Comments on the manuscript “On the effects of inter-farm interactions at the offshore wind farm Alpha Ventus” by V. Pettas et al.

This manuscript brings very interesting facts regarding the impact of newly build offshore wind farms on the alpha ventus wind farm in the German North Sea using long term data of the nearby met mast FINO1. Since offshore wind energy has been increasingly developed, this topic became very important.

The authors have shown clearly how the commissioned surrounding wind farms affect the wind conditions at FINO1 and, consequently, the loads of the turbine 04 of alpha ventus (AV04). They analyzed the annual changes of the atmospheric conditions measured at FINO1, and related them to the influence of the upstream wind farms. Finally, they concluded that the wake effects reduced the wind speed and increased the turbulence intensity at FINO1. Moreover, analyzing the loads on the tower base of AV04, they concluded that the damage equivalent loads (DEL) increased after the commissioning of the Borkum Riffgrund 1 wind farm (BR1), while the Trianel Windpark Borkum I wind farm (TWB I) didn’t cause an increase in the fore-aft tower base DEL.

Having performed a similar analysis [1-3] we want to share our knowledge, experiences and results in this comment helping to further improve the manuscript.

For the next comments, the convention used includes information on the line number (*L. x) as printed in the mentioned manuscript.

L. 34

The review of relevant literature dealing with measurements of inter-farm wake turbulence and their load effect should be extended by previously published work, e.g. [2, 3].

L. 35

When discussing the work of Wu and Porté-Agel (2017) the classification of the atmospheric stability rather than the "vertical temperature gradients (K/km)” should be mentioned. See for instance Sorbjan and Grachev (2010) for guidance. Thermal stratification is driven by the gradient of the potential temperature rather the gradient of the absolute temperature. In offshore, the difference between sea surface and air temperature is of particular importance.

Sorbjan, Z. and Grachev, A. A.: An Evaluation of the Flux-Gradient Relationship in the Stable Boundary Layer, Bound.-Lay. Meteo- rol., 135, 385–405, https://doi.org/10.1007/s10546-010-9482-3, 2010.

L. 123

The strain gauges in alpha ventus were installed in half-bridge configuration and because of that the measurements are influenced by temperature. How have the authors managed the temperature influence on the strain gauges outputs for the calibration of the sensors, i.e. the calculation of the offset?

The authors have used 360° rotation of the nacelle to calibrate the strain gauges. The temperature on the tower base during this procedure can be very different from the mean temperature of the year (or the month), causing errors in the offset calculation. I would suggest a more detailed explanation of how the authors have worked with this uncertainty.

We have done a very similar analysis for turbine AV07 [1]. We couldn’t define an offset for the strain gauges when considering full 360° rotations of the nacelle because the variation between the calibration trials was too high. We found a more consistent value when selecting many periods when the turbine was off and stationary.

L. 127

We suppose that the availability of the turbine's data is lower than the one of FINO1's data. In order to avoid a bias in your results, the selected data should represent the normal atmospheric conditions, i.e. the ones shown by all available data from FINO1. One example is the relation between wind speed and turbulence intensity (TI). After applying the filtering on the data of AV04 and dividing them into sectors, the TI per wind speed was probably not the same as the one obtained from FINO1 data. How have the authors guaranteed that the selected data were representative? We would suggest a further filter to make the atmospheric conditions of the selected data more similar to the normal ones.

L. 204

Annual meteorological trends, which can cause an increase or reduction of the yearly-mean wind speed, make it more complicated to analyze the wake effects on the wind speed in each year. It would be interesting to show if the annual variations of wind speed are not caused by annual meteorological trends. That could be done by analyzing long term data, e.g. from the New European Wind Atlas [4], as it was done in [1]. Averaging the years into periods would also reduce the effect of annual meteorological trends in the wake effect analysis.

L. 213

In the present analysis the wind farm Trianel WindPark Borkum I seems to not influence the wind speed at FINO1, however another analysis showed that the wind speed in the sector of this wind farm (255° - 310°) was indeed reduced after its commissioning [1-2].

The results were achieved by grouping the years into phases according to the commissioning date of the wind farms surrounding FINO1, as shown in Figure 1.

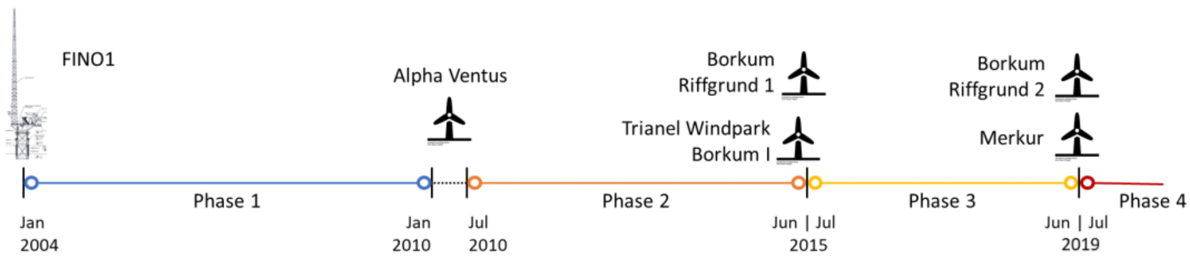

Figure 1 - Timeline of the measurement phases [3].

Figure 2 shows the reduction in wind speed in the sector 225° - 310° for phase 3, i.e. half end of 2015 to half start of 2019 (cf. Fig. 1). Could the author explain why a similar behavior is not seen in Figure 5 of their manuscript?

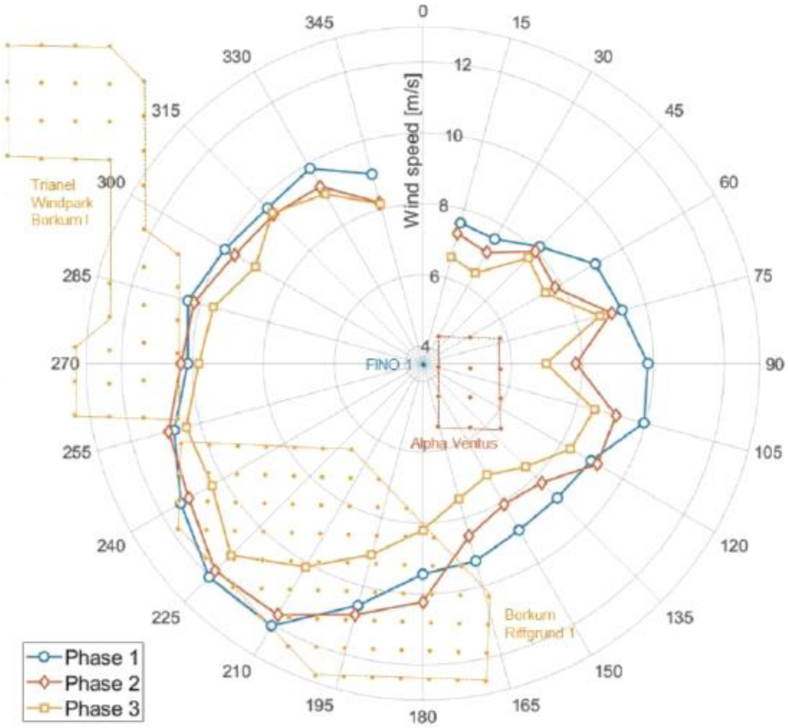

Figure 2 - Polar plot with wind speed as parameter for measurement phases 1, 2 and 3, with the projection of FINO1 and the wind farms alpha ventus, Borkum Riffgrund 1 and Trianel Windpark Borkum I [1].

L. 292

The authors claimed that the wind farm Trianel Windpark Borkum I doesn't influence significantly the conditions at alpha ventus and its loads. Since an increase in turbulence intensity at FINO1 was caused by the wakes of TWB I, it is expected that they would also cause an increase in the 10-minute damage equivalent load per wind speed. One of the reasons that could explain the persistent DEL in AV04 after the commissioning of TWB I is the lack of representativeness of the selected data, as it was pointed out for line 127.

Another option could be the change in the control strategy of alpha ventus that was implemented in 2015. The turbine AV07 had its rated power reduced from 5.3 MW to 5.1 MW [3]. In the analysis with AV07 data, this change in the rated power seemed to affect only the wind speeds above rated wind speed, causing a reduction in the DEL of the tower base fore-aft bending moment, although the TI increased, see Figure 3.

The section used for Figure 3 was 203° - 317°, i.e. it also includes the wake effects from Borkum Riffgrund 1 wind farm.

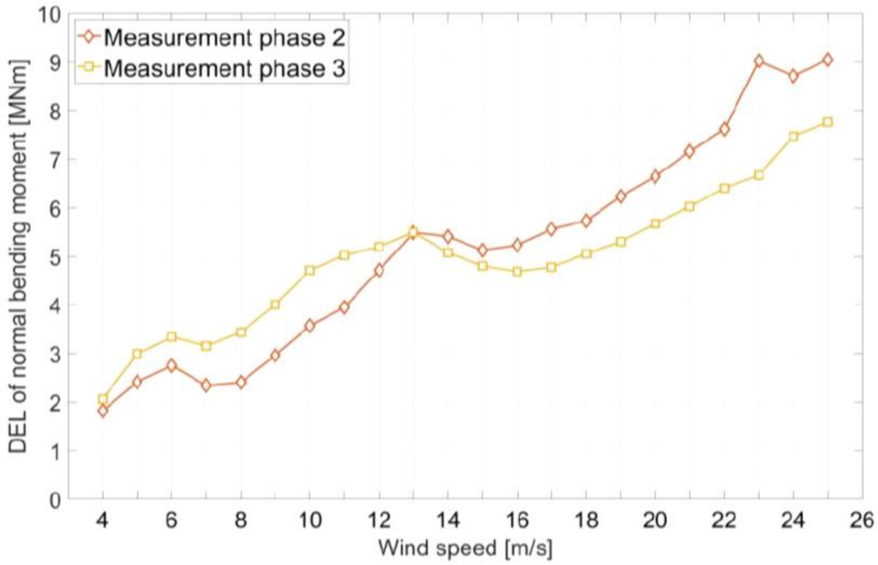

Figure 3 - Bin-mean of damage equivalent load of the normal bending moment on the tower base as a function of wind speed during phases 2 and 3 (cf. Fig. 1) [3].

Have the authors checked if the turbine AV04 experienced any change in the power controls (like it was applied to AV07) that could influence the loads?

Technical comment

We would suggest a general revision of the correct names of the wind farms, for example "Trianel Windpark Borkum I" instead of "Trianel Borkum 1".

We hope that these comments can help to further improve the manuscript and that they are considered in a revised version.

Best regards

Marcos Ortensi

Bibliography

[1] Ortensi, M., "Wind farm wake effects on the wind conditions and the fatigue loads of the offshore wind farm Alpha Ventus", master thesis, University of Oldenburg, 2020.

[2] Ortensi, M., Fruehmann, R, Neumann, T., "Long-term Effects of Wakes from Offshore Wind Farms on Wind Conditions at FINO1", *white paper UL International,* November 2020. https://aws-dewi.ul.com/knowledge-center/item/long-term-effects-of-wakes-from-offshore-wind-farms-on-wind-conditions-at-fino1/

[3] Ortensi, M., "Wind farm wake effects on the wind conditions and the fatigue loads of the offshore wind farm Alpha Ventus", *RAVE Workshop*, 2021. https://rave-offshore.de/files/downloads/konferenz/Workshop-2021/Ses2_2_RAVE2021_alphaVentus_Ortensi.pdf

[4] "New European Wind Atlas," New European Wind Atlas NEWA, [Online]. Available: https://map.neweuropeanwindatlas.eu/.