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*Published in:*
Proceedings of EWEA 2012 - European Wind Energy Conference &amp; Exhibition

*Publication date:*
2012

*Document Version*
Publisher's PDF, also known as Version of record

*Citation (APA):*
Pena Diaz, A., Rathmann, O., & Réthoré, P-E. (2012). Revising the WASP-Park&#039;S model wake decay coefficient for different atmospheric stabilities to better predict wind farm outputs. In Proceedings of EWEA 2012 - European Wind Energy Conference & Exhibition European Wind Energy Association (EWEA).

ABSTRACT ID: 15
Theme: RESOURCE ASSESSMENT Topic: Resources offshore

# REVISING THE WASP-PARK&AMP;#039;S MODEL WAKE DECAY COEFFICIENT FOR DIFFERENT ATMOSPHERIC STABILITIES TO BETTER PREDICT WIND FARM OUTPUTS

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## Introduction

Prediction of wind farm power outputs is a difficult task, particularly for large-size wind farms—above 5 km in extension—and at sites where the variation in atmospheric stability conditions is strong. Computational Fluid Dynamics (CFD) methods have been applied extensively for multiple turbines and small wind farms using Large Eddy Simulation (LES) and on larger wind farms using Reynolds Averaged Navier Stokes (RANS) turbulence models. LES methods remain far too computationally expensive to be used as a design tool, and still have some issues to preserve physical turbulence over very large distances. 2eq-RANS methods have some numerical and physical limitations and they approach the mutliscale physics of wind turbine wake using a simplistic single scale model [1]. The vast majority of the CFD methods assume neutral atmospheric conditions.

## Approach

On a long-term basis, near-neutral atmospheres are the most frequent stability conditions at many wind farm sites, and under such conditions the CFD flow models' envelope is rather valid. However, when using any type of model (CFD- or engineering-based) to predict the wind farm power output at sites biased to unstable or stable conditions or on a short-term basis (required by the wind farm operators to bid energy days or hours ahead), the errors might be simply too large.

## Main body of abstract

Although engineering wake models are also based in many assumptions and restricted to small/medium-size wind farms, they are million times faster than those RANS/LES-based and thus can be used for short-term wind farm power predictions under a wide range of scenarios. The Park model [2] used in the wind atlas analysis and application program (WAsP) [3] makes use of the wake decay coefficient to estimate the wind speed deficit downstream of a(a cluster of) wind turbine(s). [4] found that in order to match the wind speed deficits estimated by the infinite wind farm boundary layer model of Frandsen [5] to those of the Park model (computed for a infinite wind farm), the wake decay coefficient had to be modified depending on the atmospheric stability condition, surface roughness and turbine to turbine distance.

## Conclusion

Here we present the analysis of power output and wind speed deficits for a range of atmospheric stability conditions of a large offshore wind farm. The power output is found to be highly dependent on atmospheric stability; the more stable the atmosphere the lower the power output and the higher the wind speed deficit. Using the findings in [4], i.e. using the WAsP-Park wake model but varying the wake decay coefficient, we are able to better predict the power output of the wind farm under all stability conditions compared to that given by the model using the default wake decay coefficient values. We therefore suggest that for large wind farms, particularly offshore, the wake decay coefficient should be decreased slowly along the wind farm and that this reduction should be higher the more stable the conditions are.

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