Summary of authors' revisions based on reviewer feedback

The authors appreciate the time and effort the reviewers made to help us improve our work. This document summarizes the changes we made in response to their suggestions, organized by reviewer.

Bug Disclosure

During subsequent work, a bug was identified in the constraint function used for the optimization studies. The bug has been corrected and all affected analyses have been rerun. The core findings of the paper remain unchanged. The manuscript has been updated to reflect the corrected results, including: minor changes to the optimal design (Figure 6); updated optimization performance metrics (Table 4), noting that the updated run required more iterations but less wall-clock time due to differences in compute node performance; and an improved rate of convergence in the multi-start optimization study. Changes are confined to section 3.3.

Referee 1

As reviewer of the Manuscript wes-2026-10 entitled "**Efficient derivative computation for unsteady fatigue-constrained nonlinear aero-structural wind turbine blade optimization**", I have thoroughly reviewed the manuscript, and I would recommend addressing the below minor comment:

1. In page 4, … It uses blade element moment theory (BEMT) to predict an angle of attack and an inflow velocity.
    1. blade element momentum theory shall be used instead of blade element moment theory.

Except this minor comment rest of the manuscript is consolidated effectively.
I hope my critique helps the authors to improve their work and find useful in this review. Thank you!

Authors' response

Reviewer 1's comment is helpful and we will incorporate it and other grammar fixes. Specifically we will change the word moment to momentum on line 98.

Referee 2

The paper addresses a highly important problem in blade design by investigating how the efficiency advantages of gradient-based optimization can be preserved when fatigue constraints are explicitly included. Specifically, the work focuses on integrating fatigue damage calculations based on unsteady loads into a gradient-based optimization framework.

The work is well structured and demonstrates a high degree of reproducibility supported by the availability of the GitHub repository. In my opinion, no major revisions appear to be necessary. I only suggest that it may be useful to include references in which a multi-start approach is employed in optimization problems to demonstrate the robustness of the optimization results and also motivate the use of 50 starting designs (Section 3.3.2).

Authors' response

Reviewer 2's comment adds additional strength to the paper. We reworked the first paragraph of section 3.3.2 (lines 544-549) to accommodate new citations, some clarification, and motivation.

Referee 3

General Remarks:

This work presents a comparison study of different methods to obtain derivatives that allow efficient gradient-based optimization in a multi-disciplinary design context. This work is well presented and its findings are very relevant for the community.

The governing equations required for aeroelastic simulation of wind turbines are implemented in Julia for computational performance and the results match the state of the art code OpenFAST very well. The fresh implementation enables the use of algorithmic differentiation and enables the comparative study of FD with more efficient methods to obtain gradients.

The background, results and discussion are of high quality and logically structured. I recommend the following minor revisions to address a few small points for clarification.

Minor Comments:

Comment 1:

Line 328: The introduction of partial and material safety factors gamma_f and gamma_m could be added here.

Comment 2:

Figure 6: The authors note that the interpretation of the optimization result is not the main focus and this is understandable. However, looking at Figure 6, an additional point comes to mind: the pitch curve indicates a considerably later initiation of the blade pitch controller in the optimized solution compared to the initial one. I would presume this contributes to the gain in AEP. Does the optimized blade design allow for this change in operation? Furthermore, it is mentioned that TSR is another DV. Perhaps the rotational speed could be added in this figure (and figure 8) on a second y axis.

Comment 3:

Figure 7: Additional context might be helpful to interpret this figure. The induction factor shown for the initial NREL 5MW seems relatively low. Do both curves reflect the same inflow/operational condition? The wind speed could be added in the caption for reference and the authors could clarify whether the results reflect a steady (rigid) case or if they are the mean/instantaneous snapshot from an unsteady aeroelastic simulation at 10m/s (from the case described in section 2.3.3).

Comment 4:

Line 571: “The sparse parallelized forward mode approach proves over an order of magnitude faster than traditional finite differences while delivering superior accuracy. This approach also exhibits favorable scaling characteristics as problem size increases.”
While the discussion makes this a logical conclusion, this improvement in accuracy by the sparse method is not explicitly shown in a figure. I assume that the statement in Line 537-538: “The inherent error in finite differenced derivatives exceeds the optimizer’s default tolerances for gradient noise, causing premature termination” means that the authors attempted a direct comparison of FD with the sparse method that yielded unsatisfying results in the case of FD. If so, the authors could consider to clarify this in the conclusion.

Technical Corrections:

AD introduced three times in Lines 25, 82 and 172.
Line 121: ODE is not introduced.
Line 313: is beam element the correct term here or should this perhaps be blade section?
Line 412: “Table” is usually capitalized in WES. Also in Line 518.
Line 476: …”best scaling[blankspace].”

Authors' response

Reviewer 3's comments strengthen and add clarity to the paper. We summarize changes below we made in response:

- We changed the sentence on line 328 to introduce the partial and material safety factors.
- We added to the third paragraph of section 3.3.1 (starting line 517) to clarify how the change in pitch increases AEP and how the geometric, structural, and operational parameters are co-designed.
- We added an additional subplot of the rotational velocity to both figure 6 and figure 8 to demonstrate how the change in tip speed ratio changes the rotational velocity at different wind speeds.
- We added additional information to the caption of figure 7 to clarify the analyses and operating conditions shown in the figure.
- Starting on line 536, we amended several sentences to explicitly state that a finite difference optimization was attempted. Additionally, we changed the later half of the second paragraph of the conclusion (starting around line 571) to clarify how the derivative calculation approach improved derivative accuracy.
- We removed the introduction of the abbreviation of AD from lines 82 and 172.
- We converted the abbreviation of ODE into the words ordinary differential equation on line 121.
- We changed "blade element" to "beam element" in line 313.
- We capitalized the word "Table" on lines 364, 412, 511, and 518 as they reference a specific table.
- We removed an errant space before the period on line 476.

Other changes

Author affiliations: Adding country to author affiliations

Line 42: Changed citation to a different work that carries the same idea of sparsity in gradient computation optimization because the work did not clear review before final submission.