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WIND ENERGY SCIENCE DISCUSSIONS

WESD

Interactive comment

# *Interactive comment on* “Two-dimensional numerical simulations of vortex-induced vibrations for wind turbine towers” *by* Axelle Viré et al.

**Axelle Viré et al.**

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The authors thank the Reviewer for their detailed and positive feedback. We have taken the feedback into account in the revised manuscript. Changes are highlighted in red. Each comment is further addressed below.

1) Introduction, Page 1: Provide some numbers as to what you consider as a large diameter or tall wind turbine for which VIV is relevant.

Response: We have added some numbers in the introduction. We believe that towers of height between 65 and 110m are the most susceptible to VIV.



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2) Section 2.1 - While you outline the k-w CFD model in detail, there is not much mentioned about the external wind conditions. What free wind condition range is applicable to your model in terms of free wind speed and turbulence? Can you also consider wind shear and ground effect?

Response: Some more text is added regarding the limitations of the turbulence model. Within the two equations eddy viscosity model, there are only two parameters for the turbulence: one for the length-scale and another one for the intensity. There are some limitations for the boundary layer transition regime for the model. Also, the model is 2D so it does not take (vertical) wind shear into account.

3) Page 5: Why is there no aerodynamic damping term present in Eq. (18)?

Response: We noticed that this equation should be expressed in terms of force coefficient with respect to yˆstar instead of y, so this has been corrected. The non-dimensional force coefficient implicitly contains the aerodynamic damping.

4) Page 7: From figure 2, it appears that bending in only one direction is considered. For a wind turbine tower, both side-side and fore-aft modes are excited in VIV and so at least two springs in perpendicular directions should be considered.

Response: This is correct. However, this study is limited to VIV in one direction. This is now made clearer both in the text and the abstract. Although this is a limitation in the context of wind turbines, our analysis helps understanding the system dynamics in the transverse direction and also does bring new insights into VIV at flow conditions that are encountered in wind energy.

5) Section 3:0 : Can you provide a figure of the CFD mesh you used?

Response: The mesh has a "standard" o-grid topology which is commonly used for flow around cylinders. Two figures are added to the text to illustrate the mesh.

6) Page 8: You state the structural damping is 0.007. How much artificial damping due to the CFD mesh do you generate in your model? Is this artificial damping significant





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with respect to your structural damping?

Response: We did a mesh uncertainty study and the chosen mesh should not have a significant influence to the results as stated in the manuscript.

7) Same question for the turbulent flow: How much artificial/numerical damping is present in your CFD model and what affect does that have on the results?

Response: This is a very good question but a tricky one to answer. We expect the mesh to have the highest influence on the results. As stated above, we have performed a mesh convergence study in order to limit the influence of the mesh on the results. Of course, other uncertainties are also present due e.g. to the level of convergence, time scheme, round of error, etc. These are expected to be smaller. The fluid-structure interactions of course also add uncertainties. However, the strong coupling scheme ensures that both fluid and structural solvers are in equilibrium at each time step.

8) Going by the results of Table 2 on the angle of flow separation over the cylinder, what would be the best direction to orient the spring for your structural oscillation, since you consider only single dimensional oscillations?

Response: The pure vortex induced oscillations are investigated in this research. Coupling of both modes or other phenomena are not of interest as the resultant deflections (bending moment resulting from cross wind VIV) are the highest.

9) Page 12, line 240: The expression for aerodynamic damping used is not clear. There is no 'q' term in the equation as given in the explanation.

Response: 'q' was referring to a generic quantity, in order to explain what the prime and overbar denote. Here q is y_dot. This is now made clearer in the text.

10) Figure 7, Figure 8 etc: Can you also plot this versus the Strouhal number?

Response: The Strouhal number is now used on the x-axis of the figures. This is indeed also how it was done in the NASA report used as reference. The values on the





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plot are unchanged.

11) Section 3.2.4: When you state realistic wind turbine tower, what is the wind turbine tower diameter, height and natural frequency that is considered?

Response: We work with non-dimensional numbers throughout the paper. These are computed based on the properties of a real wind turbine tower from Siemens Gamesa Renewable Energy. The industrial partner prefers not to mention the dimensional values. However, the manuscript is scientifically complete and reproducible with the non-dimensional values.

12) Can you conclude on how the results of your work can be applied to an existing wind turbine tower? What wind conditions and tower natural frequencies should the turbine designer pay attention to for VIV?

Response: We have added some text related to this in the conclusion. The current research gives us a great insight into the flow behavior and the perseverance of VIV in the supercritical Reynolds number when the flow regime is very stable. It explains episodes of sustained VIV where the Strouhal relation is not even valid. The magnification of VIV for a disturbed tower (oscillating from other wind phenomena such as gust buffeting or blade-tower interaction) under the right conditions can result in continuous magnifying VIV until the wake completely breaks down. The best mitigation strategy is not in the primary structure design but having robust damping mitigation which are effective within the range of first bending frequency {0.5 – 1.1} to prevent the onset of sustained VIV.

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