Nacelle-based lidar measurements in the induction zone for power curve analysis

IEA Task 52 Lunch Seminar, March 01, 2024
Steffen Raach – sowento GmbH

Who we are?

- Established in 2016 with 70+ projects until today

- Strong connection to academia, large network in wind industry

- Mission (in three points)
  - strengthening renewable energies through **innovation from research**
  - **collaborate** in a productive and individualized, goal-oriented way with our customers, implementing cross-discipline **innovations from concept to deployment**
  - foster an environment of **critical thinking**, mutual support and **high professionalism**

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Innovations in

Lidar Technology

Floating Wind

Wind Farm

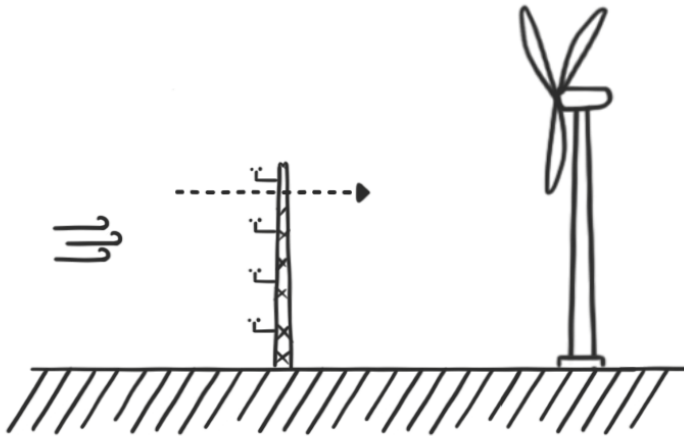# Nacelle-based lidar measurements in the induction zone

Power curve analysis
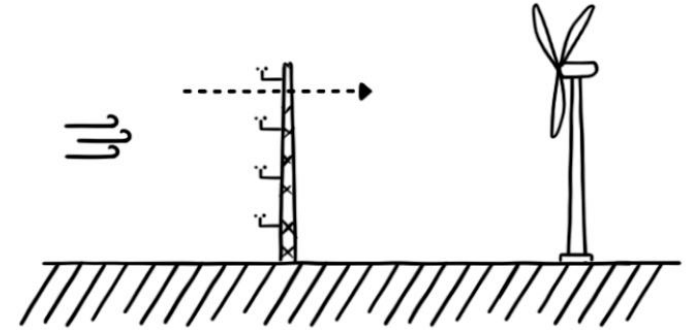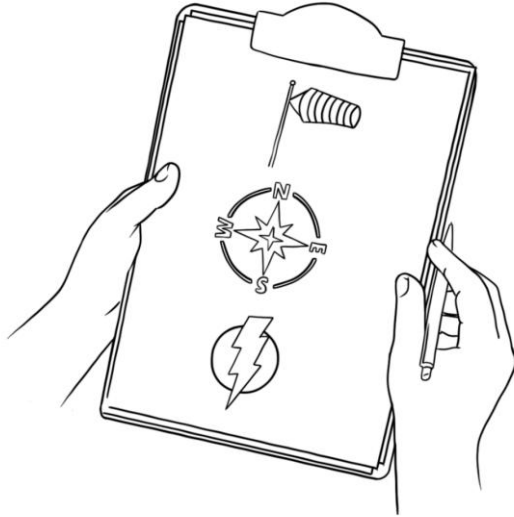
Met mast measurement campaign:
- Well established methods.
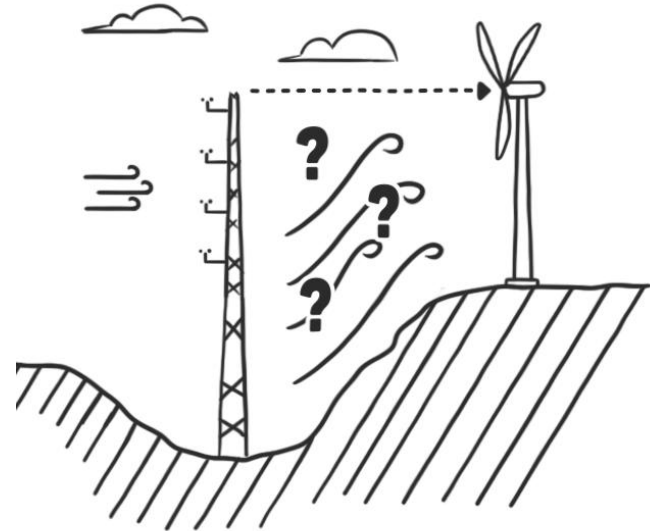- A limited inflow sector can be used.

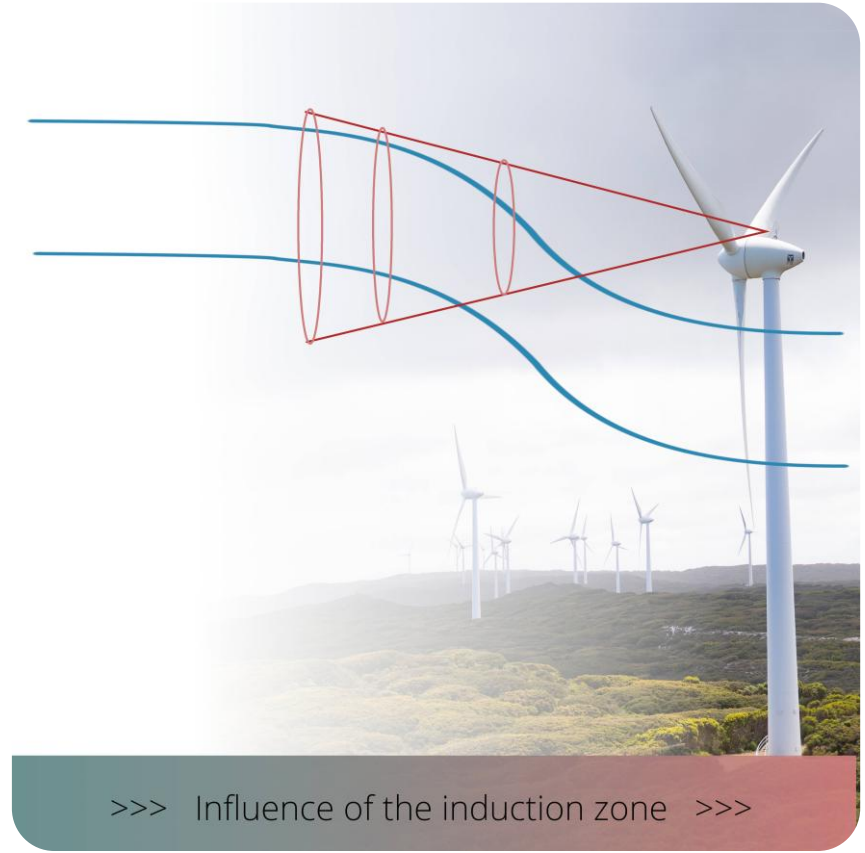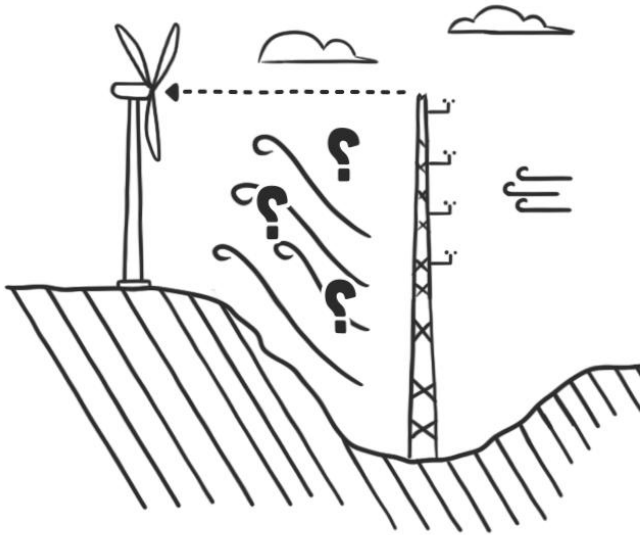# Large rotors

Complex terrain

Induction zone

>>> Influence of the induction zone >>>

Workflow

Measurement campaign
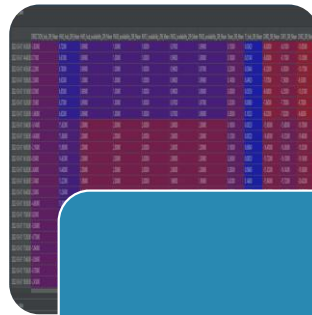
Data filtering
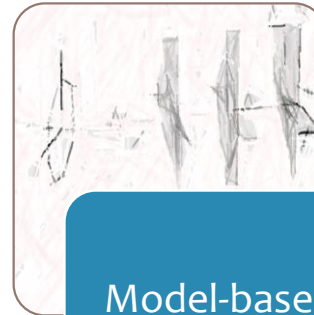
Model-based post processing
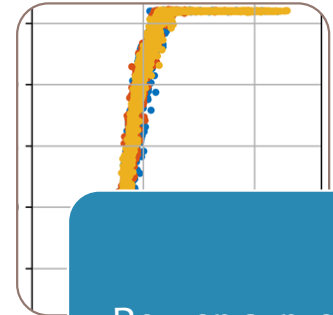
Power curve evaluation

Theory – Model-based post-processing

Free wind speed

v_∞
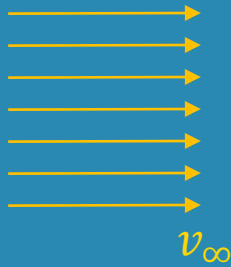
Wind shear and inflow angle

profile 1
profile 2
profile 3

+
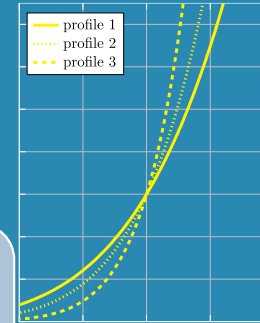
Lidar + Wind
field model
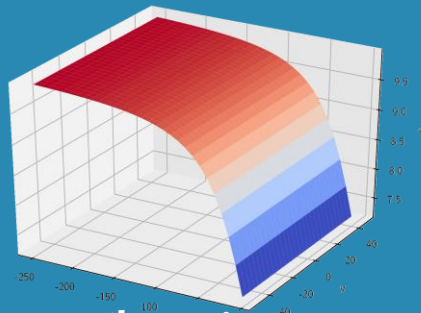
Induction zone
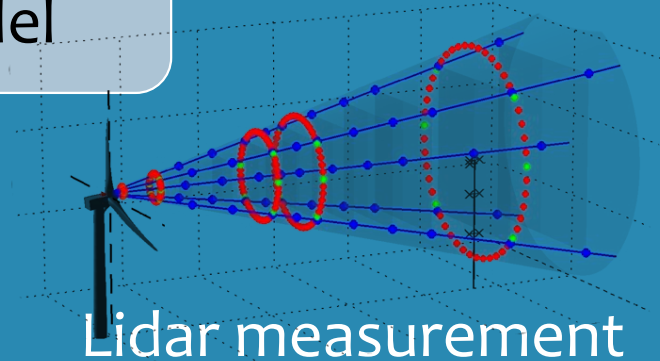
Lidar measurement

Theory – Model-based post-processing

Line-of-sight velocities V_{los}

Inclination angles

1 Fit model to measurements

Wind Model

Lidar Model

Initial WFC

1a Simulate measurement

simulated V_{los}

WFC... Wind Field Characteristics

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Theory – Model-based post-processing

Line-of-sight velocities V_{los}

Inclination angles

1 Fit model to measurements

1a Simulate measurement → simulated V_{los} → **1b** Calculate error & Update WFC

updated WFC

Wind Model

Lidar Model

Initial WFC

Fitted WFC

WFC... Wind Field Characteristics

Theory – Model-based post-processing

Line-of-sight velocities V_{los}

Inclination angles

1 Fit model to measurements

Wind Model

Lidar Model

Initial WFC

1a Simulate measurement → simulated V_{los} → **1b** Calculate error & Update WFC

updated WFC

Fitted WFC

Wind Model

Locations of interest e.g. 2.5D

2 Reconstruct wind

Wind vectors

WFC... Wind Field Characteristics

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Example result

Comparison between mast-measured and lidar-estimated horizontal wind speed at hub height and 2.5D using short-range measurements.
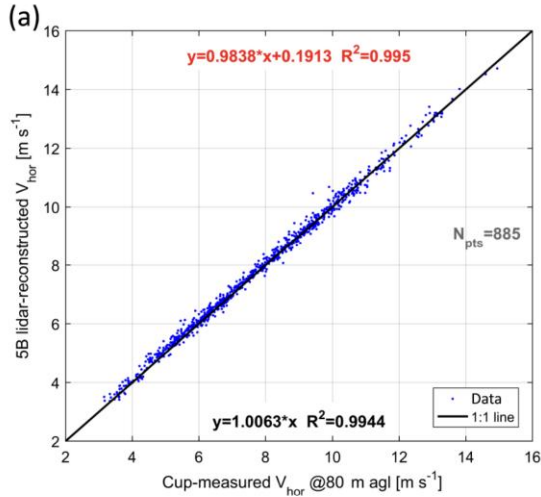
(a) 5B-Demo lidar, using five LOS and four ranges within induction zone
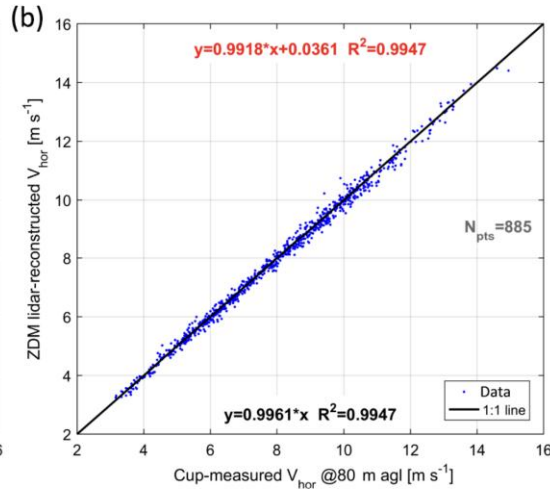
(b) ZDM lidar, using six LOS and three ranges within induction zone

Measurements

Comparison

Borraccino, A., Schlipf, D., Haizmann, F., and Wagner, R.: Wind field reconstruction from nacelle-mounted lidar short-range measurements, Wind Energ. Sci., 2, 269–283, https://doi.org/10.5194/wes-2-269-2017, 2017.

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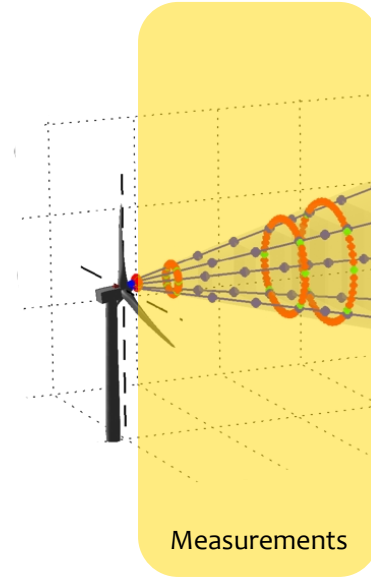
- Graphical Desktop-App

- No additional software required

- Define measurement scenario and lidar device in detail

- Load and save your configurations

- Plot results for immediate plausibility check
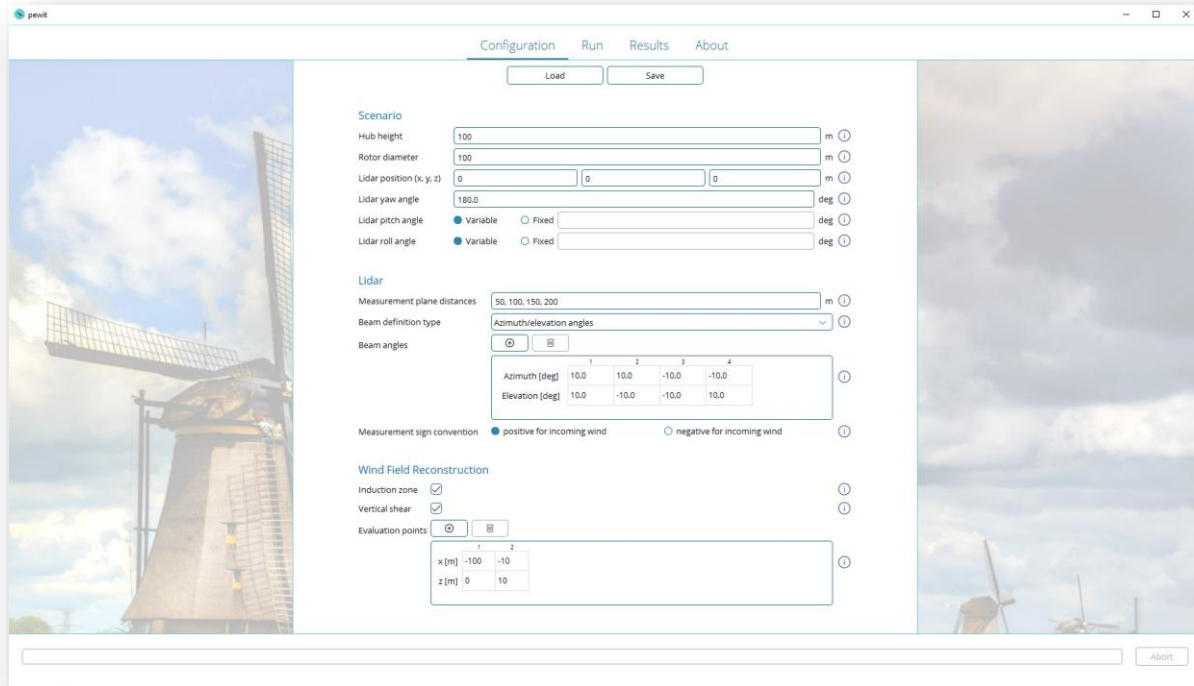
Collaboration opportunities

- Increase confidence of industry in the approach by
  - Share data set for analysis and joint publication
  - Work towards acceptance for power performance testing
- Test the pewit software with your data, free test license available
- Become a pewit user and benefit from
  - Shorter measurement campaigns
  - Decrease in uncertainty
  - Complex terrain measurement campaigns
- Get in touch for more details
  - Steffen Raach – raach@sowento.com

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Conclusions

- Challenge
    - Increasing rotor diameters and therefore large distances
    - Complex terrain measurements
    - Measuring in the induction needs post-processing

- Approach
    - Model-based post processing
    - Wind field model
    - Lidar measurement model

- Advantages
    - Large rotors: 2.5 D is far → Wind evolution, time to the rotor, small sector → longer measurement campaigns
    - Complex terrain: Terrain influence smaller closer to the wind turbine

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Let's talk…

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