Power Curve Working Group Agenda

7th Meeting, Tuesday 02 September 2014, RES, Beaufort Court, Egg Farm Lane, WD4 8LR, England

Theme: The 7th meeting focused on some of the commercial implications of the work of the group.

Attendees: Peter Stuart (RES), Stuart Baylis (PREVAILING ANALYSIS), Axel Albers (WIND GUARD), Matthew Colls (PREVAILING ANALYSIS), Joerg Wanink (GE), Paula Gómez (DTU), Daniel Stevens (SSE RENEWABLES), Gaëtan Martellozzo (EDF-EN), Richard Whiting (DNVGL), Brian Davison (NAPIER), Ralph Torr (ORE), Andy Kay (ORE), Aris Dimopoulos (INFINIS), Daniel Marmander (NATURAL POWER), Herbert Schwartz (ANEMOS-JACOB), Rebeca Rivera Lamata (DONG ENERGY), Richard Gale (EON), Peder Enevoldsen (SIEMENS), Jochen Cleve (SIEMENS), Paul Housley (SSE RENEWABLES), Daniel Bendel (SENVION), Alex Clerc (RES-LTD), Fiona O'Connor (ESB) & Chris Slinger (ZEPHIR).

Presentations:

- "01 – Introduction" (Review of Actions from Last Meeting and Round Robin 3 Results Overview – Rotor Equivalent Wind Speed with Veer), Peter Stuart (RES)
- "02 - Real World Contractual Experience of the Inner-Outer Range", Daniel Stevens (SSE)
- "03 - Use of manufacturer specific inputs to refine energy yield predictions", Richard Whiting (DNV GL)
- "04 - Use of Nacelle LiDAR data to explore impact of using non-linear averages", Chris Slinger (ZephIR)
- "05 - Power Performance Analysis using LiDAR simple terrain", Alex Clerc (RES)
- "06 - Practical Consideration using the Equivalent Power Approach", Peder Bay Enevoldsen and Ioannis Antoniou (Siemens)
- "07 - Calculation of REWS using CFX", SSE, Paul Hosley
- "08 - Impact of Ground Boundary on Production of Short Tower Turbines - A Conceptual Study", (SEE, RWE, RES & DNV GL)

Discussion:

Additional Manufacturer Inputs Discussion

The group discussed the implications of the **"**Use of manufacturer specific inputs to refine energy yield predictions" presentation. One consultant asked how likely it was for manufacturers to supply the information outlined in the presentation given the recent trend for less measured power curve information to be supplied. Another consultant responded by saying that it was important to try and give the manufacturers the message that there is something in it for them i.e. if the requested information is supplied it may result in generic/conservative loss factors and uncertainty terms being replaced with less conservative (and more realistic) manufacturer/machine specific assumptions. The same manufacturer quoted the "Power Deviation Matrices" (which have previously been

presented by one PCWG manufacturer) as a good example of the type of information they would be happy to use. One manufacturer asked why such information was necessary given that methods like rotor equivalent wind speed (REWS) and turbulence renormalisation were available. The consultant responded by saying that in their view these analytical methods do not reproduce the observed behaviour and that they suspect the gap is due to "Type B effects" (reduction in conversion efficiency). The same consultant added that they would be happy to use models over empirical approaches if the models predicted the behaviour that they actually see (in particular at the low/medium wind speed and low turbulence range). One manufacturer responded by saying that there were happy to enter into a dialog on this issue. One developer said that in his view the eventual solution may be to use a combination of empirical/proxy and analytical approaches (hybrid approach), he added that the gap between the proxy and analytical methods was not yet clearly defined and more work was needed on this. A different consultant commented that in his view shear was a better proxy than turbulence.

A different manufacturer commented that the data does not exist to generate power deviation matrices for newer machines. A consultant responded by saying that some data could be reused from a previous generation of machines and the data requirement for new machines could be set a bit lower (once good data exists for the previous generation). The manufacturer then stated that they are concerned that the data may be being sliced too much and the approach is adding too much complexity. The consultant responded by saying that they felt that turbulence intensity was the best proxy currently available. The manufacturer agreed that after wind speed and density, turbulence is probably the next most significant variable that impacts turbine performance.

One developer asked why the presentation ("Use of manufacturer specific inputs to refine energy yield predictions") mentioned that 5 historic power performance tests were required. The presenter responded that 5 tests was a pragmatic rather than a scientifically drawn number and added that if the 5 tests were consistent than they would represent a usable quantity of data. Another developer asked the consultant if they would also consider turbine performance data submitted by a developer (as opposed to a manufacturer), the consultant responded by saying that this would be acceptable.

One developer enquired about the gap between the proxy and analytical methods by asking if progress had been made on the proposal to use an open source rotor to explain the gap. The group co-ordinator commented that there had not been any progress on this specific proposal yet and said that if anyone (in particular those from the academic community) was interested in pursuing this concept they should get in touch (please email pcwg@res-ltd.com).

One manufacturer commented that proxies should be used with caution and said that he considered it bad practice to use the shear exponent across the lower half of the rotor as a proxy for the shear across the whole rotor.

One consultant commented that the currently available models were all "Type A" (available energy) models and that in his opinion the drop in aerodynamic efficiency associated with "off design" angles of attack during high shear conditions were an important "Type B" consideration, and this was in his view the main reason for the gap between the proxy and analytical methods.

Tour of Consensus Analysis

The group were stepped through the Excel Consensus Analysis of the turbulence correction (renormalisation) method. It was agreed that the consensus analysis appears to be an accurate representation of the draft standard, but the documentation of the consensus analysis should be improved, in particular flow charts should be prepared.

Round Robin Exercises

The group discussed the content of Round Robin 4 (site specific power curves). Several adjustments/clarifications were made to the definition of the exercise following the discussion. The group will aim to complete the 4th round robin in advance of the December meeting.

The group discussed possible future round robins. The group agreed to progress round robins of the power deviation matrix method and rotor equivalent wind speed method incorporating inflow angle.

Black Block Power Curve

The group was demonstrated the Black Box proof of concept which is available on DropBox at: Dropbox\PowerCurveWorkingGroup\BlackBox\Example.py

Open Source Code

The group was briefly demonstrated the PCWG open source code. It was suggested that a user interface should be added to the code[1].

Future PCWG Priorities

The group discussed which items the PCWG should prioritise going forward:

- The group agreed that the current gap between the analytical and proxy methods and associated Type B losses should be the key priority.
- The group discussed the possibility of an enhanced data sharing initiative. It was agreed that the group should explore innovative ways to achieve enhanced data sharing, potentially involving the open source code.
- The group agreed that the PCWG should extend its activities for a further year and that a roadmap of the planned activities for 2015 should be published.
- One developer raised the issue of the value of performing power performance tests and suggested that the group should explore ways to make the tests more 'user friendly' i.e. to make it easier to evidence how the tests add value.

[1] Subsequent to the September meeting a user interface was added to the open source tool. The tool itself can be downloaded at: https://sourceforge.net/projects/pcwg/files. Those interested can access the project source code on GitHub: https://github.com/peterdougstuart/PCWG.

- One manufacturer raised the issue of LiDAR performance in complex terrain and noted that the work of the PCWG has so far focused on LiDARs in flat terrain.
- One group member commented that the group should be conscious of both the resource assessment and power performance perspectives when developing the 2015 roadmap.

Actions

- Improve documentation of consensus analysis of turbulence correction (flow charts)
- Add user interface to Open Source Tool
- Publish Road Map for PCWG 2015 activities.
- Complete 4th Round Robin in advance of December Meeting
- Arrange a Round Robin on Power Deviation Matrix Method
- Arrange a Round Robin on Rotor Equivalent Wind Speed considering inflow.
- Explore enhanced data sharing exercise (possibly utilising open source tool).
- Revisit proposal to use Open Source Rotor to investigate “Type B” performance effects.