Power Curve Working Group: What have we learned and what should our next step be

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Contents

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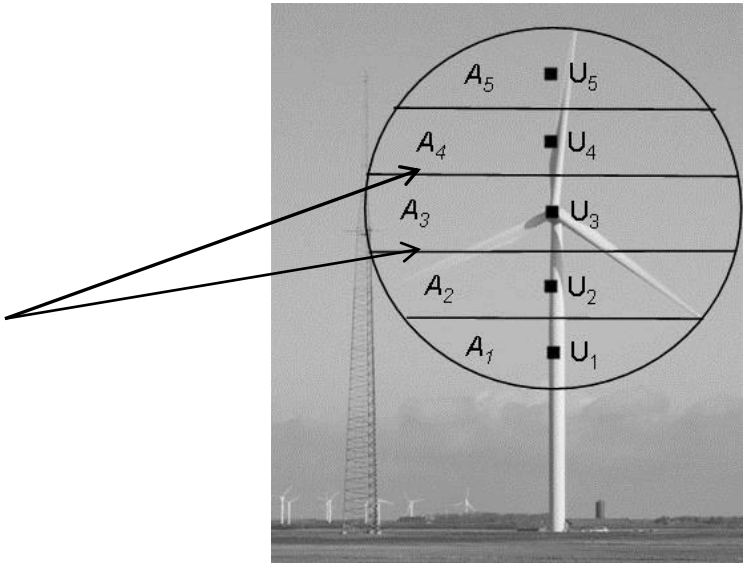
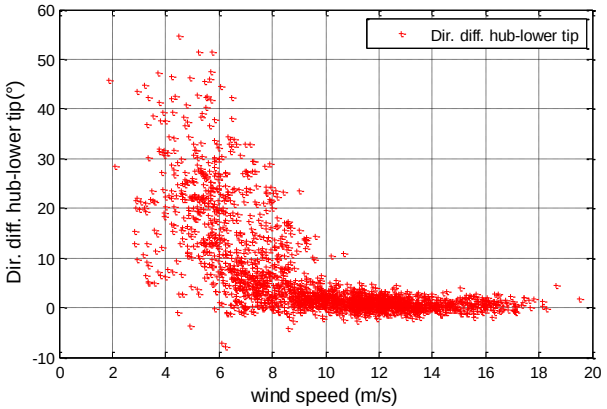
- What have we learned:
  - Equivalent wind speed (shear-veer correction)
  - Turbulence renormalization (alone or in tandem with the equivalent wind speed concept)
  - Use of the above into siting and power curve applications
  - Use of the inner-outer range principle for power curve and AEP evaluations
  - Correlation of the proxy results to shear-veer conditions
  - Touched the subject of CFD simulations

- Suggestions for next steps:
  - Do we need to re-focus?
    - (Can the group cover all subjects? EQV, TI, CFD, Inner-Outer range)
  - Equivalent wind speed: developments and limitations
  - Turbulence normalization: developments and limitations

$$V = \sqrt[3]{\frac{1}{A}\int_{H-R}^{H+R}\left(v(z)\cos(\varphi(z))\right)^3 dA}$$

- Encouraging consistent results among the participants
- Suggested future work:
  - Complex terrain applications needed badly!
  - Always use both shear and veer correction
  - Introduce interpolation between measured wind speeds and veer at different heights (avoid step changes)
  - Likewise change the sector height to a standard of 1m and use the interpolated wind speed and veer
  - Aeroelastic simulations
    - Use aeroelastic simulations (AES) to improve the knowledge on the equivalent wind speed corrections (covering a range of cases)
    - How well does the equivalent wind speed "corrects" for veer and shear? (compare simulations to measurements)
    - Is the veer correction linear ($\cos^1$ or $\cos^x$)? To what extend is it a type A or B effect? (compare simulations to measurements for different rotors)
  - Is the equivalent wind speed concept equally applicable to more terrain types? Work on more data sets needed!





- Not as consistent results among the participants compared to the equivalent wind speed
- Is TI at hub height representative of the TI over the whole rotor? (Is this question not similar to the wind speed question at hub height?)
- Is it clear how TI changes with height under different roughness, terrain and stability conditions and do we have a method to incorporate them?
- What does the zero TI power curve represent?
    - Is it an absolute size or is it the power curve for the specific turbine settings, the specific blade conditions and the specific shear and veer (which change within 10min)? Is it transferable from site to site?
- Does the inner-outer range approach makes the TI renormalization obsolete?
- More work is needed in order to reach consensus!
- Suggested future work:
    - Ti renormalization over the whole rotor, hub height is not enough

Terminology discipline

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- We all make non-consistent use of the terms and this may create misundrstandings
  - Equivalent wind speed
  - Shear correction
  - Veer correction
  - TI (re)normalization
  - ...