

## ***Interactive comment on “Proposal for Generic Characterization of Electrical Test Benches for AC- and HVDC-Connected Wind Power Plants” by Behnam Nouri et al.***

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Comments reply by authors: We are delighted to receive your precious comments and elaborate on our paper by considering them. We are thankful for your precise considerations and time regarding our paper. The following revision has been prepared according to the comments:

1. Referee’s comment: “Add a little bit more explanation on “Why” you mean the proposed new tests are necessary from the system perspective - system impact. (Black start, Grid forming, etc.)” Authors revision: As it was mentioned before, this comment is close to the first comment of Prof. Ola Carlson. The reason for the new tests from the

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system perspective would be new features and new challenges regarding renewable energy dominated power grids. The renewables should be developed robust and reliable to achieve a 100% green power system. New features of wind turbines are meant to facilitate these goals. Accordingly, a paragraph in the Introduction and a paragraph in the Conclusion are revised as follows: - The paragraph revised in the Introduction: “Primarily, power quality and transient performance during faults have been essential aspects, which needed to be tested and verified. However, by increasing trends towards 100% VRG-based grids, the VRGs are required to be developed and featured by advanced capabilities to ensure the robustness and reliability of such grids. In this way, the state-of-the-art wind turbines (WTs) are under development to be upgraded to more advanced features such as grid-forming, black start, and frequency support capabilities. These new features would necessitate test and assessment standards in the near future (Langstadtler et al.45 (2015); Asmine et al. (2017) and Gevorgian et al. (2016)). Besides, by increasing wind power installations, the requirements and appropriate test methods are required to study increasing challenges such as harmonic interactions and control performance of WPPs in connection to different types of AC and HVDC transmission systems according to (Hertem et al., 2016), (Zeni et al., 2016) and (Buchhagen et al., 2015). Thus, it is essential to adapt or define new regulations, standards, and compliance test methods to analyse the developments and issues regarding wind energy.”

- The paragraph added to the Conclusion: “Primarily, the focus of IEC standard tests had been on the compliance test of WT capabilities. Nowadays, the new features of modern WTs, such as Grid-forming, system restoration, black start, harmonic rejection, and frequency support capabilities, have been introduced by manufacturers to support renewable energy dominated power grids. These new features necessitate new or reformed test standards in the near future.”

2. Referee’s comment: “It would be nice to elaborate a little bit more on the transferability and assessment procedures from the proposed test bench results to Wind power

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plant operation, e.g. by validation of simulation models. (As the title suggest to validate the characteristics of Wind power plants), as well as the limits for the test bench tests – can anything be validated on the converter based test bench.” Authors response: This is a very good idea to mention to the transferability and model validation applications as well as the limits of converter based test benches. Therefore, maybe it would be useful to mention that the validation of simulation models can be performed for WT models as well as WPP aggregated models. The revision will be done on the final version after the discussions.

3. Referee’s comment: “It would be beneficial for the reader and understanding of the article if you could distinguish between tests, which are necessary for the design of the Wind turbine and components (Design validation) as well as tests necessary for the grid connection and interaction with the grid. E.g. will the test of harmonic background (chapter 4.1.4) / harmonic injection be relevant to validate the design of the components (design validation), as well as potential tests for new features / harmonic filtering and last but not least harmonic stability analysis. You should consider maybe to separate the tests into – design validation of the wind turbines and components, and test necessary for the grid operation under various grid conditions.” Authors response: According to this comment, we restructured the test proposals into two divisions: First, WT capability tests which include the available and futuristic capabilities that are developed for WT. Second group, grid interaction tests which include electrical characteristics of the grid that have influences on WT operation. The grid interaction tests would be performed by PHIL interface. The attached figure 1 illustrates the new structure:

Also, this comment raises an interesting discussion that what is the most purpose of the test standards? According to the IEC 61400-21-1 and 21-4 standards. The grid connection compliance is the main scope of these standards, which the main concern of TSOs and WPP developers. However, some of the tests would be applicable for design validation as well, which concerns WT and component manufacturers. There-

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fore, we would suggest mentioning that some of the tests such as harmonic injection, grid protection, control performance, and transient performance can be used for design validation of WT, components and control systems.

4. Referee’s comment: “Some more specific comments: Chapter 5.1.5 better use the wording: “Grid Protection test” not disconnection test. Figure 3. – Use bigger symbols for the Drive motor / generator Figure 2 - Add description of the filter.” Authors response: Done

Finally, we would like to appreciate your precious and helpful comments on the paper. We are sure that considering these comments would add value to the paper and make it more useful.

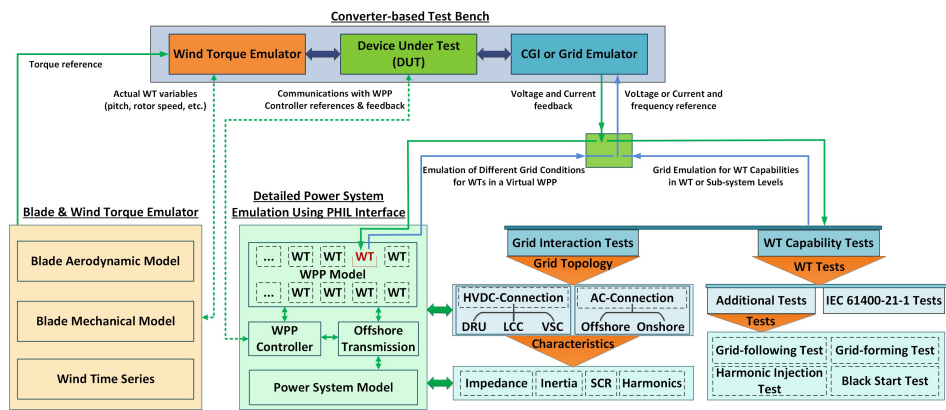
Please also note the supplement to this comment:

<https://www.wind-energ-sci-discuss.net/wes-2019-90/wes-2019-90-AC2-supplement.pdf>

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**Fig. 1.** Revised test proposal structure