Review of: Integrated Wind Farm Layout Optimization Accounting for Wake-Induced Blade Fatigue and Wake-Steering Effects on LCOE

Summary

The article presents an approach for wind farm layout optimization that seeks to balance the competing objectives of minimizing blade-root fatigue and maximizing power production. To this end, the authors develop a reduced-order model for predicting blade fatigue and combine it with a Gaussian wake model. Four optimization studies are subsequently conducted: AEP maximization, LCOE minimization for a fixed lifetime, lifetime-aware LCOE minimization, and lifetime-aware LCOE minimization with wake steering.

The primary novelty of the work appears to be the development of the blade-fatigue model, which is subsequently incorporated into the optimization framework. However, the validation of this model against OpenFAST simulations raises a significant concern. The proposed model consistently underpredicts the total fatigue loads. While the authors motivate the use of the model primarily on the basis of its low computational cost, computational efficiency alone does not sufficiently justify its use within an optimization framework when the model exhibits a systematic bias relative to the higher-fidelity reference.

This issue is particularly important because the fatigue model directly influences the optimization objective and, consequently, the layouts identified as optimal. If the model systematically underestimates fatigue, the optimization procedure may favor layouts that appear advantageous according to the reduced-order model but do not provide the same benefits when evaluated using a higher-fidelity model. Therefore, the validity of the conclusions drawn from the optimization studies is difficult to establish based on the presented results.

Furthermore, the manuscript does not appear to close the fidelity loop by evaluating the identified optimal layouts using a higher-fidelity simulation framework, such as FAST.Farm. Such an analysis would be important for determining whether the trends and optimal solutions obtained using the reduced-order models remain valid when evaluated with a more representative aerodynamic and structural model. In particular, it would allow the authors to quantify the extent to which the systematic fatigue underprediction affects the resulting layouts and economic conclusions.

Overall, although the proposed optimization framework is potentially useful and the computational efficiency of the fatigue model is of practical interest, the current validation does not provide sufficient confidence in the model's predictive capability for the intended optimization studies. Since the fatigue model constitutes a central component of the proposed methodology and directly affects the optimization results, the deficiencies identified in its validation undermine the reliability of the subsequent conclusions. I therefore recommend **major revisions** and several of the studies being redone completely. The remaining comments should be considered as suggestions that may help the authors address these issues and strengthen the revised analysis and manuscript.

Major Comments

Comment 1

Issue: The motivation for developing a new fatigue model is not sufficiently clear. Several existing studies have constructed surrogate models based on aeroelastic simulations, which could potentially provide a similar reduction in computational cost while retaining a closer connection to the underlying high-fidelity simulations. If computational cost is the primary motivation for developing the proposed model, the authors should explain why an aeroelastic-simulation-based surrogate model is not considered a suitable alternative. In particular, a surrogate model could be constructed over the coarse grid of wind speeds and directions considered in this study.

Comment 2

Issue: The discretization used for wind speed and wind direction appears to be too coarse. Given that the proposed models are intended to significantly reduce computational cost, a finer discretization of the wind speed and wind direction bins should be feasible and would likely provide a more accurate representation of the operating conditions. The authors should provide justification for the selected discretization and investigate the sensitivity of the results to a finer discretization.

Comment 3

Issue: Only three random seeds are used to validate the proposed model against OpenFAST. The authors should justify this choice, particularly given that six seeds are commonly used in wind turbine aeroelastic simulations to obtain more robust estimates of fatigue-related quantities. Additional seeds should be considered to determine whether the observed model discrepancy is consistent across different realizations of the turbulent wind field.

Comment 4

Issue: The manuscript considers several single-objective optimization studies. A multi-objective optimization formulation considering LCOE and lifetime, for example, could provide a more comprehensive assessment of the trade-off between economic performance and structural fatigue. Such an analysis could potentially provide additional insight into the Pareto-optimal trade-offs between these competing objectives and would represent a stronger contribution to the state of the art than the current set of single-objective studies.

Comment 5

Issue: The optimal layouts identified using the proposed reduced-order models should be evaluated using a higher-fidelity simulation tool such as FAST.Farm. This validation is particularly important given the systematic underprediction of fatigue observed during the OpenFAST validation. Evaluating the final layouts using FAST.Farm would allow the authors to determine whether the trends and improvements predicted by the optimization framework persist when the layouts are evaluated using a higher-fidelity model.