Impact of Wake Impingement on the Fatigue Loads in the Main Bearings and Blades of Offshore Wind Turbines

Summary

This article investigates the impact of wake imingement in wind farms on blade and bearing loads. The authors use FAST.Farm to simulate a deployed wind turbine/farm, and investigate the effect of wakes. They use a two-step strategy, where they utilize a parameteric study to understand how the wake deficit location affects bearing and blade loads. The main conclusion from this study is that for blade loads, the presence of wakes can reduce the fatigue damage for below rated wind sppeds, and increase the loads in above rated wind speeds. And for bearing loads, the relative location of the wake deficit to the rotor has a large effect. Then they extend this to the actual wind farm to understand how the loads vary within the wind farm.

The study provides valuable insight into bearing and blade loads, and how they are affected by wakes. This is specifically relevant for other wind farm design and control studies that are of interest to researchers now. However, there is not sufficient novelty compared to other works on this topic. Additionally, there are severe limitations in how the experiments are designed for this study. The article will only be suitable for publication following major revisions.

Major Comments

Comment 1 – Insufficient novelty

Issue: This article only builds on the previous articles on this topic, and does not add sufficient novel tests or results to warrant this being an independent journal article.
Recommendation: One way this can be addressed is by expanding the design of experiments as will be discussed in the next point.

Comment 2 – Insufficient design of experiment

Issue: The design of experiments for both the parametric study, and the wind farm study are insufficient as they do not cover the range of relevant wind speeds and wind directions. Additionally, the effect of turbulence intensity has not been considered, especially when its effect on fatigue loads has been well studied. Also, the effect of wind shear is not included, and its effect on bearing loads would be relevant to understand. Finally, yaw misalignment will also be important to look at, and understand how it affects the bearing and blade loads.
Recommendation: Both the case studies need to be run for finer discretizations of wind

speed and for the second study finer wind direction discretization is required. Additionally, the effect of wind shear, yaw misalignment, and turbulence intensity must be accounted for when possible.

Comment 3 – Effect of multiple wakes

Issue: This issue also stems from the lack of finer discretization for wind direction. Within the context of this study, when it has been established that the relative position of the wake has an effect on the bearing loads, then it is imperative to also look at cases when multiple wakes act on a given turbine, and how they can impact the bearing loads.
Recommendation: The current study needs to consider multiple wakes, or provide sufficient justifications for not considering them.

Comment 4 – Simulation setup

Issue: The simulation setup, including but not limited to, the number of seeds used, length of the simulation, transient period at the start, simulation time has not been provided.
**Recommendation:** This information needs to be included.

Comment 5 – Figures 3 and 4

Issue: There are a couple of design choices with respect to figures 3 and 4 that make these figures unintiutive and hard to follow and possibly misleading:

- The way the figures are presented, it is easy to misunderstand these figures as an aerial view of the wake behind a turbine.

- Why is the turbine spacing shown from right to left, instead of left to right which is the natural reading direction?

- What are the dotted lines in the subfigures in figure 3? Why is the line for the subfigure corresponding to 20 m/s wind only shown for 90 % of the figure? WHy are there only 2 lines for the 8 and 10 m/s cases, but 4 for the 12 and 16 m/s cases?

- For the 12 m/s case in Figure 3a, why is there basically a 0 percent change in the DEL in the region below 4D turbine spacing?

- I find the normalization of the colorbars misleading. For example, when comparing the subfigures for 10 m/s and 16 m/s in Figure 3a, a reader may interpret the magnitude of the damage values as being comparable (but of opposite sign) because the color scales appear visually similar. However, this is not the case. The increase in loads for the 16 m/s case is only about one third of the magnitude of the decrease observed for the 10 m/s case. Because the colorbars are normalized separately, the color mapping suggests comparable magnitudes even though the underlying values differ significantly. This issue is further exacerbated in Figure 4, where the two fields are shown together, making it even more difficult to interpret the relative magnitudes correctly. Consider

the attached figure, from the figure it looks like the magnitudes are vastly different, but looking at the colorbar, these magnitudes might actually be equal.
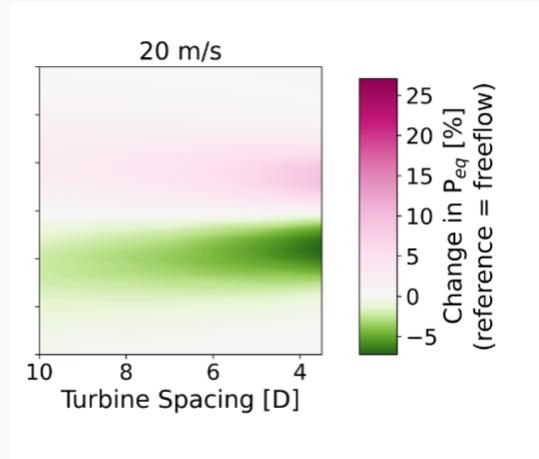
Recommendation: Please consider addressing these issues with respect to these figures. Although it might sound nitpicky, I think these changes are essential as Figures 3 and 4 present some core results for the article.

Minor Comments

Comment 1 – Comments regarding writing

Issue:

- **Line 50** Novelty lies in utilising a model of a deployed turbine, together with the layout and meteorological data from an existing wind farm, to obtain fatigue metrics for decision support, and in the extended discussion of asymmetries in main bearing loading. (**Consider mentioning this earlier in the section.**)

- **Line 195** Consequently, **power production becomes less fatigue-efficient**, meaning that the turbine accumulates more fatigue damage per generated MWh than under non-waked conditions. (**Consider rewording this sentence.**)