author.
E-mail address: gustavo.bohme@gmail.com