A Numerical Study on the Effect of Wind Turbine Wake Meandering on the Power Production of Hywind Tampen

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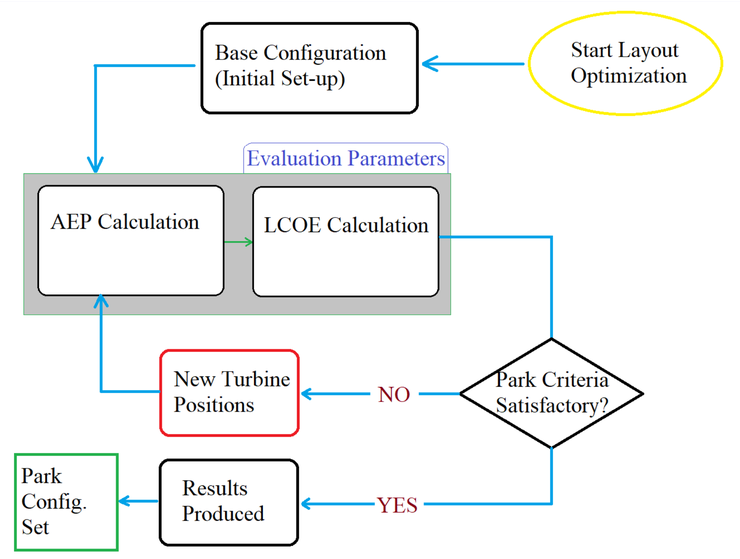
Motivation

The study applies the SIMA-DIWA software for study a floating wind park. A replica of Equinor's configuration referred to as the original layout, is made and used as a basis for comparison. An up-scaled version will also be presented to show the effects of applying greater spacing between turbines. The purpose of the study is to elucidate the importance of wake meandering effects with regard to velocity deficit, power production for wake-affected turbines and its effect on fatigue loads. The three different configurations are simulated, and power curves were calculated with a wind direction of 90 degrees (from the south). Results from the distinct configurations are compared and discussed. Velocity curves from worst-case simulations for the original and alternative layout are exposed, with respective inflow angles at 100 and 0 degrees. Velocity curves are elaborated, and the discussion on them emphasizes wake meandering and mechanical loads on the rotor.

Methodology

- SIMA-DIWA software is employed in present study. SIMA-DIWA software is based on dynamic wake meandering concept and it characterized as a mid-fidelity tool for rendering wake characteristics.
- The DWM model, SIMA-DIWA [1], is validated as a simulation tool against results from a CFD software and a compatible DWM model.
- SIMA-DIWA software together with ParaView was utilized as engineering tools in the process of layout optimization
- An approximate of the initial Hywind-Tampen layout, together with two separate propositions will be made. DIWA will be used consistently to simulate and compare the three diverse layouts cases.
- In order to imitate the field accurately, simulations done in this report contains 11 turbines (same as projected for Hywind Tampen) with similar spacing, using 10 MW rated power turbines developed by DTU. The rotor diameter is slightly bigger than the 8 MW turbine, at 172.5 m.



Results and Discussions

- All simulations were done with constant ambient wind speed and TI, set to 10 m/s and 10 % respectively.
- The average power on all turbines combined was 80.89 MW for the original layout, 87.23 MW for the alternative layout, and 85.66 MW for the up-scaled configuration.
- Wake meandering was most prominent at downstream turbines located close to the worst-case area, which consequently relates to magnified fatigue loads and decreasing power production.
- Although overall AEP for the original layout was higher relative to the alternative layout, it does not necessarily imply aeroelastic superiority.
- From the power curve - for the original layout - the meandering component of the wake is prominent. It manifests itself as fluctuations with a lower frequency and greater amplitudes, relative to small-scale instabilities.
- In the process of designing the alternative layout, it turned out to be expedient to reduce the spacing in the y-direction. Which probably can be explained by the physical nature of the meandering.

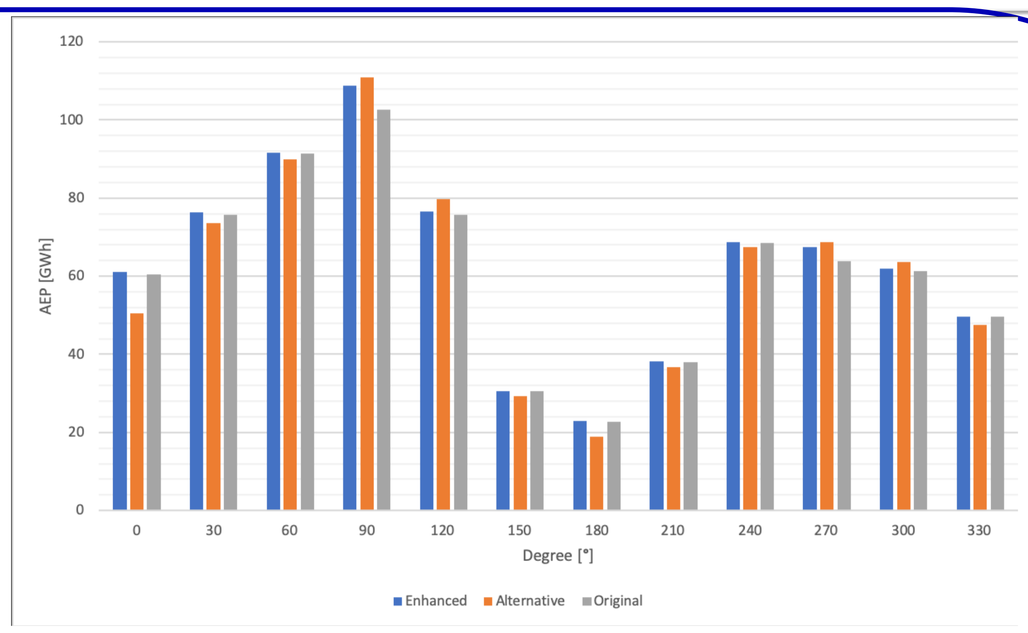
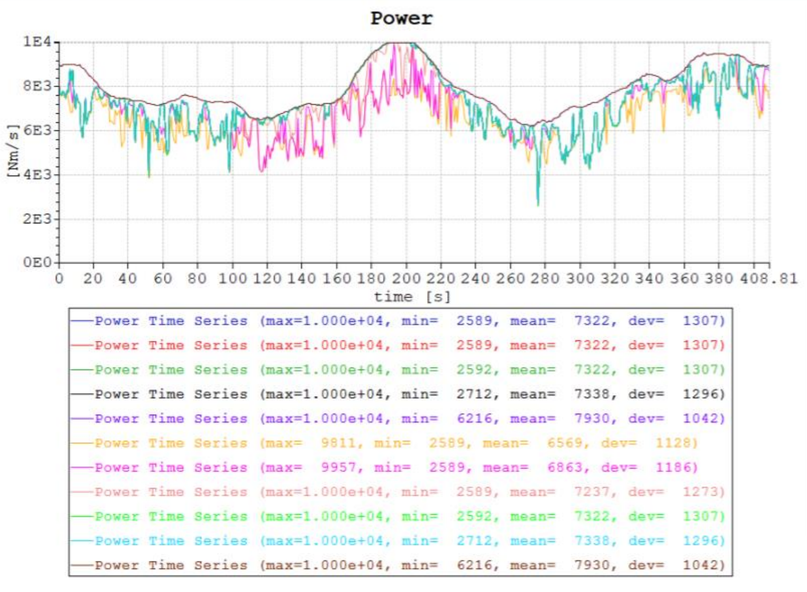


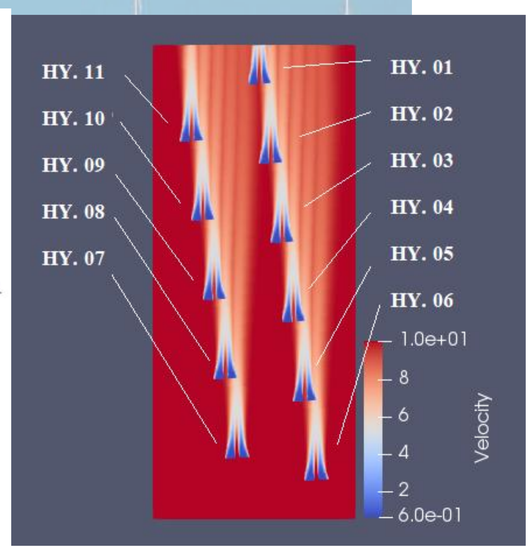
Figure AEP for different wind directions

Table : Economic and environmental results for different layouts.

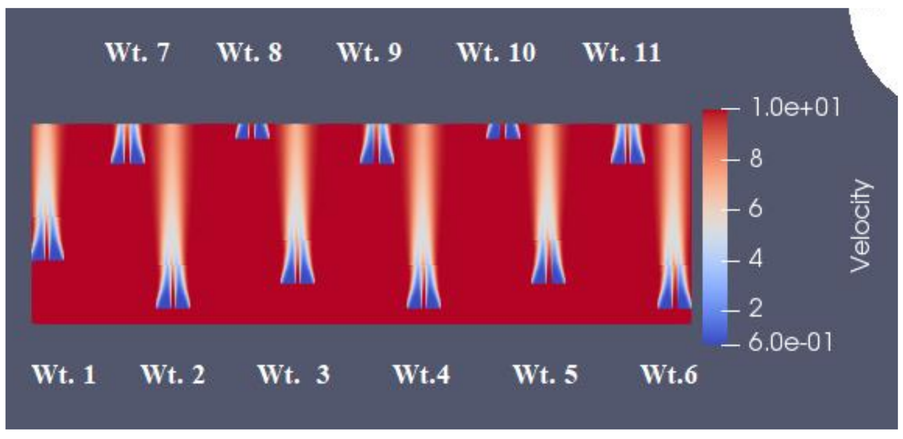
	LCOE [NOK/kWh]	Annual CO2 reduction [ton/year]
Original	1.053	254 400
Alternative	1.058	253 200
Enhanced	1.034	259 100



Power curve for the original layout with 90◦ wind direction (from south).



Instantaneous axial velocity distribution for the up-scale configuration with wind from south.



Instantaneous axial velocity distribution for the alternative configuration with wind from south.

Acknowledgments:

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References

1) Balram Panjwani, Marit Kvittem, Lene Eliassen, Harald Ormberg and Marte Godvik, Effect of Wake Meandering on Aeroelastic Response of a Wind Turbine Placed in a Park, Journal of Physics: Conference Series, Volume 1356