Power Curve Working Group Meeting Minutes

Impact of Outer Range Conditions on Wind Turbine Power Performance

13th Meeting Minutes, Tuesday 15th September 2015, New Orleans, United States

Attending: Gil Lizcano (Vortex), Halberg, Errol (0), Thomas F. Fric (GE), Taurin Spalding (Natural Power), Cory Sieg (EDF), Jonathan Kossuth (Northern Power), Teasha Feldman-Fitzthum (Cadinal Wind), Peter Stuart (RES), Ken Jaffe (Nordex), Steven Clark (Renewable NRG Systems), Jason Michael Fields (NREL), Justin Wolfe (EON), Carl Ostridge (DNV GL), Vineet Parkhe (DNV GL), Dan Bernadett (AWS True Power), Evan Osler (Renewable NRG Systems), Julie Baudry (Mainstream), Paula Major (Mainstream), Brian Healer (RES), Taylor Geer (DNV GL), Sonia Wharton (Lawrence Livermore National Laboratory), Patrick Moriarty (NREL), Andrew Clifton (NREL), Scott Eichelberger (Vaisala), Ioannis Antoniou (Siemens), Erik Hale (EDF).

Objectives:

- Gather US PCWG member feedback on the structure of PCWG-Share-01
- Increase familiarity with the process of setting up datasets in the PCWG Analysis Tool
- Discuss power curve information harmonisation document

Presentations

- 01 - Summary of Recent PCWG Activities, New Orleans, Peter Stuart (RES)
- 02 - PCWG Analysis Tool, Peter Stuart (RES)
- 03a - Candidate PCWG-Share-02 Method - 3D Power Deviation Matrix, Alex Head (Prevailing)
- 03b - Candidate PCWG-Share-02 Method - Production by Height, Dan Bernadette (AWST)
- 03c - Candidate PCWG-Share-02 Method - Machine Learning, Andy Clifton (NREL)
- 04 - Using turbine specific information to determine power performance a practical example, Taylor Geer (DNV GL)
- 05 - The Potential to Use Mesoscale Models to Predict the Turbine Specific Frequency of Outer Range Conditions, Gil Lizcano (Vortex)
- 06 - A New Theoretical Basis for Describing Low Turbulence Wind Turbine Performance, Peter Stuart (RES)

Discussions

Intelligence Sharing Initiative Discussion (PCWG-Share-01)

One developer asked about the level of support for PCWG-Share-01 amongst manufacturers and commented that his organisation's legal department had expressed reservations about how the initiative is perceived by manufacturers. The group chair responded that in general the manufacturers had been very supportive and several manufacturers had indicated their own intentions to submit results. The group chair asked if some form of statement of support from the manufacturers would help the process of gaining acceptance for participation and the developer responded that such a statement of support would be of benefit. Two other developers commented that he did not perceive any issue with manufacturer concerns over the initiative, especially given that the initiative had been designed in such a way that the sales power curve is not used and only highly anonymised performance metrics will be shared with the data aggregator.

One working group member expressed confusion about the meaning of the flow chart in the PCWG-Share-01 document due to their perception that participants needed to publically share their data. The chair clarified that PCWG-Share-01 does not require participants to share their data and the flow chart in the definition document expresses how participants only need to share highly anonymised performance metrics of the methodologies being tested. The group chair added that this distinction had given rise to the terminology 'intelligence sharing' as opposed to 'data sharing'. The group chair further added that there was an entirely separate effort related to publically sharing datasets via the PCWG website and that three datasets are currently downloadable (but for the avoidance of doubt this is entirely separate to PCWG-Share-01).

One manufacturer asked about the potential for bias to be introduced in PCWG-Share-01 if participants only make submissions based on datasets which exhibit unusually poor performance. The chair clarified that the intention was for participants to collectively submit results based upon a representative spread of 'good' and 'bad' and that the 'cherry picking' of unrepresentative datasets was not desirable. Furthermore the group agreed that data should not be adjusted or filtered (other than the filters specified in the definition document) prior to submission as this would defeat the purpose of the exercise

One developer expressed their support for the initiative and committed to submitting results derived from 40 datasets. The same developer expressed that the limiting factor was simply the bandwidth required to prepare and analyse the data, but that nonetheless they were committed to participation. The chair commented that there was the potential to link up developers with 'data but no time to analyse it' and consultants 'with time to analyse, but no data' and added that several PCWG members had already linked up in this way and were progressing well.

One developer expressed concerns about the implications of PCWG-Share-01, for example the potential for future machines to emerge for which the conclusions on PCWG-Share-01 are invalid. The chair responded that this could be addressed in the write-up of PCWG-Share-01 which could include appropriate caveats about the range of turbines for which the conclusions are valid.

One consultant asked if the sole purpose of the initiative was to examine the change in performance from the Inner Range to the Outer Range. The chair confirmed that was the case and added that the absolute performance level within the Inner Range was a separate question beyond the scope of PCWG-Share-01.

The chair drew the group's attention to the hypothesis matrix which is contained in the PCWG-Share-01 definition document. The chair stated that the hypothesis matrix was an 'educated guess' partially based on real data which was introduced so that the power deviation matrix method could be examined by PCWG-Share-01 without participants having to share their own power deviation matrices (which were viewed as too sensitive). The group chair added that the limitations of the hypothesis matrix should be clearly explained within the dissemination task e.g. if a matrix based off a substantial amount of machine specific data was available it could be used in favour of the PCWG hypothesis matrix. One member commented on the fact the 'x-axis' of the matrix in the PCWG-Share-01 definition document was not normalised and suggested that it should be. The group chair responded that this comment had been received from other members and the matrix would be updated so that it was normalised. The group agreed that the normalisation should be performed on

the basis of the ‘zero turbulence rated wind speed’ as defined in the turbine correction in the draft IEC 61400-12-1 standard.

The group discussed the list of meta-data fields (which will be included with submissions) as defined in the PCWG-Share-01 definition document. The group noted that the existing document includes the year of the power performance test which measured the data used to generate a set of results. The group briefly discussed the pros and cons of including the year of first operation of the turbine model type (as opposed to actual turbine installation) in order to establish the vintage of the technology associated with a given set of results. A manufacturer commented that turbine models normally undergo several revisions and that it would be difficult to pin down such a date. After some discussion the group agreed that it was not practical to include such a date within the list of meta-data fields. Another manufacturer stated that sometimes power performance test do not happen at the start of operation and that it would be good to include the commercial operation year. The group agreed that the year of first commercial operation was a useful and pragmatic additional to the list of meta-data fields.

One working group member asked if only wake-free data was being used in PCWG-Share-01. The chair confirmed that this was the case and that the definition document stated that the IEC 61400-12-1 direction filtering criteria should be applied to remove wakes.

The group discussed the treatment of air density within PCWG-Share-01. The group chair stated that the intention was that the IEC 61400-12-1 density correction would be applied within PCWG-Share-01, but that the accuracy of this correction would not be examined by PCWG-Share-01. One consultant asked if the density correction was calculated by the PCWG Analysis Tool to which the chair responded that it was. The group agreed that the accuracy of the IEC 61400-12-1 density correction should be examined within a later intelligence sharing initiative e.g. PCWG-Share-02. Furthermore the group agreed that elevation should be included in the list of meta-data fields submitted in PCWG-Share-01.

The group discussed the use of the word ‘optional’ in the list of meta-fields. It was agreed that ‘optional’ should be amended to ‘if available’ to encourage participants to submit this information. The data aggregator made a comment that if necessary the definition of which fields are optional (and which are required) could be revisited after the initial aggregation of data. One member suggested that the field ‘IEC Compliant’ should be made required. The group agreed and acknowledged that the definition document still allowed for a response of ‘unknown’.

One member suggested that the anemometer manufacturer should be included in the list of meta-data fields. After some discussion the group concluded that this would not be consistent with the fact that the turbine manufacturer is not included and agreed not to include anemometer manufacturer in the list of meta-data fields.

One member asked if the PCWG-Share-01 definition document permitted the submission of results based on remote sensing data alone. The group chair confirmed that the definition documented document did permit remote sensing only submissions.

One manufacturer asked how the different options of the Inner Range definition (A, B and C) had been chosen. The group chair responded that they were ‘best guess’ definitions chosen so that at

least one of the Inner Range options would place sufficient data in the Inner Range in order to define an Inner Range power curve. The group chair added that these definitions may need to be tweaked following initial participant feedback. The same manufacturer suggested that the group consider a wind speed dependent formulation of the inner range to allow for a sufficient data population to exist at lower wind speeds. The group agreed that a wind speed dependent definition of the Inner Range should be considered for the purposes of PCWG-Share-01.

One working group member asked if the control mechanism (pitch, stall etc.) was included in the list of meta-data fields and the group chair confirmed that it was.

One working group member suggested that it would be good if there was some geographic diversity to the results submitted to PCWG-Share-01 e.g. submissions from the Tropics or a monsoon environment.

PCWG Analysis Tool Demonstration

The latest version (0.5.7) of the PCWG Analysis Tool was demonstrated to the group. The availability of a screencast demonstration on the PCWG Website was highlighted (www.pcwg,org > Analysis Tool > Screen Cast Demo).

An academic PCWG member enquired about whether or not it was possible to enter a direction filter in the tool. The group chair confirmed that it was, but added that the GUI currently only allowed filtering 'above' and 'below' a given directional value and that it would be easier (and more comprehensive) to allow filtering across a given directional range.

One member queried the choice of a simple 2 degrees Celsius filter for removing icing and indicated that such a filter could remove some data of interest. The chair said that this question had been discussed in some detail at the June 2015 meeting and that at that meeting it was decided that a simple temperature filter was pragmatic. The chair added that simple temperature based filtering was common in power performance analysis and that any alternative would be a large step change in complexity.

One working group member suggested that the standard filters applied (such as the temperature filter and any directional filters) should be listed in the anonymised export report. The good agreed that this should be the implemented.

The group discussed the merits of including a normalised power vs wind speed scatter plot to allow the data aggregator to perform a quality check. The group agreed that this should be implemented.

One working group member suggested that it should be possible to add comments to the dataset and analysis objects in the PCWG Analysis. The same member added that these comments should be included in the anonymised report and would allow for participants to communicate any miscellaneous information to the data aggregator. The group agreed that this should be implemented.

One academic working group member asked if the group had any success criteria for the data sharing initiative. The group chair responded that there were currently no objective criteria which would define if the intelligence sharing initiative is a success or not. One consultant commented that

a reasonable approach would be to attempt to reduce the uncertainty associated with modelling Outer-Range conditions to half of what it is now. The good chair added that PCWG-Share-01 should establish some good baseline data which can be used as the basis for evaluating the success of future rounds of the intelligence sharing initiative.

Discussion on Harmonisation of Stakeholder Communication

The group discussed the DRAFT PCWG document 'Guidelines for Preparation of a Turbine Performance Information Pack'. The group chair began by stating that because this document was DRAFT it was only available via DropBox and not available via the PCWG website. The group chair briefly explained that the document was intended to simplifying transactions by setting a clear expectation of the ideal set of information that would be placed in a transaction data room. The chair added the guidelines should reduce the time spent seeking clarifications and express a clear 'starting point' for the application of corrections for Outer-Range conditions.

One consultant, picking up on the earlier discussion, suggested that the document contain an example whereby the Inner Range Formulation was wind speed dependent. One academic member of PCWG suggested that the document should contain a definition of terms.

One working group member suggested that the document should contain an example of a warranty which is dependent upon the power curve measurement uncertainty.

One member suggested that the guidelines document should stress that the context of a document adhering to the guidelines is site and client specific e.g. by including a fictitious site and client name in the example. The group chair also suggested that the guidelines should stress that the intended context of a document adhering to the guidelines is a controlled/confidential commercial situation.

One manufacturer expressed reservations over the inclusion of the 'control curves' (Power vs RPM and Power vs Pitch) in the example 'additional information' section presented in the guidelines. The group chair clarified that such information was not intended as being useful for resource assessment purposes, but rather as being helpful in the operational context when monitoring if turbines are behaving as expected. An additional manufacturer expressed their reservations about the inclusion of this example and added that it felt out of place in a resource assessment document. The group agreed with the principle that the document should contain all necessary information to perform an accurate resource assessment and should help avoid stakeholders having to make assumptions in the absence of important information. Furthermore the group agreed that the other tables (e.g. thrust curve) in the example 'Additional Information' section were consistent with this principle and should be included. The group agreed that the current example 'control curves' should be removed from the 'Additional Information' section and a new section added called 'Operational Information' which should include a less commercially sensitive example. The group discussed the inclusion of the noise reduced modes and agreed that the example should have a structure whereby the majority of the information in Sections 2-2 is repeated for each noise reduced mode. The group agreed that the turbine performance information linked to the noise reduced modes is inherently tied to the associated sound power levels and octave band spectra (and their respective warranties) and that this information should be included in the document. Finally the group agreed that low/high

temperature criteria associated with turbine shutdowns and de-rating should also be included in the document.

The group discussed whether the DRAFT guidelines implied the creation of a new document or applied to an existing document e.g. turbine supply agreement (TSA). Several working group members expressed a desire to avoid creating 'more work' and a document which would be 'redundant to the TSA'. One working group member said in their view the document represented guidelines for preparing the turbine performance information in the TSA. The group chair said that this fitted with the principle of the guidelines serving as a 'check list' for other documents as opposed to enforcing a strict template format. The group supported the concept of the guidelines serving as a checklist.

One working group member suggested that it may still be worth defining a template format (in addition to the checklist function) as this would make it much easier to compare information received from multiple suppliers.

One member of the IEC 61400-15 standard committee stated that after the DRAFT PCWG guidelines are finalised they can serve as input for the definition of the IEC 61400-15 standard.

Meeting Wrap Up & 2016 Roadmap Discussion

The group briefly discussed the possibility of extending the PCWG's activities into 2016. The chair asked the group what subjects they could explore in 2016. One working group member said that he believed the group could address the issue of Inner-Range performance, adding that in their view it was a larger problem than Outer-Range performance. One consultant added that in their view the group should continue into 2016 and that the second intelligence sharing initiative (PCWG-Share-02) is one activity they could focus on. One working group member suggested that the group could study turbine performance under waked conditions which has so far been out of scope of the working group. Another consultant commented that the group should work to understand the underlying physics better in order to enable the industry to develop better turbines and wind farms. One academic member of the working group commented that in his view much of the value of the PCWG has been due to its focus on a single issue and suggested that it should not try and do everything.

The group chair committed to circulating a survey to evaluate members' thoughts about whether the group should continue into 2016 and what subjects it should examine.