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Interactive comment on "Periodic dynamic induction control of wind farms: proving the potential in simulations and wind tunnel experiments" *by* Joeri Frederik et al.

Anonymous Referee #3

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The paper is well structured and makes a relevant contribution with first scaled wind tunnel experiments of dynamic induction farm control, as well as load evaluation by aeroelastic simulation for excited upstream wind turbine. Sound methodology is applied to results analysis. Publication is recommended upon addressing some minor comments listed below, added to those of the other referees.

* Page 8, Line 1 -> Which was the reason behind the choice of a pitch amplitude of 2 degrees? Could you please better specify? Has this pitch amplitude any relation to the amplitude used in the scaled tests? Besides, the experiments have shown greater dependency on the amplitude than on the frequency (Strouhal number). Wouldn't it

be coherent to perform in future work the load simulations also in accordance to this by varying the pitch amplitude in order to see the effect on loading of changing such amplitude?

* Section 7- Conclusions could be further elaborated by gathering nice comments previously included in the paper and by precising better some aspects:

-> It is shown that by acting on turbine 1, turbine 3 remains unaffected.

-> It is shown that, for a given mean wind speed, the change in the power gain mostly depends on the amplitude of the DIC and not on the frequency. Would it be any dependence on the mean wind speed? The experiments have examined the effect of DIC under different TI conditions. It would also be interesting to see in the future the effect under different mean wind speed conditions.

-> Page 15, Line 17 to Page 16, Line 1: "In all, it can be concluded that the dynamic induction control approach shows great promise, as now both simulations and scaled experiments show that it is possible to achieve a power gain. However, significant differences are found between simulation and experiments, which still need to be addressed." -> The conclusion included does not apply to the presented simulation results, which consist in the simulation of one single turbine, mainly for loading evaluation. These simulations don't provide insights into the behavior and power gain at farm level. Equally, it is not clear which are the significant differences between simulation and experiments this statement makes reference to.

* Is there any hypothesis on why the increase in the DIC amplitude provokes such decrease in the final power gain?

* For practical application of the technology, taking into account that DIC is intended for region II -among others-, have you considered the possible risk of stall when applying a periodic pitch variation of several degrees around fine pitch? The value of 2 degrees used in simulations (section 5) could prove to be relevant.

* The lowest tested amplitude for DIC has proved to be the best one. So, one question that arises is whether further decrease in the amplitude would lead to even better results. It would be interesting to determine in the future which is the minimum "A" that provides the maximum power gain.

* In the wind tunnel experiments it has been possible to measure the thrust coefficient thanks to the knowledge about the wind conditions. This has allowed the determination by trial and error of the pitch variation in order to provide a thrust coefficient (amplitude, frequency) matching the desired one. How would this technology be applicable in real wind turbines where such detail of information about wind conditions is not so easily and precisely available?

———————————————————————————————- For the sake of clarity and reproducibility:

* It would be advisable to indicate upfront from the very beginning of the paper that it focuses on below rated conditions and excitation of collective pitch angle. Also, to leave an explanatory comment about induction as in-wake speed deficit.

* Table 1: Missing frequency units in last row (“Frequency of excitation in St”). It’s understood that it is “Hz”, but better to leave it explicit.

* Table 2: Please make coherent the denomination for the amplitude variable A (third column in the table) with the description in the table caption (CT,DIC).

* Page 7, Line 18 -> It could be added as examined load the “hub torsional moment”, taking into account that these results are presented in Table 3.

* Page 8, Line 9 -> It could be added “mean” therefore indicating “mean hub wind speed of”

* Figure 7 and Figure 8, caption -> It could be added “mean” therefore indicating “mean wind speed”

* Table 3. The table caption would be clearer if it is indicated that the percentages refer to improvement with respect to baseline. Equally, it is indicated “AEP” in the caption, although the values are not included in the table. The percentage of variation of power with respect to baseline is of great interest, in order to compare the order of magnitude with the results of turbine 1 in the wind tunnel experiments. So, it would be advisable to introduce such information, not only in terms of AEP, but also through a figure of comparison with baseline, for example power time plot corresponding to Figure 5.

* Section 6. It would be advisable to indicate the layout of the wind farm tested in the wind tunnel, either through written explanation or through a descriptive figure.

* Table 4, caption -> Caption could be clearer by making reference to baseline: “An overview of the total power increase with respect to baseline by applying”

* Table 4 and Table 5 -> It would be advisable to indicate the frequency units (first row).

* Page 11, Line 5 -> When mentioning the change of +2% in blade root loads, it would be advisable to specify “flapwise”. Equally, when mentioning the negligible impact found in edge-wise and in the hub, it would be clearer to mention the respective percentages, since for edgewise, it’s only 0.4%, but for the hub it accounts for 1% to 2%. The discussion of load results is mainly done for St = 0.4 and St = 0.5, while the best fit for experiments is provided by St = 0.33 (low TI) and St = 0.29. Which would be the correspondence between the St results in the scaled tests and those for a full-scale model such as the one simulated in CP-LAMBDA?

* Page 11, Line 18 -> When making reference to the experiments with different amplitudes on a sinusoidal input, it would be convenient to introduce the reference to Table 2. Equally, it could be helpful to indicate again that the sinusoidal input is “applied to the collective pitch”, which is the range of variation of the pitch angle, and which correspondence this would have with the pitch angle in a full-scale wind turbine.

* Page 13, Line 3. In the same way that it is indicated explicitly for low TI experiments

(Page 11, Line 17), it would be nice to indicate the approximate value of TI applied in the high TI experiments.

* Page 13, Line 6. For higher clarity, it could be indicated to which production it makes reference the sentence. It is understood that it refers to: “the baseline power production of this turbine is already slightly lower than in low TI conditions”.

* Page 14, Line 8 -> For the sake of clarity, it would be advisable to introduce again the reference “Schreiber et al. (2017)”, which was already indicated in Page 4.

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* Page 3, line 8 -> “were” instead of “where”

* Table 1 The frequencies of excitation in St indicated for the aeroelastic simulations “Between 0.3 and 0.5” don’t match the range of frequencies of DIC stated in Section 5, Page 8, where it is stated that this frequency varies from 0.00952 Hz to 0.0595 Hz. Equally, the frequencies indicated for the experiments [0.09-0.41] don’t match the frequencies included in Table 4 and Table 5 [0.5-2.3].

* Page 6, line 15 -> “kHz” instead of “kH”

* Figure 5, xlabel -> It would be preferable to indicate time units in accordance to the symbol stated by the International System of Units: “s”

* Figure 7 and Figure 8, xlabel -> It could be introduced a space between Wind Speed and the unit [m/s]

* Page 11, Line 1 -> According to SI unit rules and style conventions, unit should not be italic “m/s”.

* Page 11, Line 3 -> In accordance to style convention, there should be a space between the number and unit “15 m/s”

* Page 11, Line 22 -> It seems that the verb is missing in the sentence: “the power is

divided”

* Figure 9, Caption -> The reference in the figure legend and caption should be coherent between CT and C’T.

* Figure 11, legend -> It seems that “baseline” would fit better than "benchmark", also keeping coherence with previous figures such as Figure 9.

* Page 14, Line 2 -> It seems that the sentence “However, since the power gain at turbine 3 is slightly lower, the total power is also lower than in the baseline case” would indeed make reference to turbine 2, according to the figures.

* Page 15, Line 15 -> To be corrected “weighted” instead of weighed. It would be preferable to specify “the increase of the weighted DEL with respect to baseline”. Equally, the values of DEL included could be misleading without specifying which load they make reference to. Indeed, the 0.3-0.4% refers to blade root edgewise, which is the least affected by DIC.

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