What do Observations tell us about Far-distant Offshore Wakes?

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DNV

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INTRODUCTION

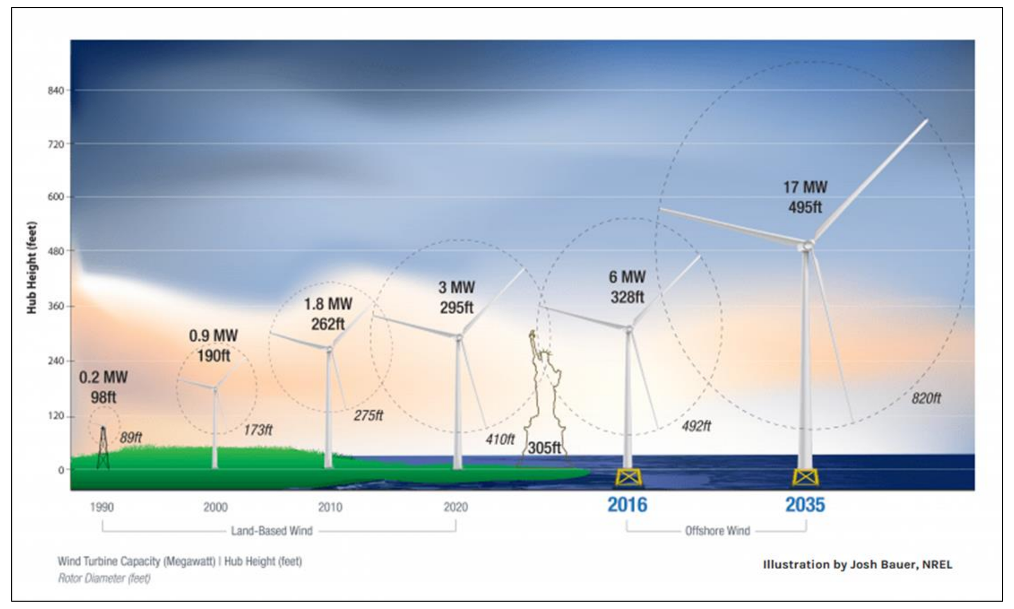
Industry forecasts worldwide predict that **offshore wind installations will continue to grow** and form a significant contribution to the electricity generation mix over the next decade, with **30 GW expected in the U.S. by 2030**.

This continued growth will lead to areas of **high-density offshore wind farm development** or "clusters" with increasingly larger turbines. This poses an interesting question regarding **the impact of large clusters of turbines on downstream projects and how long these effects persist.**

Recent industry research has investigated the effect of cluster wakes on the operation of far downstream wind farms, with some studies suggesting wakes persist for up to 55 km in stable atmospheric conditions. Historically, extensive validation of wake models has always been a challenge offshore due to a lack of suitable datasets, and in particular, **wake recovery components of wake models** remain relatively under-validated.

DNV looked at four operational offshore projects in Europe to validate the performance of wake recovery assumptions in current engineering wake models.

Are we getting offshore long-distance wakes right?

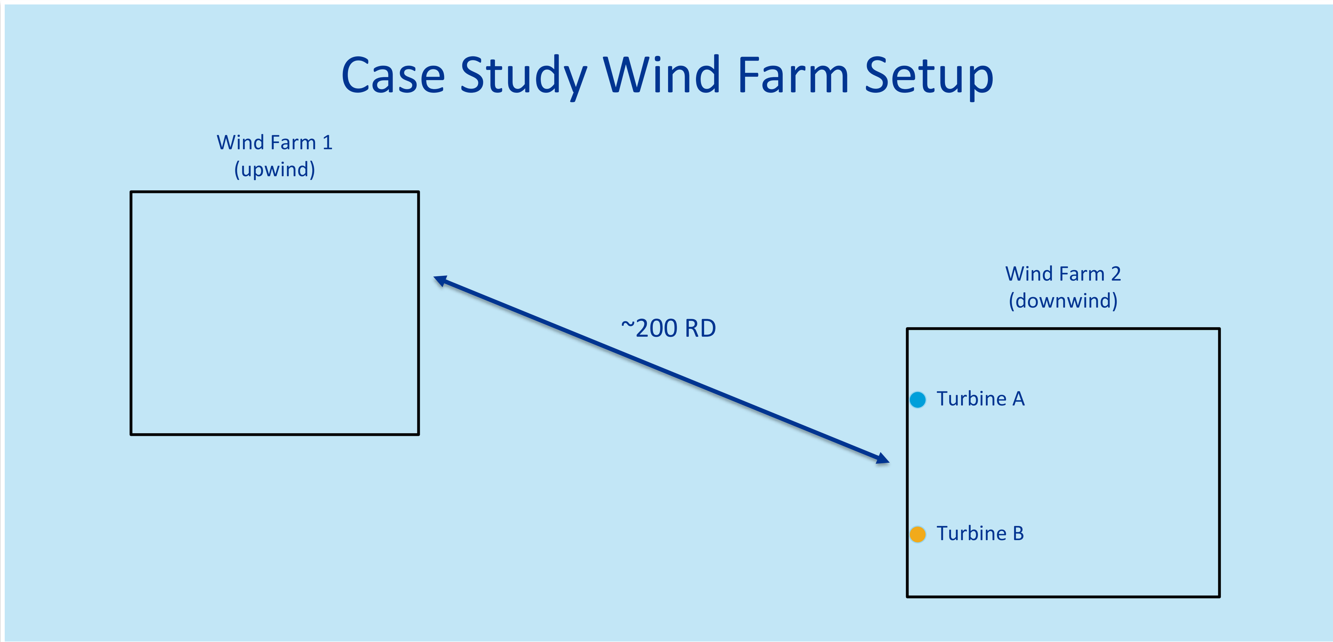


METHODOLOGY

Datasets of high-resolution offshore production data from operational projects in an arrangement where **two distinct turbine clusters are separated by up to 40 km** were used.

Turbine pairs have then been identified in the "downwind" project, depending on the turbine layouts and prevailing wind direction, to **investigate the relative change in production by direction**, giving an indication of the impact of the upstream project.

This observed impact has then been **compared to the modelled impact from the industry standard Eddy Viscosity wake model** with Large Wind Farm (LWF) Correction – specifically investigating the impact of changing the large wind farm recovery settings.

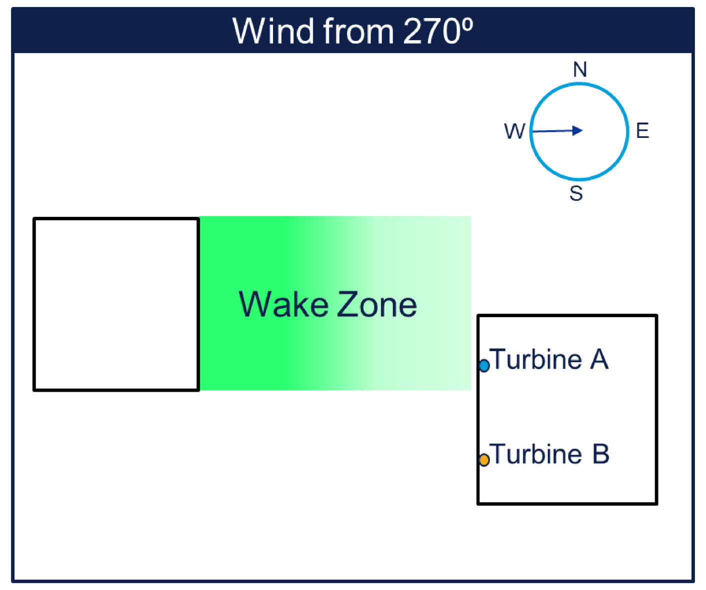


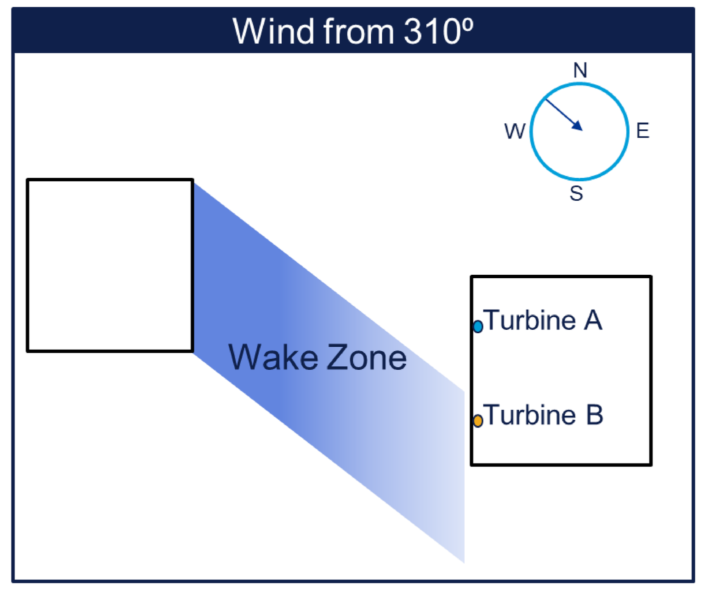
The operational projects included:

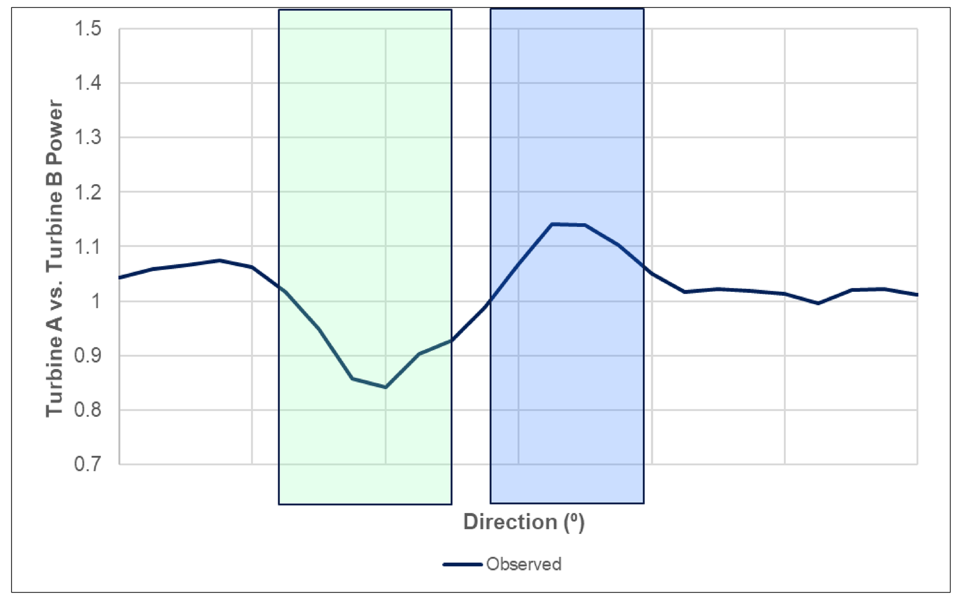
- Multiple years of operational data from each project
- Production data filtered for availability and performance issues
- Rotor diameters (RD): 100 m – 150 m
- Neighboring projects: ~120 – 300 RD upwind
- Hub heights: 80 m – 120 m

RESULTS

In this case study, DNV looked at the ratio of power at Turbine A vs. Turbine B at direction sectors where only one turbine was waked at a time to assess the wake loss from the upwind wind farm.

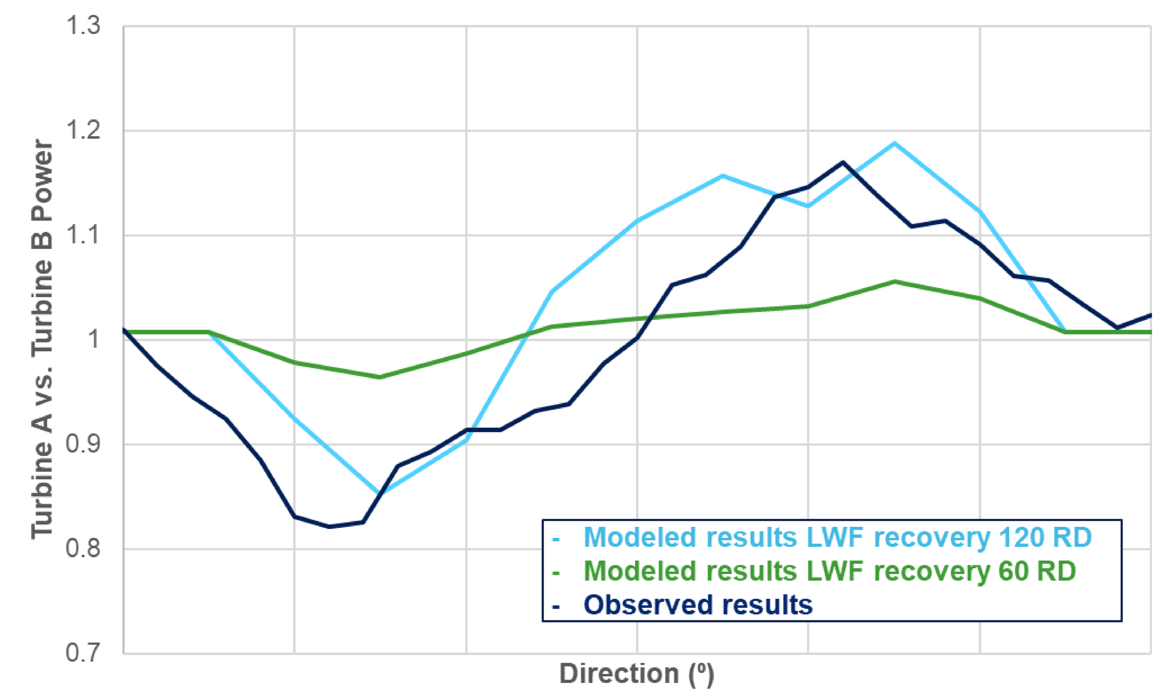






The wind farm in this case study shows a **maximum wake impact of ~15% in the affected sectors for both turbines at approximately 160 RD** away from the upwind wind farm.

DNV then compared the operational data results with two LWF recovery settings in the Eddy Viscosity wake model. **The results with the LWF recovery at 120 RD show much better agreement with the observed trend** than the standard settings of LWF recovery at 60 RD.



Changing the Eddy Viscosity wake model setting from a LWF recovery of 60 RD to 120 RD to better reflect observed results will have effects on high-density development areas such as the U.S. East Coast. **Tests conducted with lease areas off the U.S. East Coast** using a 15 MW, 236 m rotor theoretical turbine model with generic lease area wind farm layouts with 1x1 nautical mile turbine spacing showed **wake losses increased up to 1%** when comparing the Eddy Viscosity wake model outputs with the 60 RD and 120 RD LWF recovery settings.

CONCLUSIONS

- Increasing wind farm layout density, larger turbines, and regional build-out are **increasing wake propagation distances.**
- **Far distance wakes were observed in the operational data.**
- The **default settings** in industry standard engineering models are **likely insufficient.**
- Engineering models need further validation but **with updated settings engineering models can better capture far distance wakes.**
- **High fidelity models (CFD) are likely to give the best results** for cases outside of the validation envelope.