Renewable energy consultants

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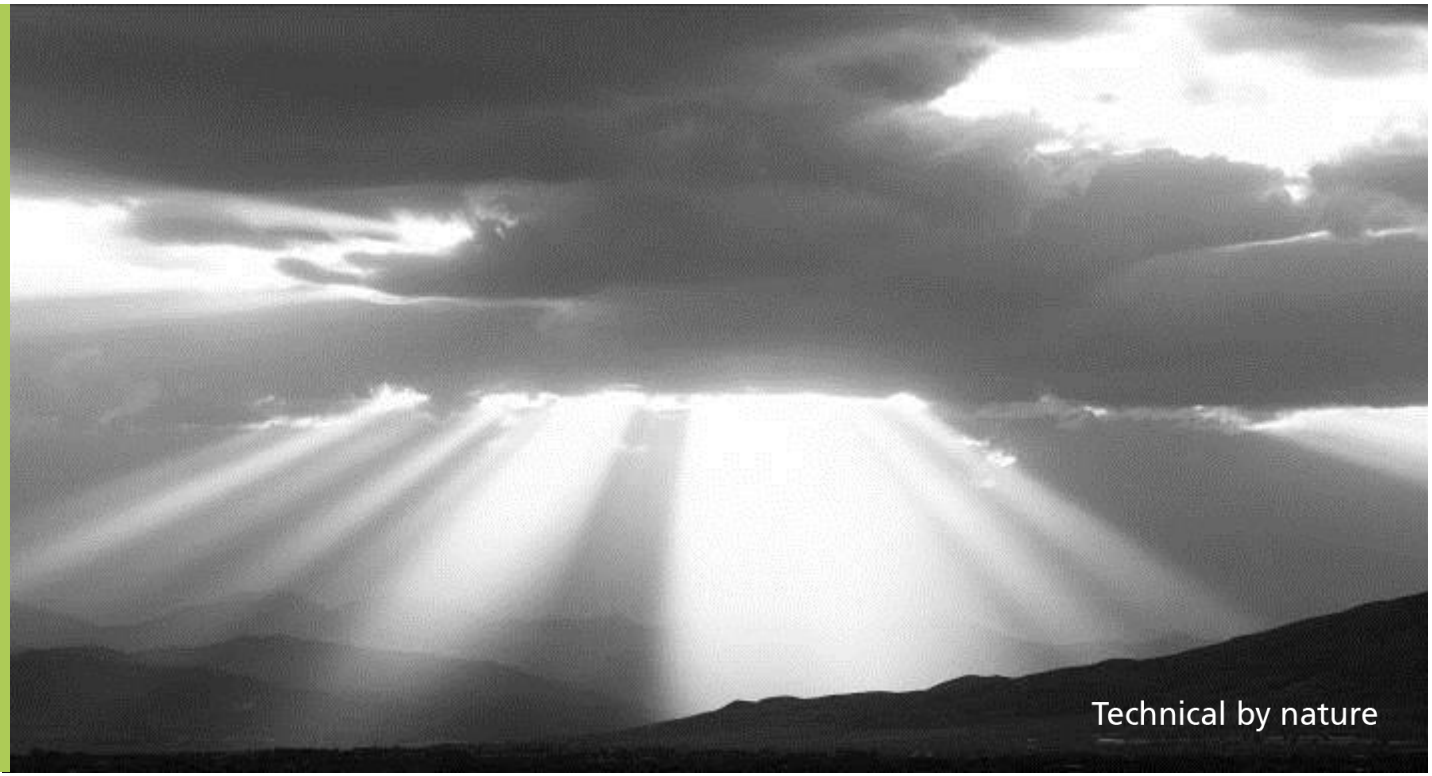
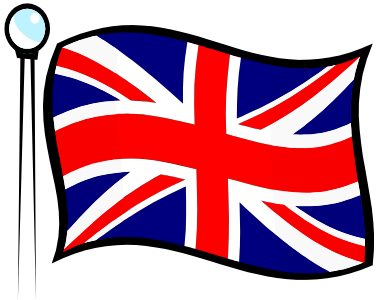
Turbine Performance in “Non-Standard” Wind Conditions Wind Energy Working Group -Review of Previous Meetings

Hamburg, 30th May 2013 Andrew Tindal



London Meeting



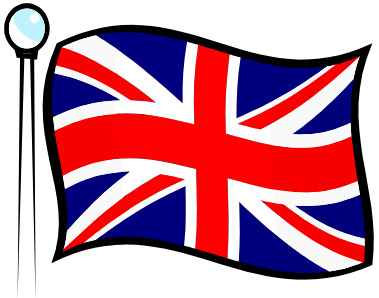
4th December 2012
Key Outcomes Part 1

- The power function of a wind turbine is dependent on wind speed, density, vertical wind shear, vertical wind veer, turbulence intensity, directional variation and inflow angle.

- There is a need for greater clarity on the range of conditions for which power curves are representative. This will give a clear starting point for considering corrections for 'nonstandard' conditions.

- Corrections should be applied for 'non-standard' conditions which are different from those for which a power curve is representative. These corrections fall into two categories:
  - Type A: Adjustments made to reflect changes in the energy available for conversion across the rotor in a ten minute period due to 'non-standard conditions'.
  - Type B: Adjustments made to reflect changes in the conversion efficiency due to 'non-standard conditions'.

London Meeting



4th December 2012
Key Outcomes Part 2

- The corrections for wind shear, wind veer and turbulence intensity in the current working draft of the IEC Power Performance standard should be considered as candidate methods for incorporation into resource assessment methodologies (Type A corrections).

- Further collaboration between manufacturers, developers and consultants is required to improve communication of power function information and explore corrections for non-standard Conditions.

Brande Meeting

12th March 2013
Key Outcomes Part 1:

- The dependency of power output to five parameters (wind speed, density, wind shear, wind veer and turbulence intensity) should be made more explicit in power curve documentation.

- A proposal was made to improve stakeholder communication by supplying power curves with two ranges of conditions:

  - The 'inner range': the conditions for which a manufacturer believes a turbine will achieve its power curve (without correction).
  - The 'outer range': the conditions for which a manufacturer expects a turbine's Performance will degrade below its power curve (and will require correction).

These ranges of conditions could be tied to the level of warranty e.g. X% warranty for the 'inner range' and Y% warranty for the 'outer range' where Y < X

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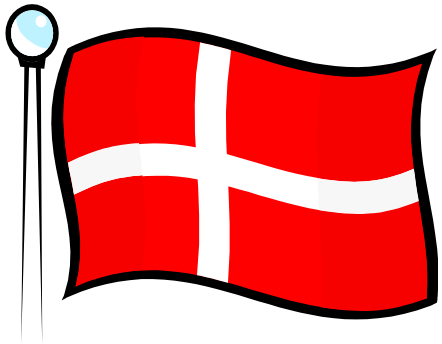
Brande Meeting



12th March 2013
Key Outcomes Part 2:

- The use of rotor equivalent wind speed in wind resource assessment offers the opportunity to correct the wind speed input to the power curve so that it representative of the whole rotor. This approach is an effective way of dealing with the sensitivity of power output to wind shear.

- Tip-height measurements (using remote sensing devices e.g. LiDAR/SoDAR) have a big role to play in improving wind resource assessment. If such information is available it should not just be used in just the 'traditional' way (to verify mast measurement wind shear), instead it should form a core part of the resource assessment strategy.

- A round robin exercise will be conducted within the working group using a dataset including tip height measurements from a RES site in Sweden.

Path of least resistance to improve the accuracy of pre-construction energy predictions?

Accept manufacturer lead "Inner Range, Outer Range " proposal and move to early adoption

For likely "Inner Range" sites :

- Business as usual
- OEMs should be able to provide an evidence base to demonstrate the supplied power curve represents a reasonable "central estimate" for such conditions
- Over time may achieve increasing industry consensus on "Inner Range, Outer Range" thresholds

Path of least resistance to improve the accuracy of pre-construction energy predictions?

For likely "Outer Range" sites:

- The stakeholders within this group continue to test, develop and improve power curve adjustment and uncertainty models

- Either the Developer / Consultant adjusts the "Inner Range" Power Curve for "Outer Range" conditions or the OEM supplies a refined power curved for the "Outer Range" conditions

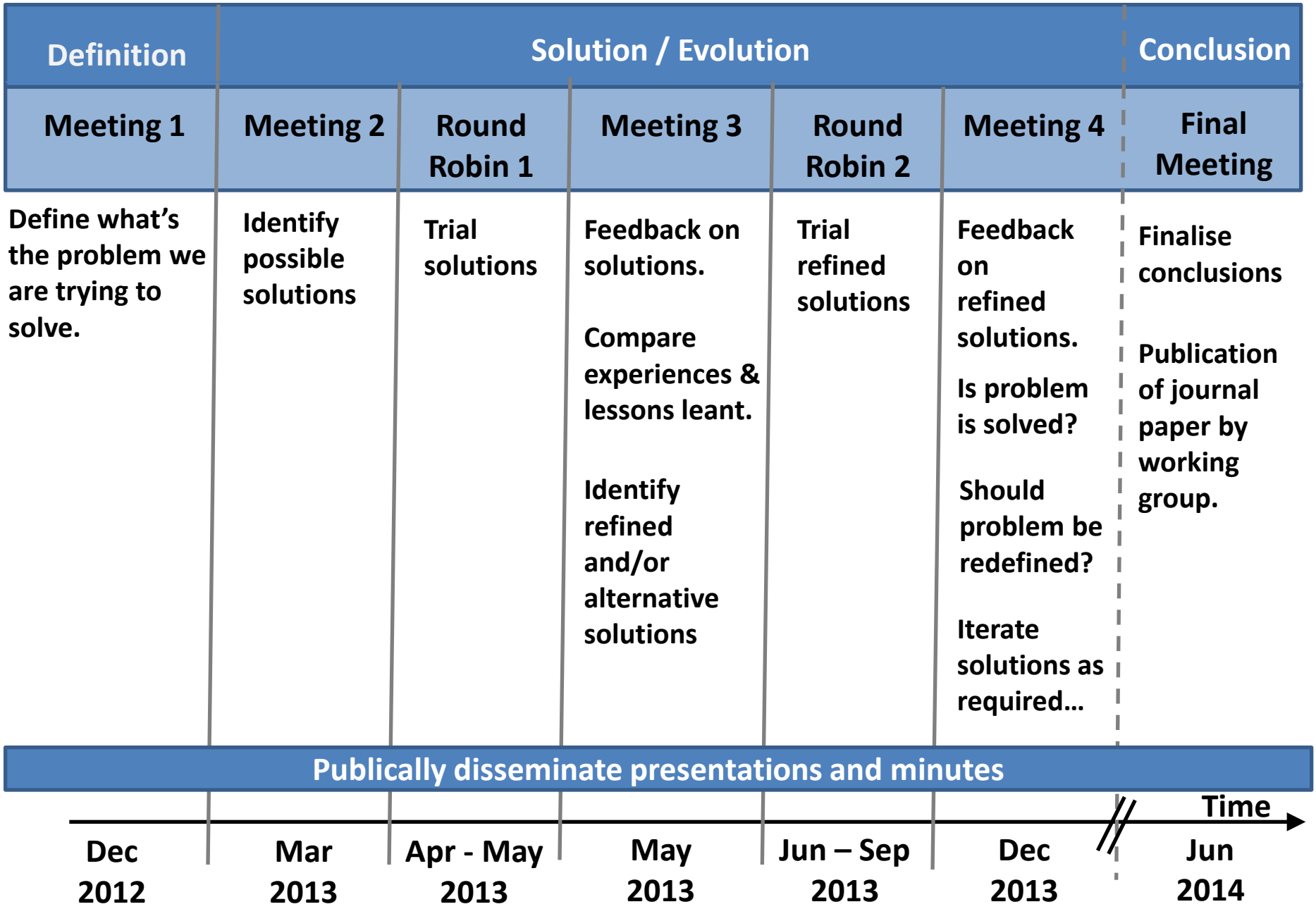
- Enhanced measurements are considered for pre-construction measurement campaigns and power curve tests to better quantify and understand "Outer Range" conditions

Guiding principle?

The Developer / Investor community want:

Realistic “P50” Power Curve for the “Real World” conditions at their site – what ever they are.

Power Curve Working Group Roadmap



Questions?
Discussion to be continued in afternoon