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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "The Power Curve Working Group's Assessment of Wind Turbine Power Performance Prediction Methods" *by* Joseph C. Y. Lee et al.

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We thank you for your support of this study and your recognition to the importance of this work. We also appreciate your past involvement with the Power Curve Working Group. Please see our response to your comments below.

1. The reviewer commented the use of NME in the manuscript. We understand that NME averages out positive and negative errors. The reviewer made a valid point that using NME does not reflect the error of power production from each 10-minute period. Meanwhile, the focus of this study is to evaluate the correction capabilities on the overall bias of each trial method over long periods, hence we choose to use NME instead

of NMAE. We want to investigate whether a correction method generally overpredicts or underpredicts production in different meteorological conditions, and NME is valid for such purpose. Moreover, because the metadata and the data sample size vary in the collected submissions, we primarily discuss the average bias in this study, as a foundation for future analyses.

NMAE is useful to evaluate the prediction error in specific, short-term events, while the metric does not provide information on the direction of bias. In this study, our focus is on average bias rather than the cumulative error of a correction method. In fact, the statistical results from NMAE are analogous to those of NME, please see the Fig. 1 below. As the reviewer suggested, we will assess NMAEs in future study, when we have large sample size and higher quality data.

We want to clarify we cited Clifton et al. (2016) for the P50 definition, rather than "average bias having a direct impact on P50", which is not in the reference. We are also changing the P50 definition to median AEP, thank you for pointing it out. You can find the changes we made to the manuscript below, from lines 212 to 226.

"A positive NME means the correction method overpredicts power production in over half of the data samples. Generally, NME represents the average bias on power production of the correction method. Such bias on power-curve modeling affects the long term P50, which is the median expected AEP over many years of production and is used to inform investment decisions. Meanwhile, NMAE denotes the average cumulative error of every 10-minute sample in a data bin, which is applicable for short-term power-production forecasting and time series analysis, making NMAE a stricter metric than NME. In NME, however, the positive and negative 10-minute errors cancel each other. Overall, the statistical results of NME (Sect. 4) are analogous to those of NMAE (not shown). For our purposes, we are interested in analyzing the long-term power prediction bias, and hence, we only discuss the NME for the rest of this manuscript; NMAE is introduced here because the metric is also generated by the PCWG analysis tool (Sect. 3.2). "

2. The reviewer mentioned the downside of increasing the dimensions of PDM, thank you for pointing it out. We added a paragraph in the manuscript, from lines 664 to 667:

"Note that increasing the number of data bins by switching from a 2DPDM to a 3DPDM spreads the data samples thinner, and smaller sample sizes in each bin could weaken the overall statistical confidence of the correction method (Lee et al., 2015). Therefore, methods such as the regression tree ensemble (Clifton et al., 2013) provide solutions for such dimension expansion problem. "

3. The Power Curve Working Group has been working on the Share-3 exercise, as presented in this manuscript, since mid-2017. Gathering support from a large industry group took an enormous amount of time and effort from the organizers and the participants, hence we gradually added trial correction methods over the previous data share initiatives (Table 1). In fact, a machine learning subgroup within the Power Curve Working Group has been dedicated to exploring data science applications for future sharing exercises.

This manuscript is about applying data science and statistics to improve the current practice of power curve modeling. The sharing exercises of the Power Curve Working Group do not require the sharing of raw data because of data privacy concerns (Sect. 3.2), so the release of training data sets proposed by the reviewer could be difficult to implement. In the last paragraph of the Conclusions, we advocate for data sharing. When most of the members of the Power Curve Working Group agree to publicly disseminate their own data sets, we will consider using the data science approach suggested by the reviewer.

4. Turbine manufacturers provide turbine power curves based on a controlled environment, while some manufacturers provide additional power generation information based on the real-world, complex meteorological conditions. The IEC 61400-12 standard highlights the procedures on deriving empirical power curves, also known as site-specific power curves, through power performance tests on the field with real-world in-

flow conditions. Because discrepancies sometimes exist between the reference power curves (often provided by the turbine manufacturers) and those seen in testing, the Power Curve Working Group aims to explore the underlying sources of errors. The analogy the reviewer provided differs from the typical usage of the IEC 61400-12 standard in the industry.

References

Clifton, A., Kilcher, L., Lundquist, J. K. and Fleming, P.: Using machine learning to predict wind turbine power output, Environ. Res. Lett., 8(2), 024009, doi:10.1088/1748-9326/8/2/024009, 2013. Lee, G., Ding, Y., Xie, L. and Genton, M. G.: A kernel plus method for quantifying wind turbine performance upgrades, Wind Energy, 18(7), 1207–1219, doi:10.1002/we.1755, 2015.

Please also note the supplement to this comment:
https://www.wind-energ-sci-discuss.net/wes-2019-69/wes-2019-69-AC1-supplement.pdf

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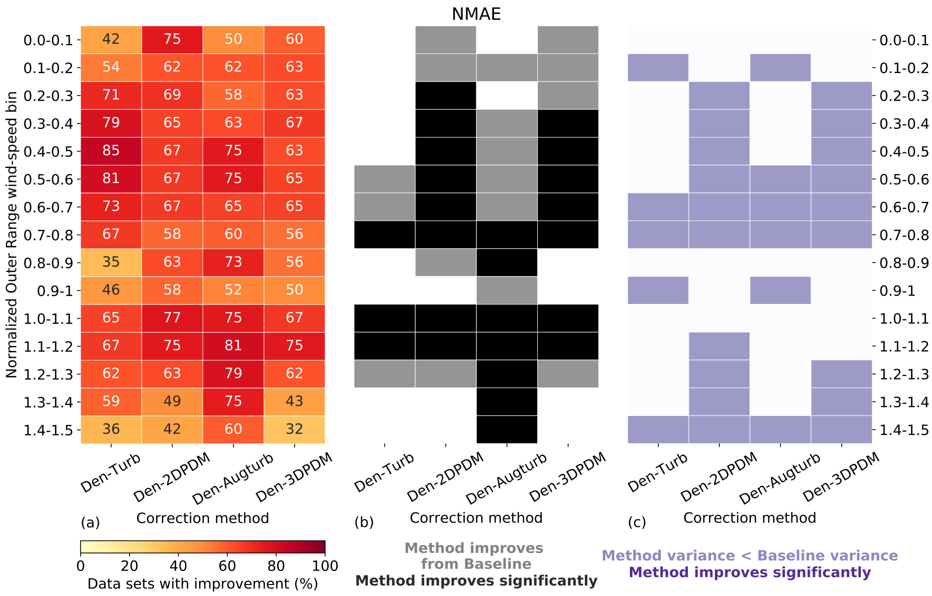

Fig. 1. As in Fig. 11 in the manuscript, but using NMAE. The features generally match those in Fig. 11.