Authors' response to reviewer 3

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 present work summarizes the previously published approach for optimization of a passively adjusting floating wind farm and examines 1) the application of DWM rather than static methods and 2) the dynamic responses of the FWTs. The results are believable and the work is generally understandable, and the results are basically as expected (allowing larger mean deflections gives a softer mooring system, which takes up fewer dynamic loads than a stiffer system and thus appears to perform "better" than a "conventional" system).

Thank you.

In general, it would be good to include some more caveats about the results. For example, claiming improved fatigue life based on only simulations of a single environmental condition is a bit misleading. The fact that the baseline design allows for a conventional power cable design, while the passive repositioning system requires a power cable that can tolerate much larger offsets, should also be highlighted. I would furthermore argue that a chain-only design is not exactly state-of-the-art for floating wind, where lighter systems with lower environmental impact are also being examined.

These are all very valuable and useful comments and we would like to thank the reviewer. To consider the reviewers recommendation the following was done:

- We went through the paper and emphasised in the abstract, in section 3.5, and in the conclusion that the results shown for fatigue damage are non conclusive for the overall lifetime fatigue damage of the FOWT and only represent the loads at rated wins speed.
- We updated the text below Figure 8 as follows: "The baseline design can be coupled with a conventional power cable design, while the passive repositioning mooring system designs require a power cable that can tolerate much larger offsets. The effect of the larger FOWT's relocation on the cable design is not discussed in this paper.". Additionally, the following sentence was added to the conclusion "Additionally, studying the effect of the FOWT's larger displacement on the cable costs and cable design is still missing in the current work."
- To address the material comment we added the following sentence to the text "Novel lighter materials with lower environmental impact for the

mooring lines are not checked in this work."

When examining the dynamics of the system, it is also very relevant to discuss the control system applied in the simulations. Most reference control systems are actually unstable in surge, and would in principle be "more unstable" for longer natural periods. Did you deal with this issue, or simply ignore it?

The controller used in this work was tuned for the baseline Activefloat platform as shown here [1, 2]. There was no retuning for the controller within this work. We did not see any instabilities with any of the mooring system designs in any of the dynamic simulations we did in the current work. We added this paragraph to the text "The controller tuned for the Activefloat coupled to the 15 MW reference turbine in the work of [1, 2], is used in the current work. The controller is a simple generator torque controller for the below rated wind speed and collective pitch controller for the above rated wind speeds with no tower top feedback and no yaw control. The controller was not retuned in this work with the change of the mooring system designs and was used as is for all simulations in this work."

The issues related to wake deflection prediction are quite interesting. It is possible to tune the FAST.Farm parameters to achieve similar wake deflection as LES simulations for this turbine, as shown in `https://doi.org/10.1016/j.renene.2023.119807`. On the other hand, it wasn't possible to match both yaw and tilt-induced deflections simultaneously. I would also note that DWM may not accurately model the boundary flow around the farm very accurately as the number of turbines increase (especially with pitched floaters causing upward wake deflections).

Yes, they are very interesting. I was not aware of the paper shared by the reviewer. Thank you for sharing it as this is very useful to my work and my future research plans. I have checked it and it adds credibility to the results. Therefore I added the reference to the conclusion section.

Specific comments:

Line 26: why does "open" need to be specified here?

There is no need to specify the tools being open-access here. It is removed to avoid confusion. Thank you for catching this up.

Line 92-93: Is a minimum distance constraint actually needed? Why doesn't the optimizer capture the fact that larger losses occur and avoid this area anyhow?

Thank you for your question. The minimum distance is needed especially for the less probable wind directions of the wind rose. The gain for getting two turbines really close together (less than the minimum distance) in the less probable wind direction can lead to higher energy gain for more probable wind direction. Therefore, setting the minimum constraint is crucial to avoid two turbines closer than the minimum defined distance..

Line 102: wouldn't it be even better to design a passively adjusting layout from scratch, rather than assuming that it is simply a correction to the optimized fixed layout? This is probably too computationally expensive in practice, but I don't see a reason to believe that the results would be identical.

That is a very good comment. Yes, we do not expect the results to be identical if a passively adjusting layout is designed from scratch. We did not go for this approach cause our goal now is to proof that there is a potential to having these soft mooring lines and allowing passively adjusting layouts. We are not claiming that the design presented in this paper is the global optimum. We have updated the introduction to clarify this "The wind farm layout and the mooring system designs presented at this work are not the global optimum designs, as this is not the goal of the method as stated and presented in our work [3]."

Moreover, we prefered to follow the step by step approach we used to show the targeted energy gain which can be achieved. This energy gain represents the limit of the optimization process as shown in Table 2 it decreases the wake losses by 2%, such targeted layout cannot be emphasised if an optimization process from scratch was used.

Finally, we updated the conclusion to include this point as future research as we believe this should be the future of floating wind farms designs. This sentence is now added to the conclusion "Finally, the optimization process should include from the beginning the ability of the FOWTs to relocate their positions passively, and this should be integrated in a full optimization routine instead of the step by step approach followed in this paper."

Line 125: I'm having a hard time following "the energy gain was reduced by 40% to 30% of the gain calculated at 10 m/s." Is $30 - 40\%$ a range, or do these percentages refer to two different things?

Thank you for the comment. The results discussed in the paper [3], showed the AEP for two different wind roses with identical wind direction probability distribution, but different Weibull distribution at each wind direction. This led to a difference in AEP gain. We updated now the text as follows: "The 40% to 30% values represents the results of two wind roses with identical wind direction distribution but different Weibull distribution."

Line 168: Do I understand correctly that the yaw angle is calculated, but nonetheless not included in FLORIS?

Yes, this is correct. In FLORIS, the pitch, roll and yaw angles of the FOWTs are not included. This is also mentioned previously in line 99 therefore we did not update the text here.

I like the concept of figures 9 and 10, but have a hard time reading actually frequencies with these colors. Would it be possible to give a range of natural periods along the 10 m/s watch circle in the text? This would be useful in understanding, for example, how different we expect the behavior to be, or whether or not 3600 s is sufficient to capture a sufficient number of oscillations at the natural frequency.

We added the range of natural periods to the text as requested by the reviewer. The text added is the following "As an example to the spread of the natural frequency of the customised mooring systems at wind speed of 10 m/s, the baseline mooring system design natural periods range from 97 s to 130 s in the x-axis direction, and ranges from 97 s to 147 s in the y-axis direction. On the other hand at 10 m/s the natural periods of the customized mooring system design coupled to turbine 1 ranges from 108 s to 404 s in the x-axis, and from 128 s to 448 s in the y-axis. The dark areas in Figures 9, and 10 represents the higher natural period region (lower natural frequency). The x-axis and y-axis do not change with the change of wind direction and are fixed global axis."

Line 292: "OWFL when coupled to the OWFL" – I understand what you mean, but could be worded better.

Thank you for catching this typo. We updated the sentence as follows "This shows that the energy gain achieved by the OWFL when coupled to the customised mooring systems,..... "

Line 315: Is the rotor-average wind speed defined in rotor coordinates?

Yes, this is true and thank you for the question. However, the rotor coordinates are not identical in both tools. The rotor is tilted and pitched in FAST.Farm while this is not the case in FLORIS where the rotor is not tilted or pitched. This is explained in the text in lines between 317 to 320. We added this sentence to clarify "This is because the rotor average wind speed is measured in rotor coordinates for both tools, but the rotor coordinates are fixed in FLORIS while they move with the rotor in FAST.Farm."

Line 320: when discussing wake meandering, it is confusing to me whether you refer to the deficit part of the model, deflection part, meandering part, or all 3.

I am discussing all three parts of the model. I have went throw the paper and updated the text to make sure I am using the correct verb for each part. When talking about meandering I used the verb meander, for deflaction I used deflect and for the deficit I referred to it using wind speed.

Line 328: How large is the effect of the mooring system on the mean pitch angles?

The effect on the mooring system on the pitch angle is negligible and less than 1°. It depends on the overhang of the mooring lines and which line is heavier and if it is upwind and downwind. This is why the change in wind speed is also negligible less than 0.1 m/s. The text is updated as follows "The change in the mean pitch angle is small and less than 1°."

Line 353: It would be interesting to know whether the dynamic motions or just the mean motions matter in the comparison. You could run the baseline model with the tilt corresponding to the tilt+pitch of the floater and a yaw angle equal to the mean yaw angle to see this.

Yes, this is an interesting point. In this work, we already updated the FAST.Farm source code (AeroDyn module) to remove the dynamics of the motions of the floater while calculating the rotor average wind speed. Therefore, we believe that all the results we show in this paper in all cases of FAST.Farm do not have an effect of the FOWTs dynamics but only the mean offsets are considered. Therefore, a more detailed study is out of scope of our current work. We updated the text as follows (Line 316): "We updated the source code of the FAST.Farm used in this work so the rotor average wind speed do not include the FOWTs dynamic motions."

Line 358: wouldn't it be easier to write 0.17D?
You are right thank you. We updated the text as suggested.

Figure 15: Check figure title
Thank you for catching this. The Figure is updated.

Line 375 and 397: were/where
Thank you. We updated the typos mentioned.

Line 413: note that the reduced stiffness will in principle reduce the platform motion responses to first-order wave forces (as the system is even farther from resonance). This difference is probably small in this case, though.

Thank you so much. We have added this comment to the text as we believe it adds a lot of value.

References

[1] Mohammad Youssef Mahfouz, Climent Molins, Pau Trubat, Sergio Hernández, Fernando Vigara, Antonio Pegalajar-Jurado, Henrik Bredmose, and Mohammad Salari. Response of the International Energy Agency (IEA) Wind 15 MW WindCrete and Activefloat floating wind turbines to wind and second-order waves. *Wind Energy Science*, 6(3):867–873, 2021.

[2] Mohammad Youssef Mahfouz, Mohammad Salari, Fernando Vigara, Sergio Hernandez, Climent Molins, Pau Trubat, Henrik Bredmose, and Antonio Pegalajar-Jurado. D1.3. Public design and FAST models of the two 15MW

floater-turbine concepts, December 2020. This deliverable is a draft version, and still under revision by the EC.

[3] 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.