Authors' response to reviewer 2

We thank the reviewer for the valuable comments and suggestions, which we consider very important and help us to sharpen and improve the manuscript. Here are our responses written in green to each comment.

The authors response is shown in green.

General comments:

The paper describes a methodology to design mooring systems that passively adjusts the position of floating wind turbines in a farm to avoid wakes from upwind turbines. The thinking is innovative, and the authors seek to demonstrate the energy yield gains in applying the methodology. The paper is well written and very detailed, perhaps too detailed, as it is on the long side and sometimes difficult to follow. The discussions of the observed differences in results between FAST/MoorPy, FAST.Farm/FLORIS are important and clarifying. However, descriptions of these two could be presented in a way that gives a better overview for the reader that is not familiar with these softwares.

Thank you for your kind comment. We tried to be detailed to help the reader understand the methods presented. This is a new topic with a new method introduced and we wanted to increase the level of clarity of our work. We agree that following the paper can be hard without understanding the tools used, but these tools are well introduced in details in many references. We have cited all of these references in detail for the reader. Since the development of these tools is not part of our work, we believe that more details on the tools is out of scope of the paper.

It is also unclear why 10 m/s was chosen. Something about at which wind speeds the highest gains are expected should be mentioned. Also, it is mentioned in the conclusions that "a more realistic" case will be studied in the future, but it would be useful to know at this point what the design strategy would be if one had to design mooring systems for more than one wind speed. It would also be interesting to know the author's thoughts on how significant the observed increase in energy yield is for the total AEP.

Thank you for your comment. The methodology is independent of the wind speed value. We chose 10 m/s because this is where we predict the gain to be the highest as it is the wind speed just below the rated wind speed of the FOWT at 11 m/s. We cannot use above rated wind speeds to design the mooring systems in this method, as above rated there are no power losses due to the wakes. We updated now section 2 in the text as follows "The 10 m/s wind speed used has no effect on the FWF design because the method is independent of the wind speed.. A wind speed just below the rated wind speed of the turbine is recommended as this is where the energy gain is the highest."

When referring to a "more realistic" case in the conclusion, we meant that we would add more constraints on the same method. For example, we are now writing a paper about applying the method on the Horns Rev I wind farm layout, while choosing only one mooring system design for all FOWTs in the farm and not a different mooring system for each FOWT. Moreover, we are also planning to decrease the maximum displacement done by the FOWT. We updated the text now as follows: "We are planning to use one customised mooring system design for all FOWTs in the FWF instead of having different mooring system for each FOWT. Additionally, we will decrease the FOWTs excursion limits to bring them closer to the current limits used within the current state-of-the-art mooring system designs."

The energy gain will be lower when the full wind rose is applied as no gain will be produced at above rated wind speeds, and less gain will be produced for lower wind speeds. In our work in [1], the gain was reduced by 40% to 30% when a full wind rose was applied. We did not want to add it in this work because the goal here is to study the dynamic performance of the customised MS design and the FWF power production. Section 2.2 is now updated as follows "The energy gain achieved in through this paper only considers a constant wind speed of 10 m/s, and not the full wind spectrum. As shown in our work in [1], when all wind speeds are considered the energy gain was reduced by 40% to 30% of the gain calculated at 10 m/s. The calculation of the full wind rose energy gain is out of scope of this paper because we instead focus on the comparison of the steady state and dynamic models."

The description of the mooring system database in sec 2.3 is very detailed, and quite confusing. I understand that the concepts of "mooring system watch circle" is described in a previous paper, but it would be helpful if the concept was described better in the current paper.

Thank you for your comment. We have restructured section 2.3 and decreased the level of detail. We have now added a paragraph and a Figure to explain the watch circles..

It is stated that the allowable displacement of the mooring system is 1D. For a 15MW turbine at 200 m water depth, this is 120% of the water depth. Normal offset requirements to secure cable integrity is in the range of 10-30% of the water depth. This criterion is also why one ends up with fairly stiff mooring systems. Soft systems like the one in the design here, also could have other issues that are not addressed here, such as snap loads. Please comment on this.

Thank you for bringing this up. We are aware that currently there is a constraint on the excursion done by the FOWT due to the cable design. However, to the best of our knowledge we have not see any work done discussing the limits of the cable or studying the effects of such motions on the cable's fatigue loads. We think that these limitations come from the oil and gas industry and more research is needed to understand what are the real physical limits. We hope our work will motivate more research in this direction, to answer this question regarding the cable. We updated the text in section 2.3 as follows: "Although the current state of the art generally limits the FOWTs excursions to be less than 30% of the water depth, we are going to neglect this in our current work, and allow larger excursion limits."

Moreover, even with 30% displacement if we integrate the mooring system design as part of the FWF layout design we can benefit from these motions to increase the AEP of the farm even a small increase in AEP can be valuable. This is one of the aspects we are planning to look into in our next paper and this is what we meant by more realistic design in the conclusion. We updated the text in the conclusion as follows: "In future work, we are planning to make our designs more realistic and consider real-life scenarios. We are planning to use one customised mooring system design for all FOWTs in the FWF instead of having different mooring system for each FOWT. Additionally, we will decrease the FOWTs excursion limits to bring them closer to the current limits used within the current state-of-the-art mooring system designs."

Finally, you are correct that there are other issues to look after while designing the soft mooring systems. We have checked for snap loads in all our simulations for fatigue and extreme loadings. There were no incidents of snap loads in any of the customised mooring system design. We believe this is because of the constraints we had on the mooring system database results where very soft mooring systems where not accepted by the constraint on the maximum allowable yaw angle. We updated sections 3.5 and 3.6 as follows: "Finally, we checked the mooring lines tensions for snap loads as the mooring systems presented are less stiff than the state of the art mooring designs. However, we have not seen any snap loads in the operation conditions in any of the cases we checked."

"Finally, we have not seen any snap loads in the extreme loading conditions in any of the cases we checked."

Continuing on soft mooring systems. It is weel established that soft mooring systems experience less fatigue than stiff systems, thus the difference in fatigue damage between the base case and the adjusted system is not necessarily related to the fact that it uses passive position adjustment. It is therefore not fair to compare the fatigue damage to a base case that was designed for a 12%WD offset.

Thanks again for bringing this up. Yes, we also expected the soft mooring system designs to have lower fatigue loads. However, we believe this comparison is valuable for two main reasons. First, it shows that allowing bigger motions of the FOWTs decreases the fatigue loads on the mooring system, which means we can use smaller mooring diameters can be used to achieve the same fatigue damage. It is an advantage for the new customised mooring systems over any of the current state of the art mooring system designs that should be highlighted.

Second, the main goal of this paper is to study the dynamics of the customised mooring systems design, and a crucial part of this is the fatigue response.

Specific comments:

Sec 2.4: What is "brute force optimization"?

Brute force optimization is an optimization in which all possible solutions are tried. We did not explain in detail the optimization process in this paper. This is the core part of our method and is explained in details in our work in [1]

Sec 3.2: It is stated that the base case design is a linear mooring system. Is it not catenary? Please explain.

It is stated that the stiffness is linear, not that the mooring system is linear. This means that the force-displacement curve is linear and the stiffness does not have big changes as the force acting on the FOWT changes..

Fig 8 and 9: It would be helpful if the text transfers these frequency ranges to periods.

The captions are now updated as follows "The range of the colour bar extends from 0.001 Hz (time period of 900 s) to 0.01 Hz (time period of 90 s).".

Sec 3.3: Are tower top deflections really that significant for platform offset, compared to (the mentioned) platform rigid body motions?

In this section, we are stating the difference in the MoorPy model and the OpenFAST model. The MoorPy model is static does not consider any dynamic effects, while the OpenFAST model is a time domain dynamic model. It is expected that there will be small differences between the two models as there is a difference in the details used to model the turbine's structure and excitation forces. In this part we are stating the difference, leading to the small deviations in the watch circle of both models. However, we do not think that the tower deformation has a higher effect, we believe the difference comes from the change in the aerodynamic forces acting on the rotor as the floating platform moves in pitch, roll, and yaw. This is well captured by the BEM model in OpenFAST but not in MoorPy. However, to be able to quantify this we would have to simulate a case while turning off the DoFs of the tower in OpenFAST to make it rigid.

Fig 11: Please include units in these figures.

There are no units in this figure as it shows the percentage energy gain calculated using equation 1. We updated the caption as follows "(left) The percentage of energy gain at each wind direction for the targeted wind farm layout, (center) the percentage of the final wind farm layout using static wake models, and (right) the percentage of the final wind farm layout using dynamic wake models.".

References

[1] Mohammad Youssef Mahfouz and Po Wen Cheng. A passively self-adjusting floating wind farm layout to increase the annual energy production. *Wind Energy*, 26(3):251–265, 2023.