Power Curve Working Group Meeting Minutes

Impact of Outer Range Conditions on Wind Turbine Power Performance
12th Meeting Minutes, Friday 26th June 2015, DTU Risø Campus, Roskilde, Denmark

Attending: Peter Stuart (RES), Joseph Kane (RES), Lee Cameron (RES), Poul Hummelshøj (DTU), Paula Gómez Arranz (DTU), Peder Bay Enevoldsen (Siemens), Ioannis Antoniou (Siemens), Rebeca Rivera Lamata (Dong), Joanna Mckenzie (SSE), Breanne Gellatly (AXYS Technologies), Paul Veers (NREL), Daniel Marmander (Natural Power), Erik Tuxen (DNV GL), Gaetan Martellozzo (EDF), Carlos Andre Niederbacher Silva (Nordex), Hector Alonso (Barlovento), Stathis Koutoulakos (Vattenfall), Stuart Baylis (Prevailing), Bert Gollnick (Senvion), Jochen Cleve (Siemens), Demetrios Zigras (Nordex), Rodolphe Lebosq (Enercon) & Scott Eichelberger (Vaisala).

Objective: to finalise the 1st PCWG Intelligence Sharing Initiative definition document and gather feedback from participations on the preparation of their datasets.

Presentations

- 01 - Power Curve Working Group Update, Peter Stuart (RES)
- 02 - A New Theoretical Basis for Describing Low Turbulence Wind Turbine Performance, Peter Stuart (RES)

Discussions

PCWG Intelligence Sharing Initiative Discussion (PCWG-Share-01)

Note: The outcome of the meeting discussions (in combination additional feedback received via email) were incorporated into the final version of the document *'PCWG: 1st Intelligence Sharing Initiative (PCWG-Share-01)'* which was circulated to PCWG members on 28th August 2015.

The group discussed the content of the DRAFT document *'PCWG: 1st Intelligence Sharing Initiative (PCWG-Share-01)'*. The key topics addressed were:

- **Readiness of methodologies for incorporation into the Intelligence Sharing Initiative**: The group agreed that only methodologies which have been adequately explored within the PCWG should be examined under PCWG-Share-01. The group agreed that the creation of an agreed consensus analysis for each methodology was a prerequisite for its inclusion. It was thus agreed that the methodologies ready for incorporation into PCWG-Share-01 are:

    - **Rotor Equivalent Wind Speed (REWS)**
    - **Turbulence Renormalisation/Correction**
    - **2D Power Deviation Matrix**

  The group agreed to work towards preparing additional methods (e.g. 2D power deviation matrix, Production By Height etc.) for participation in a future intelligence sharing initiative i.e. PCWG-Share-02.

- **Power Deviation Matrix Structure for Intelligence Sharing Initiative**: The group discussed the definition of the power deviation matrix to be tested under PCWG-Share-01. There was some discussion on the relative merits of 2D vs 3D matrices and it was concluded that PCWG-Share-01 should focus on examining a single 2D matrix. The group agreed that 3D matrices should be studied in a future intelligence sharing initiative (PCWG-Share-02). There was then some discussion on what parameters should be used to define the dimensions of the power deviation matrix; the group agreed that turbulence was the most important variable (after wind speed) and that although shear is important it is less important than turbulence. One manufacturer commented that they were happy that shear was being address via the inclusion of REWS in PCWG-Share-01. It was therefore agreed that PCWG-Share-01 should examine a single 2D power deviation matrix with dimensions of wind speed and turbulence intensity.

  The draft hypothesis power deviation matrix for PCWG-Share-01 was presented to the group. One PCWG member commented that the x-axis of the matrix should be normalised wind speed as opposed to absolute wind speed.

- **Number of Levels Required to Define REWS**: The group discussed what criteria PCWG-Share-01 should prescribe in terms of the number of measurement levels required to generate Rotor Equivalent Wind Speed (REWS). It was unanimously agreed that there was no benefit in defining REWS using two measurement heights. After some discussion the group agreed that PCWG-Share-01 should prescribe that (for the purposes of the intelligence sharing initiative) REWS is defined from a minimum of three measurement heights with at least one measurement height above hub height and one measurement height below hub height.

  An academic PCWG member pointed out that Boundary Layer theory has recently been developed to allow the vertical extrapolation of measurements from lower heights to higher heights in order to define REWS from relatively low measurements. It was agreed that while such developments in Boundary Layer theory were interesting and beneficial to the work of the PCWG and they should not be considered for the purposes of PCWG-Share-01. The group agreed to work with the academic member in question to examine the new Boundary Layer theory in due course.

- **Sector width**: The group discussed the merits of a narrower calibration sector width versus a wider sector width. The possibility of performing a sensitivity study on sector width was briefly discussed and in particular the sensitivity of the turbulence correction to sector width was highlighted by one member. In the end the group settled on using a 10° sector width to align PCWG-Share-01 with IEC 61400-12-1.

- **Meta Data**: The group discussed what meta-data should be included with submissions to PCWG-Share-01. A detailed list meta-data was compiled and incorporated into the draft definition document.

PCWG Analysis Tool Demo (PCWG-AT)

The latest version of the PCWG Analysis Tool (PCWG-AT) was demonstrated to the group. The readiness of the tool to support PCWG-Share-01 was discussed. The following key points were raised:

- **Issue Tracking**: the official way of submitting issues/bugs/suggestions for PCWG-AT was presented. Members wishing to submit issues/bugs/suggestions should do so via GitHub using the link https://github.com/peterdougstuart/PCWG/issues and click the 'New Issue' button.
- **Terminology**: a member of the IEC 61400-12-1 committee commented that the terminology used in the tool doesn't currently align with the different contexts in which it may be used (resource assessment and power performance) e.g. 'correction' vs. 'normalisation'. The member felt that this could be a source of confusion in the future and should be addressed.
- **Beta Testers:** It was agreed that a mailing list of PCWG-AT beta testers should be established. Beta testers will assist in verifying that new versions of the tool are ready for release.
- **User Documentation:** It was agreed that the user documentation of the tool should be improved.

A 'hands-on' session was held whereby PCWG members trialled the analysis tool on their individual datasets. During this session some additional smaller comments and suggestions were made which are documented in Table 1.

Suggestion/Feedback	Git Hub Issue Link	Status
Full support for both comma separated and tab separated files.	https://github.com/peterdougstuart/PCWG/issues/43	Done
Option to automatically parse shear/rews heights from column headers.	https://github.com/peterdougstuart/PCWG/issues/86	
Bug when exporting if no specified power curve	https://github.com/peterdougstuart/PCWG/issues/87	
Hidden validation messages in minimised sections.	https://github.com/peterdougstuart/PCWG/issues/88	
Full support for multi-height shear in UI	https://github.com/peterdougstuart/PCWG/issues/89	Done
Add option for None to list of Site Calibrations	https://github.com/peterdougstuart/PCWG/issues/90	Done
Filters deselecting themselves	https://github.com/peterdougstuart/PCWG/issues/91	Done
Tool Tips	https://github.com/peterdougstuart/PCWG/issues/92	
Minimum Number of REWS heights	https://github.com/peterdougstuart/PCWG/issues/93	
Reference Number (traceability)	https://github.com/peterdougstuart/PCWG/issues/94	
Incorrect Date Format (if two digit year in file)	https://github.com/peterdougstuart/PCWG/issues/95	

Table 1. Minor suggestions/feedback made during the June 2015 PCWG Meeting

DRAFT 'Turbine Performance Information' Document (harmonisation of communication)

The group briefly discussed the DRAFT document *'DRAFT Guidelines for Preparation of a Turbine Performance Information Pack'*. The following comments were received during the meeting:

- One working group member suggested that the guidelines should provide a mechanism/framework for a statement that the supplied power curve is a central estimate.
- One Developer member stated that they believed the diagram (Figure 1) should be amended to include (or make more explicit) the scenario of an owner operator.

- One member said that they felt that the Inner Range definition may not perfectly overlap with the warranty definition and a list of the additional warranty filters should be included.

Meeting Wrap Up

The following items were agreed during the warp up session:

- It was agreed that a section of the September 2015 (New Orleans) and October 2015 (Aarhus) meeting agendas would be dedicated to the methods which are not being examined by PCWG-Share-01 and should be prepared for PCWG-Share-02.
- It was agreed that the first round of comments on the DRAFT 'Turbine Performance Information Pack' (harmonisation of communication) document should be sent to PCWG@res-ltd.com by mid-September with a view to circulating a final version after the October meeting.