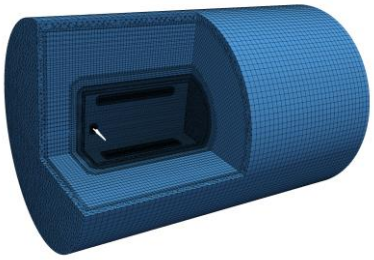
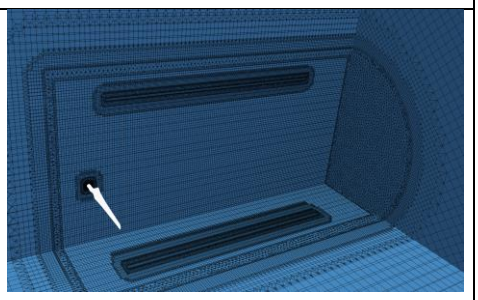
Replies to the reviewer 1:

We would like to thank the reviewer for his/her very constructive suggestions/corrections to our manuscript. Below are the point-to-point replies to the comments raised by this reviewer. As notified by the Associate Editor, we are required to address the comments from the reviewers to a satisfactory level before the revised manuscript can be submitted. We hope we can have the chance to show the reviewers our revised manuscript after considering all the comments from them.

<table>
<tr><td colspan="5">Major comments</td></tr>
<tr><td>1</td><td colspan="4">Novelty</td></tr>
<tr><td></td><td>Comments</td><td colspan="3">1. The authors highlight the novelty of their work as being “the first ever work on wind turbine optimization implementing and using the DAFoam to data based on adjoint and RANS solvers with reverse AD technique”. A first thorough application of a widely available DA framework to wind turbine design holds value, but I believe this statement illustrates the marginal novelty of the current work. The authors cite some papers where discrete adjoint optimization is performed on the same NREL VI turbine as considered here (L166), and the DAFoam website even features a tutorial for the NREL VI wind turbine case: https://dafoam.github.io/mydoc_tutorials_aero_nrel6.html . As such, I find the claim somewhat exaggerated. A documented application of a software tutorial does not warrant a journal publication. The authors should therefore much more clearly outline how their manuscript advances the state of the art. Furthermore, in the conclusion, the authors claim the aim of this study is “to contribute towards the development of an open source MDO platform”, however, I see no development in the current work, but rather an application to a specific case.</td></tr>
<tr><td></td><td>Replies</td><td>Contributions</td><td>In our work</td><td>In the tutorial given in DAFoam</td></tr>
<tr><td></td><td></td><td>The types of the design variables:</td><td>As shown in table 1, pitch, twist, chord length, dihedral as well as local shape as design variables</td><td>only the local shape is considered as the design variable.</td></tr>
<tr><td></td><td></td><td>Geometry</td><td>In our paper, we considered the whole geometry, optimized only one blade, and copied the optimization to the other by using the symmetry constraints to link the displacements of the corresponding FFD points.</td><td>the full geometry isn’t considered, and two blades are optimized in terms of the shape in y direction only. Moreover, two blades are optimized separately with two block of FFD points without considering the root of the blade.</td></tr>
<tr><td></td><td></td><td>Constraints</td><td>LE/TE constraints: LE/TE is the short for Leading edge/Trailing edge. They are linear constraints based on the FFD control points to prevent the local shape variables from creating a shearing twist since twist has been considered as a design variable itself in our research.</td><td>No constraints are considered.</td></tr>
</table>

			Thickness constraints: between 50 % and 200% of the local initial thickness values. Volume constraints: between 100% and 200% of the initial values.	
		Solver	In our optimization, we used DASimpleFoam, which is a discrete version corresponding to the incompressible solver SimpleFoam in OpenFOAM	The compressible solver, DaTurboFoam is used
		Aero structural case	As the preliminary step of our multidisciplinary optimization, we have implemented an airfoil aero-structurally as a 2D case of the MDO. And it is added as a separate section in the paper.	
2.	The CFD setup is insufficiently detailed:			
a.	comments	Figure 3a: Can the wind turbine geometry be included in this figure, or in an overall illustration of the entire domain. How large is the domain with respect to the turbine geometry?		
	Replies	Far field domain is in a cylindrical shape of 10R in length and 6R in diameter, where the distance from the front of the region to the blade is 2R while the wake region's length is 8R.		
				
b.	Comments	Boundary conditions should be discussed, this is missing		
	Replies	Boundary conditions are as shown below:		

Boundary Conditions	epsilon	nut	nuTilda	k	Omega	P	U
blade	epsilonWallFunction	nutUSpaldingWallFunction	fixedValue	kqRWallFunction	omegaWallFunction	zeroGradient	fixedValue
inout	inletOutlet	fixedValue	inletOutlet	inletOutlet	inletOutlet	fixedValue	inletOutlet

c.	Comments	The description of y+ in line 229, based on a local cell fluid velocity, is confusing, if not completely incorrect.
	Replies	It should be Free-stream velocity
d.	Comments	It is not clear whether a wall function is applied and, if yes, which one.

<table>
<tr><td></td><td>Replies</td><td>Yes, the wall function is applied and they are epsilonWallFunction for epsilon, nutUSpaldingWallFunction for nut, kqRWallFunction for k and omegaWallFunction for Omega.</td></tr>
<tr><td rowspan="2">e.</td><td>Comments</td><td>L237: It seems irrelevant to mention “HPC with 72 processors” without clarifying which processor was used and detailing computational aspects such as wall time or memory usage.</td></tr>
<tr><td>Replies</td><td>Wall time, 72 processors and 503.8 GB RAM were in use.
<table>
<tr><td>Optimization scheme</td><td>S1</td><td>S2</td><td>S3</td><td>S4</td><td>S5</td></tr>
<tr><td>Design variables</td><td>Pitch</td><td>Shape and twist</td><td>Shape and chord</td><td>Shape and dihedral</td><td>Twist, chord, and dihedral</td></tr>
<tr><td>Wall time</td><td>25,737.1896 s (7.1492 hours)</td><td>104,596.301 (29.0545 hours)</td><td>182,851.6606 s (50.7921 hours)</td><td>107,912.0536 s (29.9755 hours)</td><td>76,750.749 s (40.7641 hours)</td></tr>
</table></td></tr>
<tr><td rowspan="2">f.</td><td>Comments</td><td>L232: “Although Reynolds-averaged Navier– Stokes equations (RANS) CFD analysis is more computationally expensive and CFD has limitations, it may be preferable to simulate a wind tunnel test for examining surface pressure distribution.” I’m having trouble understanding the relevance and intention of including this sentence.</td></tr>
<tr><td>Replies</td><td>What we meant here is that CFD is more computational expensive compared to the low fidelity simulation and the RANS-based CFD has limitations compared to the URANS-based CFD. This sentence is reworded.</td></tr>
<tr><td rowspan="2">g.</td><td>Comments</td><td>It is not completely clear whether the simulation performed is a steady RANS or a URANS. L238 makes me suspect the former, but this should be more clearly mentioned earlier in the setup description.</td></tr>
<tr><td>Replies</td><td>RANS-based simulation and it is mentioned as subtitle: 3.1 RANS formulation and CFD simulation.</td></tr>
<tr><td rowspan="2">h.</td><td>Comments</td><td>Which OpenFOAM solver is used? I suspect simpleFoam, but this should be explicitly mentioned.</td></tr>
<tr><td>Replies</td><td>Discretized version of simpleFOAM is DAsimpleFOAM in DAFoam. In our research, we used the DAsimpleFoam. It has been added to the revised manuscript.</td></tr>
<tr><td rowspan="2">3.</td><td colspan="2">3. The discussion of the adjoint equations seems unnecessary and is formulated a little too informal.</td></tr>
<tr><td>Comments</td><td>a. L268: R is used both for a vector space of real numbers, as well as for the definition of the residual. Also, the vector space dimensionalities n_x and n_\omega are not explicitly defined
b. The train of thought to arrive at Equation 5 is not clear
c. Overall, the adjoint derivation adds very little to the narrative other than the statement that ‘The computational cost of the gradient computation is independent of the number of design variables’. I would suggest to remove the derivation and instead refer to literature for a more thorough and rigorous explanation.</td></tr>
</table>

	Replies	Adjoint derivatives have been improved and a few more references are added: References added: He, P., Mader, C. A., Martins, J. R. R. A., & Maki, K. J. (2018). An aerodynamic design optimization framework using a discrete adjoint approach with OpenFOAM. *Computers & Fluids*, *168*, 285–303. https://doi.org/10.1016/j.compfluid.2018.04.012 Kenway, G. K., Paige, C., & Martins, J. R. R. A. (2013, June 24). Automatic Differentiation Adjoint of the Reynolds-Averaged Navier-Stokes Equations with a Turbulence Model. 21st AIAA Computational Fluid Dynamics Conference. https://doi.org/10.2514/6.2013-2581
4.	The manuscript is lacking adequate references to literature in key places:	
	Comments	The manuscript is lacking adequate references to literature in key places where the authors explicitly mention prior research has been conducted, for example a. L48 The sentence mentions "in certain research" without referring to such works. Overall, more references should be added here. b. L65 "While the majority of studies investigate …., others explore the combination of the two" References should be added. c. L132: "As a result, their applications have often been limited to …" Add at least 1 reference per example
	Replies	More references are added, and corresponding revision has been made. For example: Akram, M. T., & Kim, M.-H. (2021). Aerodynamic Shape Optimization of NREL S809 Airfoil for Wind Turbine Blades Using Reynolds-Averaged Navier Stokes Model—Part II. Applied Sciences, 11(5), 2211. https://doi.org/10.3390/app11052211 Chetan, M., Sakib, M. S., Griffith, D. T., Gupta, A., & Rotea, M. A. (2022). Design of a 3.4-MW wind turbine with integrated plasma actuator-based load control. Wind Energy, 25(3), 517–536. https://doi.org/10.1002/we.2684 Sessarego, M., Ramos-García, N., Zhong Shen, W., & Sørensen, J. N. (2016). Large Wind Turbine Rotor Design using an Aero-Elastic / Free-Wake Panel Coupling Code. Journal of Physics: Conference Series, 753, 042017. https://doi.org/10.1088/1742-6596/753/4/042017
5.	The authors use a very cumbersome style of incorporating references in their sentences which impedes fluent readability of the manuscript. Surely this can be formulated in a less wordy manner. Examples:	
	Comments	The authors use a very cumbersome style of incorporating references in their sentences which impedes fluent readability of the manuscript. Surely this can be formulated in a less wordy manner. Examples: a. L83: Ning (Andrew Ning, 2013) addressed this … b. L86: Chehouri et al. (Chehouri et al., 2015) conducated an in-depth … c. L142: Peter and Dwight (Peter & Dwight, 2010) discussed these …

		d. L143: Martins and Hwang (Martins & Hwang, 2013) expanded … e. L166: T. Dhert et al. (Dhert et al., 2017) and Mads H. Aa. Madsen et al. (Madsen et al., 2019) have recently …
	Replies	The revision has been made to all the style of incorporating references mentioned and the whole paper.
6.	The writing structure and style of the manuscript should be improved overall, the manuscript could be significantly streamlined to improve readability:	
a.	Comments	L39 and L57 deliver an identical message, please revise and avoid unnecessary repetition
	Replies	Corresponding revision has been made.
b.	Comments	L73 "Wind turbine performance (power production and loads) has been shown to be affected by the aerodynamic forces created by the wind" This is a trivial statement, can be omitted easily.
	Replies	The statement is removed and modified.
c.	Comment	Section 2.2 adds very little to the overall narrative of the manuscript and could be omitted. Also, in the final line where computational expense is discussed, citing a paper from 1952 seems outdated.
	Replies	This section has been removed.
d.	Comment	Section 2.3: categorizing RANS CFD as high fidelity should be done with caution. Perhaps the authors should refer to RANS techniques as CFD-based methods rather than high fidelity, as there is significant uncertainty regarding turbulence modeling
	Replies	Thanks a lot for the suggestion, we call our RANS as high-fidelity as we used the Spalart-Allmaras model as the turbulence model, which is mentioned in L217. Sa
e.	Comment	Section 2.3.1, is there needed to make a separate sub-subsection for this topic, if there is no distinguished counterpart 2.3.2? Could be just a paragraph rather than a sub-subsection.
	Replies	This section has been transformed into a paragraph.
f.	Comment	Words are often capitalized unnecessarily, e.g. i. Section 2.3 title: why is Gradient capitalized? ii. L128: genetic algorithms, simulated annealing, particle swarm optimization should not be capitalized iii. L152: partial differential equations
	Replies	All of them are revised accordingly.
7.	The quality of the figures should be improved significantly:	
	Comments	a. The resolution of most figures is too low for publication in a journal article. Wherever possible, I would suggest to use vector image formats or higher resolution rasterized figures. For example, Figure 4 is perfectly suitable for a vectorized format. b. Figure layout and font size should be improved for almost every figure. A non-exhaustive list of corrections to be made: i. Figure 4: The 3 x 2 layout with an empty subplot is awkwardly formatted with the bottom right empty axis. I recommend another subplot layout, or at least remove the empty axis entirely. ii. Figure 5: font size in colorbar text is too small iii. Figure 6: font size is too small overall iv. Figure 8: update the x ticks to only contain integers, it does not make sense to label half iterations. Also, make your figure self-contained. The label "Optimality" by itself does not mean anything.

		v. Figure 12: fonts way too small vi. Many figures are quite sparse in terms of information density, and hence take up a lot of space relative to the information presented. Figures could easily be combined to make the paper more compact and concise, e.g. Figure 9 and 10 could perfectly be placed side-by-side.
	Replies	All the comments~~revisions~~ mentioned has~~ve~~ been ~~made~~considered and better~~figure~~ quality figures have been used. ~~is improved.~~

minor comments		
#	Comments	Replies
1	1. Abstract, first sentence is very long, complex, and convoluted. Simplifying would benefit readability	The first sentence is split into a few sentences and readability is improved accordingly.
2	2. L184: Can the authors clarify what the reverse AD technique is?	It is reversed-mode automatic differentiation. It is clarified and a reference is added.
3	3. L252: "Figure 5 depicts the vorticity contour with the fine mesh L0, which shows uniform distribution, while the vorticity is still thick. Nevertheless, it is good enough for RANS simulation to present that the mesh in the wake zone is sufficiently fine." What is meant by 'the vorticity is still thick'? How does this justify the mesh resolution?	The mentioned statements are omitted. (We mentioned it here because in our recent research we use URANS and VLES to get a very detailed vorticity contour with refined meshes **https://doi.org/10.3390/fluids7070236**).
4	L374: "the optimality is less than 0.0002". 'optimality' is not an unambiguously accepted term. Please provide further detail on what is meant here. Same for optimality tolerance. Are these related to a gradient norm?	Optimality criteria methods are the techniques that use the optimality conditions or some heuristic rules to develop efficient iterative techniques to find the optimum solution. Sagidolla, I do not think this is what the reviewer wants to see. You may need to provide a clearer explanation, or change your way of writing for L374.
5	~~5.~~ Figure 9 seems superfluous, it shows the same exact green line as Figure 8, but with a different axis. Please merge both figures.	These two figures have been combined.
6	6. L459: What is meant by "The dihedral change might be somewhat illogical partially because of the limited computational capabilities of the HPC"	We assume that if we use more refined mesh, more FFD points on more capable HPC, we can get better results. The statement is omitted.
7	7. L491: "The aim of this study: to contribute towards …" please write in full sentences	Revised accordingly.
Technical / typographical corrections		
#	Comments	Replies
1.	1. L14: hi-fidelity -> high-fidelity	Revised accordingly.

2.	2. L28: “excellent results are achieved” -> non-descriptive and somewhat suggestive, please reformulate in a quantifiable manner much earlier multiple times in the manuscript	This sentence is removed.
3.	3. L43: “for its improving” -> for improving	Revised accordingly.
4.	4. L46: Fast (should be FAST) and Open Fast (should be OpenFAST) are essentially the same software. Also, it would make sense to add a reference per code.	Revised and references are added for each code.
5.	5. L94: abbreviation MDF is not used anywhere else in the manuscript, can be omitted. Same for SA and PSA in L129	The mentioned abbreviations are omitted accordingly.
6.	6. L115: Navier Stokes -> Navier-Stokes	Revised accordingly.
7.	7. L151 & L158: PDE is introduced twice	The latter is omitted.
8.	8. L129: GA is introduced twice	The latter is omitted.
9.	9. L151: do not capitalize partial differential equations	Revised accordingly.
10.	10. L152: “performing an accurate differentiation of the system of PDEs is quite difficult” This is a very vague statement, especially since it’s followed by a discussion of the adjoint technique which allows gradients to be computed with relative ease. Please refine this statement.	It has been refined.
11.	11. L184: AD is undefined	AD is automatic differentiation. It is defined and a reference is added now.
12.	12. L234: RANS is introduced here, but is already used	It is modified.
13.	13. L249: “The torque and Cp vs x/c for” don’t use ‘vs’, please use full sentences.	Revised accordingly.
14.	14. Use C_P instead of Cp throughout manuscript	Revision is made accordingly.
15.	15. L263: FD is not defined	It is a type of the Jacobian method, which uses a coloring-accelerated finite-difference method to compute all partial derivatives. It is defined and a reference is added.