Response to the reviewers

Dear Reviewer:

We would like to express our sincere gratitude to reviewer for the valuable comments, and the time devoted to review our work. The reviewer gives an accurate summary of our work and brings forward constructive questions. All of the comments are very helpful in improving the quality of our manuscript. We have studied comments carefully and responded to them which are described in detail below.

Scientific comments:

Comment No.1: The authors mention they use “site-specific” wind parameters, but the wind speed is obtained from the turbine specification, and air density and turbulence intensity are from the literature. In this case, the statistical characteristics of the selected probability distribution fortunately match the measurement. But what if you choose another site? Why not to use the measured statistics directly, e.g. sampling from probabilities in discrete intervals, instead of fitting to a distribution and resampling?

Response 1: Thank you for your comment. The proposed method in this paper is applicable to specific turbine models, relying on the wind turbine models used during the generation of the load database. Consequently, the range and values of wind speed must be determined based on the turbine's parameters, specifically from its cut-in wind speed to cut-out wind speed. Furthermore, the ranges for wind parameters such as air density, wind shear, and turbulence intensity are derived from statistical analysis of 541 measured datasets. To maximize coverage with limited samples, the wind parameter distributions were fitted, followed by Monte Carlo (M-C) resampling to densify samples around frequently occurring values, thereby efficiently utilizing high-fidelity load simulation resources. For load assessment at a specific site, the turbine model to be employed is known, thus determining the meta-model trained from the corresponding load database. Given that the value ranges of wind parameters in the database span from P1 to P99, and the constructed meta-model exhibits certain generalization capabilities, it theoretically enables rapid evaluation of DLC 1.1 for any specific site.

- **Comment No.2:** Figure 5b is not explained. "P-value" is defined neither in the text nor the caption. Does it represent the polulation parameter? Why increasing the block size gives larger P-values if population parameter=0 for independence?

Response 2: Thank you for your comment. We will add necessary textual descriptions to all figures in the manuscript.

The p-value in Figure 5(b) is defined in the context of independence testing as the probability of observing the data (or more extreme outcomes) under the assumption that the null hypothesis (i.e., mutual independence) holds true. In essence, the p-value assesses the plausibility of the null hypothesis. For the DcorrX independence test employed in this paper, a smaller p-value provides stronger evidence of an association between the variables, whereas a larger p-value supports the notion of independence.

In load time series, a larger block size corresponds to greater temporal separation between peak loads, resulting in weaker correlations and stronger evidence of peak load independence. Accordingly, in the DcorrX independence test, a p-value approaching 1 indicates greater support for independence.

- **Comment No.3:** While the Weibull distribution emerges as the most common optimal fit (52%), the fact that Normal (34%) and Gumbel (14%) distributions perform better for a substantial proportion of wind speeds suggests that a wind-speed-dependent or mixed fitting approach could improve accuracy. Including a sensitivity study of distribution choice on extrapolated loads would be helpful.

Response 3: Thank you for your comment. As the reviewer pointed out, a single fitting distribution indeed cannot accommodate all wind speeds. This issue has been mentioned in the discussion section of Chapter 6.1 in this paper, as illustrated in Figure 15. We have now begun to explore methods such as adaptive selection of optimal distributions and Gaussian mixture models. Although these approaches have shown improvements in fitting local load distributions, the construction of subsequent meta-models with variable network structures remains a challenging problem that we are still tackling.

- **Comment No.4:** Please clarify how the hyperparameter importance is obtained.

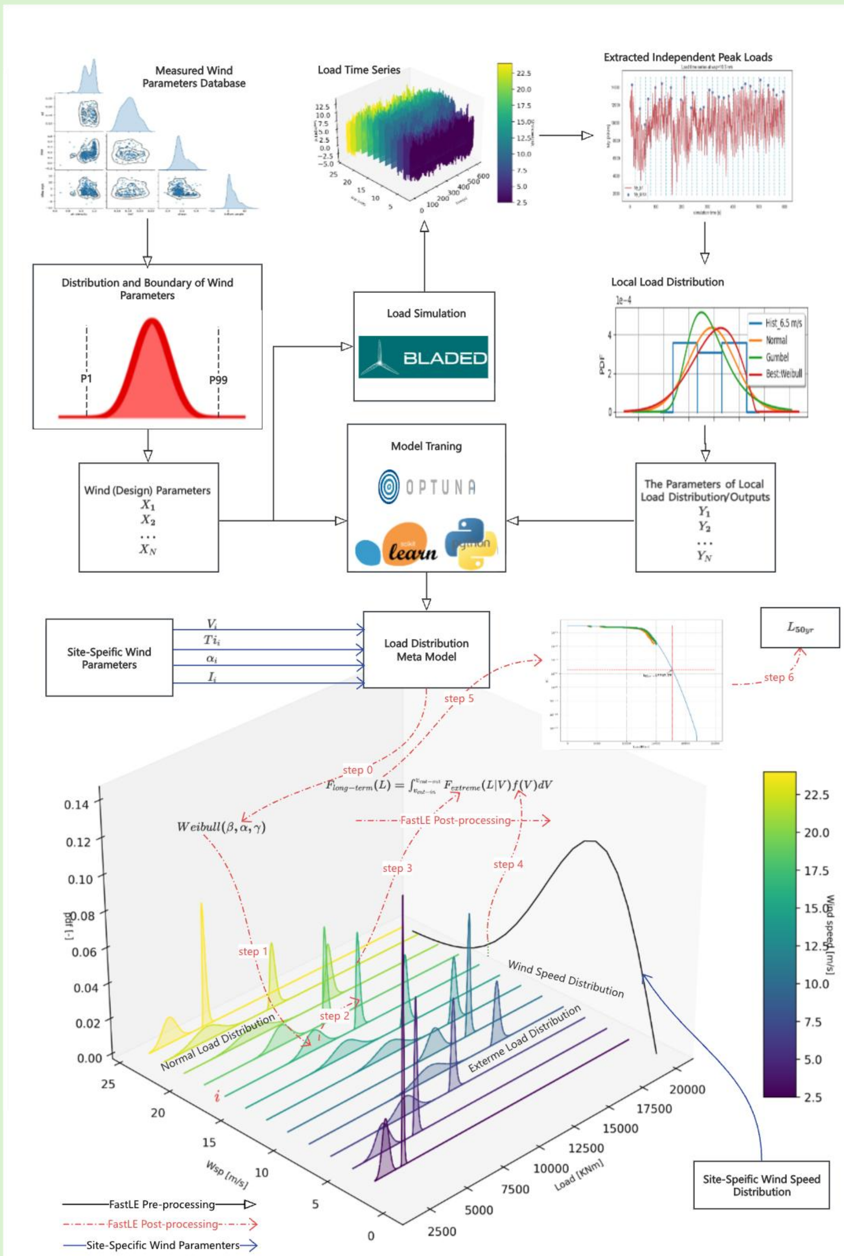
Response 4: Thank you for your comment. For the analysis of hyperparameter importance, this paper employs the PED-ANOVA method, as detailed in the literature: https://arxiv.org/abs/2304.10255. This is implemented using the Python class optuna.importance.PedAnovaImportanceEvaluator(), with further details available at: https://optuna.readthedocs.io/en/latest/_modules/optuna/importance/_ped_anova/evaluator.html#PedAnovaImportanceEvaluator.

- **Comment No.5:** Did you consider normalization of MLP input and output parameters? Due to the difference in the order of magnitude between the two outputs, the MLP possibly gives more importance to the paras_1(scale) over paras_0 (shape).

Response 5: Thank you for your comment. In this paper, both inputs and outputs have been normalized using the method: $z = (x-\mu)/\sigma$, where μ is the mean of the training samples, and σ is the standard deviation of the training samples. This is implemented via sklearn.preprocessing.StandardScaler(), as detailed at: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html.

- **Comment No.6:** A figure of the proposed framework (similar to Figure 4) would be helpful to understand the added contribution of this paper compared to the IEC-proposed method.

Response 6: Thank you for your positive feedback on the figures. The flowchart of the FastLE method described in this paper is shown below, and it will be presented in the manuscript subsequently.



- **Comment No.7:** Page 14, Line 244, the error is in percentage or true value? Formulate what it meant by “error”?

Response 7: Thank you for your comment. In this paper, the error is defined as error=(predicted value−actual value)/actual value, which will be added to the manuscript subsequently.

- **Comment No.8:** Page 18, Line 276, the time required to generate the training data for FastLE should be taken into account.

Response 8: Thank you for your comment. This time required to generate the training data for FastLE will be included in the relevant section of the paper.

Technical comments:

- **Comment No.9:** Reference needed for “It is widely recognized that lower wind speeds contribute minimally to the tails of long-term load distributions.”

Response 9: Thank you for your comment. We will add the following references to the paper.

[1]Fogle, J., Agarwal, P., Manuel, L. (2008). Towards an improved understanding of statistical extrapolation for wind turbine extreme loads. Wind Energy, 11(6), 613-635. https://doi.org/10.1002/we.303

- **Comment No.10:** Add the references “To effectively speed up the load extrapolation, this study references certain literature to introduce wind parameters into the Meta model for load components.”

Response 10: Thank you for your comment. We will add the following references to the paper.

[1] Dimitrov, N., Kelly, M. C., Vignaroli, A., Berg, J. (2018). From wind to loads: wind turbine site-specific load estimation with surrogate models trained on high-fidelity load

databases. Wind Energy, 21(12), 1384-1402. https://doi.org/10.1002/we.2257

[2] Graf, P. A., Stewart, G., Lackner, M., Dykes, K., Veers, P. (2016). High-throughput computation and the applicability of Monte Carlo integration in fatigue load estimation of floating offshore wind turbines. Wind Energy, 19(5), 921-946. https://doi.org/10.1002/we.1870

- **Comment No.11:** Some abbreviations are used without defining.

Response 11: Thank you for your comment. We have checked the abbreviations in the manuscript and added full names for undefined abbreviations.

- **Comment No.12:** The manuscript still needs to be carefully proofread.

Response 12: Thank you for your comment. We have reorganized the manuscript and made some minor revisions.

- **Comment No.13:** Figures could be made more self-contained by including parameter definitions and clearer legends.

Response 13: Thank you for your comment. We will add necessary textual descriptions to all figures in the manuscript.

Once again, thank you very much for the constructive comments and suggestions which would help us in depth to improve the quality of the manuscript. We will try our best to improve the manuscript. Please feel free to contacts with any questions.

Kind regards,

Pengfei Zhang