Data integrity(*):

Prerequisite to Real World Power Curves

(*)integrity:

1. data's consistency and freedom for corruption
2. the state of being whole or entire

Ioannis Antoniou (RO),
Peder Enevoldsen (RO),
Soren O. Lind (CTA)

Contents

- Challenges associated with power curve measurements:
  - Anemometer calibration
  - Data integrity of siting measurements
  - Data integrity of power curve measurements

Anemometer calibration challenges

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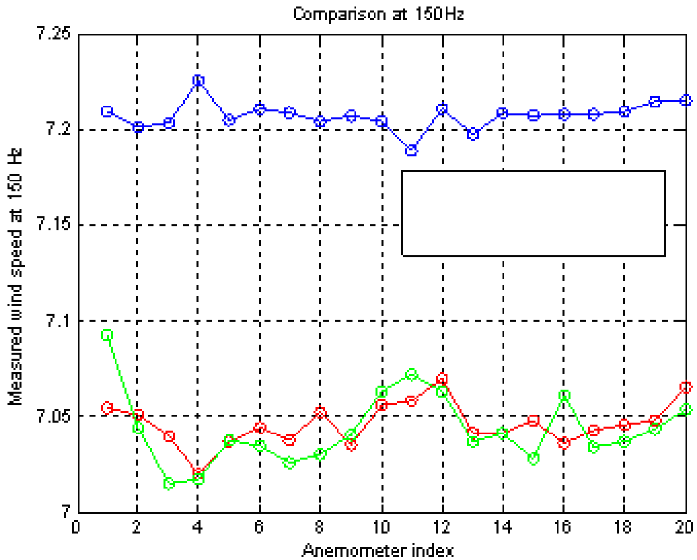
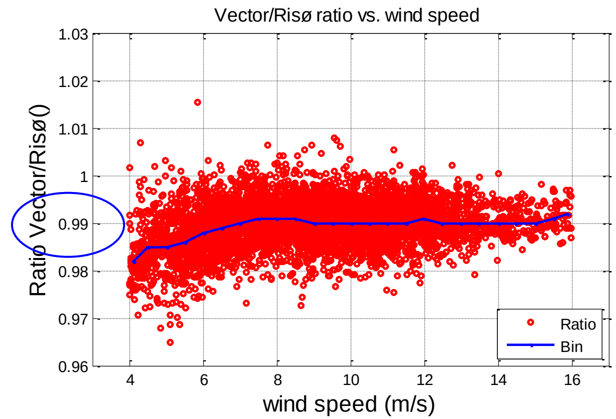
- SWP acknowledges the need for improvements of the anemometer calibrations in order to lower the inter-calibration differences and uncertainties between wind tunnels.
- SWP encourages that the allowable inter-tunnel acceptance range is (at least) halved relative to the present limit (**from present 1% to 0.5%**) .





RR of 20 anemometers in three wind tunnels			
MAWS=8m/s	**T1/T3 (%)**	**T2/T3 (%)**	**T2/T1 (%)**
Mean	**101.90**	**102.00**	**100.10**
Max.	**102.30**	**102.30**	**100.30**
Min.	**101.50**	**101.40**	**99.60**

Siting measurements

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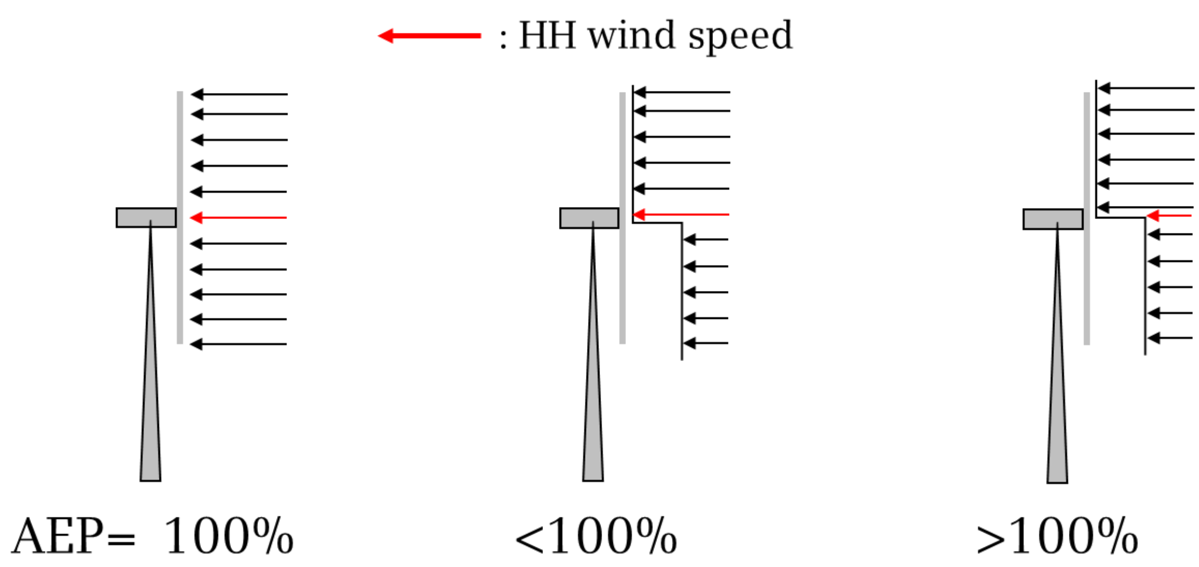
- Problem:
  - Incomplete pre-construction measurement campaigns with focus diverted from data integrity
  - Too little attention to other parameters than wind speed distribution

- Solution: The siting departments wish list
  - Documentation of the measurement campaign:
    - Mast layout
    - Boom orientation
    - Sensor calibration (cup, wind-vanes
    - Mast shadow influence and eventual corrections of the data
    - Atmospheric temperature, pressure, humidity
  - Measurements at hub height (avoid extrapolation from lower heights)
  - Wind speed and wind direction measurements at more heights (to determine the local shear and veer)
  - High frequency measurement campaigns of wind speeds, not just 10min statistics (to identify frequencies which may influence the turbine structure)
  - Even better: Combine use of met masts with remote sensing to measure the wind profile above hub height

- Data integrity jeopardized by :
  - Increasingly complex terrain locations
  - High hub height (new uncertainty source)
  - Large rotors (new uncertainty source)
  - Available measurement codes and practices not sufficiently precise to cope with the new challenges (hub height wind speed does not reflect the reality over the whole rotor)
  - The energy equivalent wind speed over the rotor needs from now on to be considered as the alternative to the hub height wind speed



Meeting the needs of the customer: **Site specific PC**

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- Knowledge of the local conditions makes it possible to meet the customer's economic considerations and offer site-specific power curves
- Data integrity is a must

- A realistic approach combines:
  - The turbine's generic power curve
  - Site specific information (wind shear-veer profile, wind-rose and TI distribution, local topography)
  - Flow simulations
  - Experience from previous measurement campaigns in similar terrain

- The output:
  - **A state-of-the-art site-specific power curve!**

Conclusions

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- Due to the large rotor evolution:
- The hub-height wind characteristics are not any longer always representative of the wind speed over the whole rotor and a new IEC revision 61400-12-1 is needed in order to incorporate the new measurement procedures
- New uncertainty sources (due to wind shear and veer over the rotor) need to be considered, additionally to the already existing ones
- Data integrity during the siting period is fundamental for being able to offer realistic power curves to the customer.

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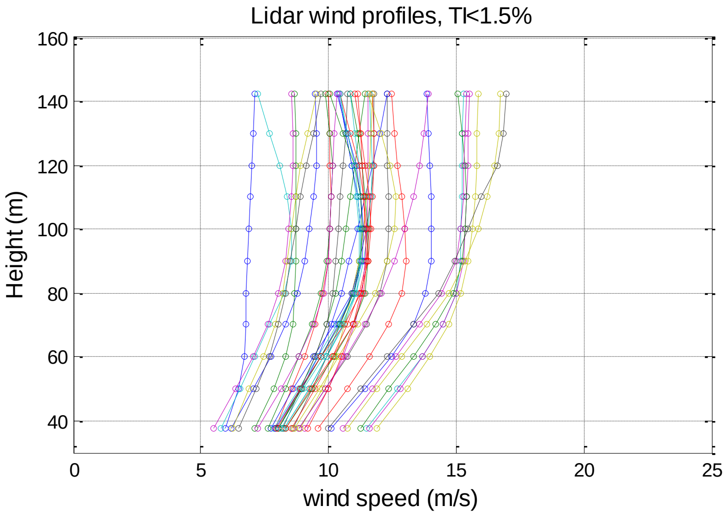
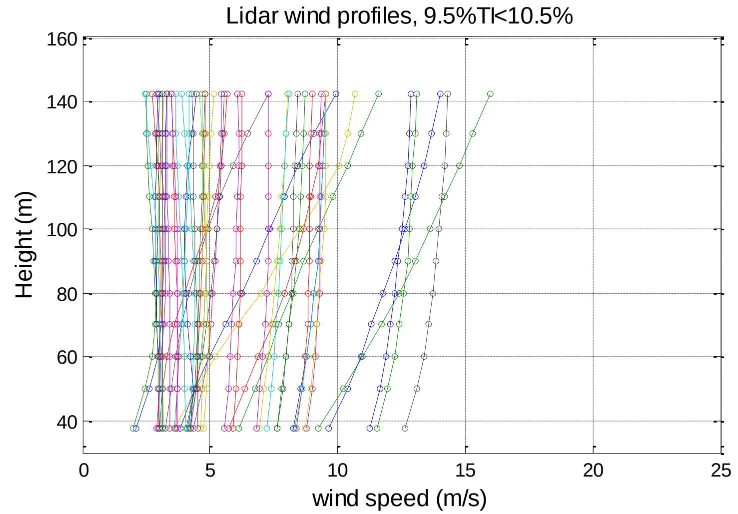
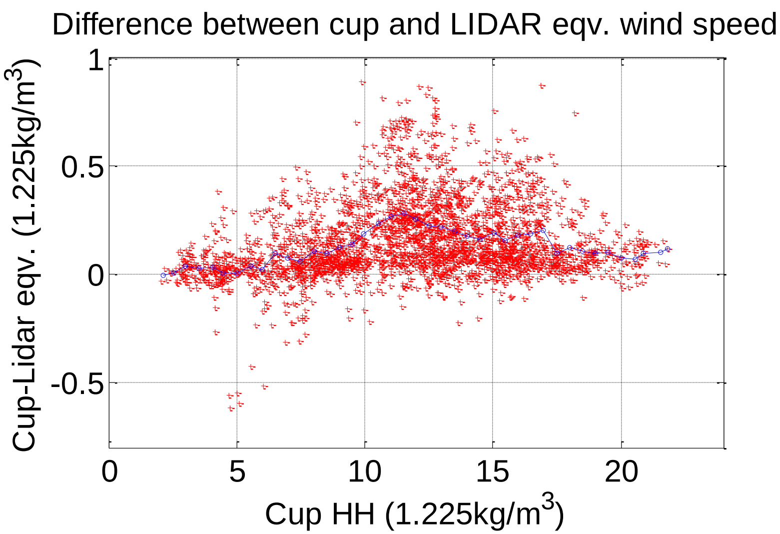
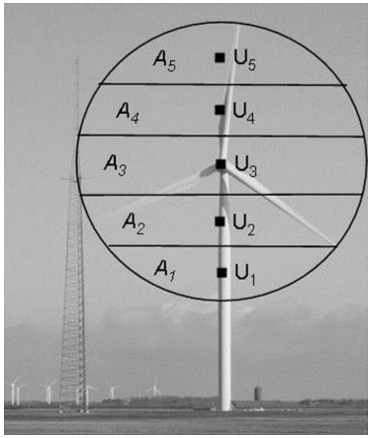






$$V = \sqrt[3]{\frac{1}{A}\int_{H-R}^{H+R} \left(v(z)\cos(\varphi(z))\right)^3 \, dA}$$



Additional info: Influence of wind shear, wind veer and TI on the AEP

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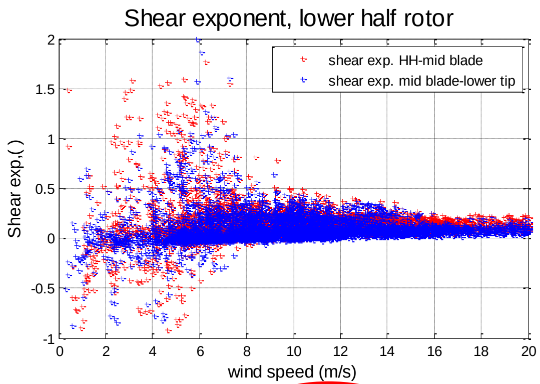

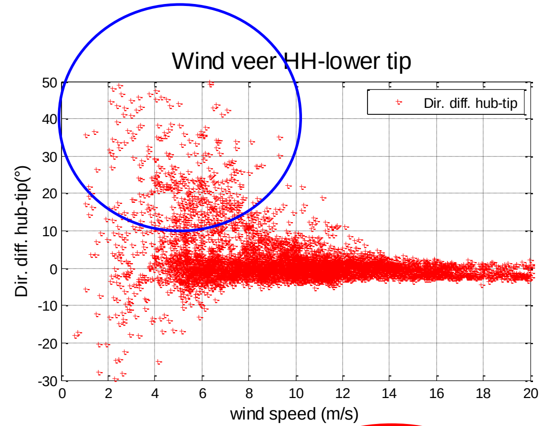

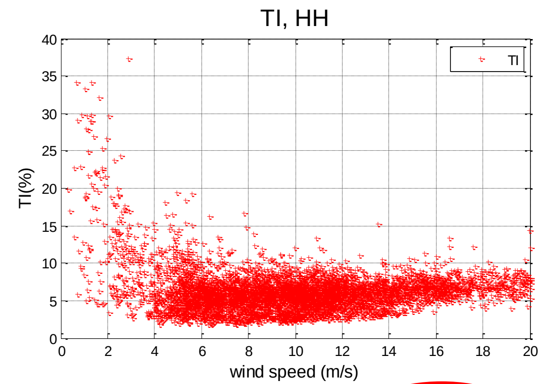

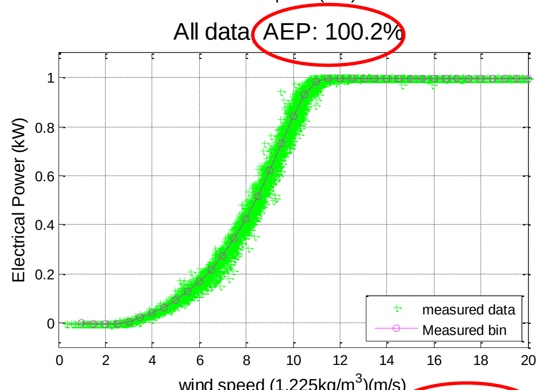

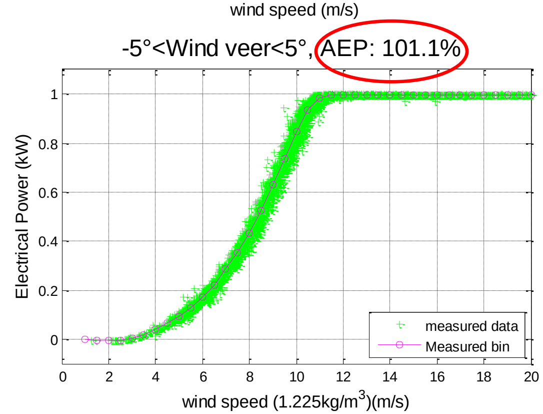

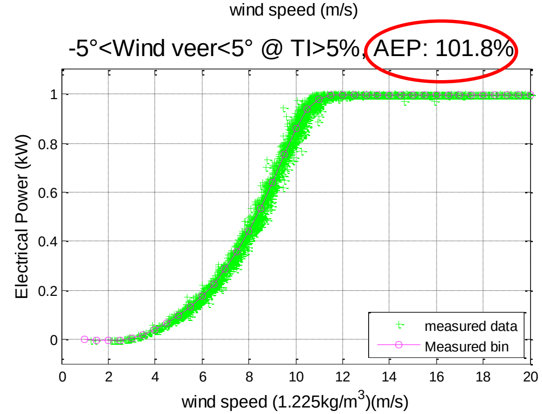

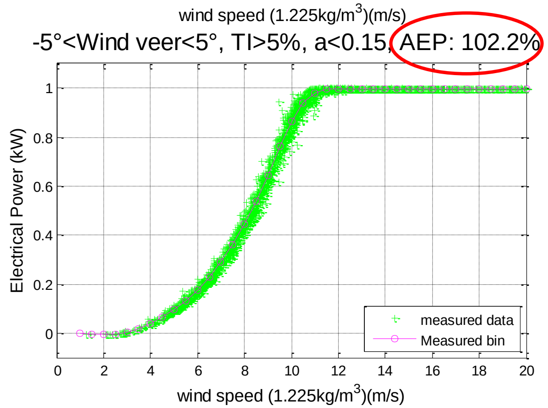

Question:

Does the turbine produce better during low shear, low veer and higher TI conditions?

OR:

Has our filtering, modified the energy contents of the wind profile ? (without our measurement method being able to register it!)