Active grid in a wind tunnel used for wind energy research

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Abstract

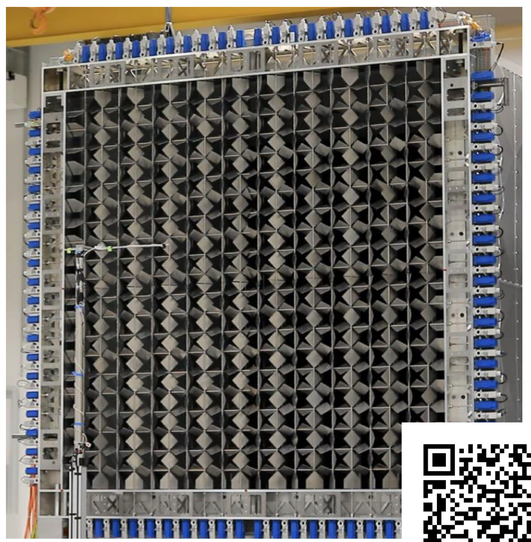
Wind turbines are operating in atmospheric turbulence. The problem of real atmospheric turbulence is that it will never repeat, events are typically unique. To optimize wind turbines for such working conditions it is a desire to bring such turbulent wind conditions into laboratories with the possibility to control and to reproduce them. We use an active grid, which, based on specific driving modes of the grid, allows for such desired investigations.

Wind tunnel

Göttingen type wind tunnel:

- 3 x 3 x 30m³
- 32m/s open test section;
  42m/s closed test section

Active grid

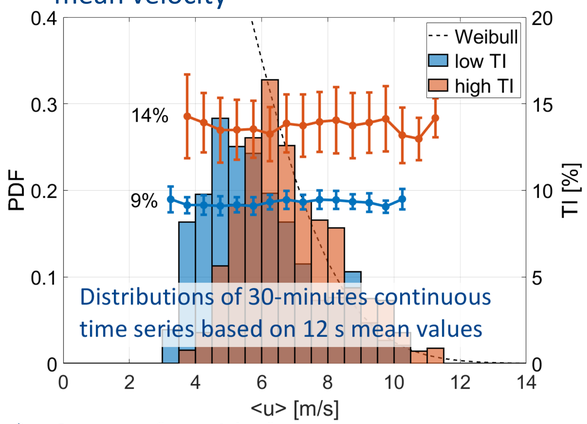


VIDEO + MORE INFO →

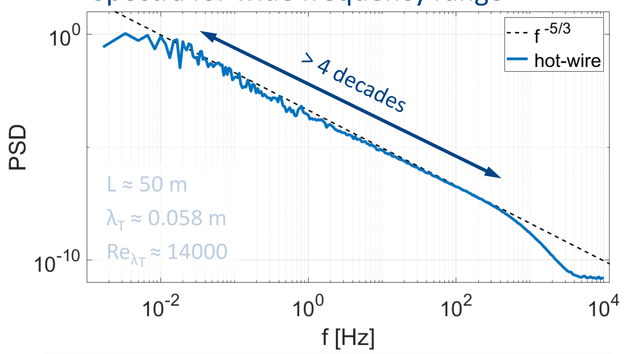
- 80 individually controllable shafts
- Reproducible inflow conditions [1]
- Generation of:
  - Atmospheric-like turbulence
  - Highly turbulent flows
  - Special events (gusts, sinusoidal, …)
  - Reproduction of measured wind fields

Atmospheric-like turbulence

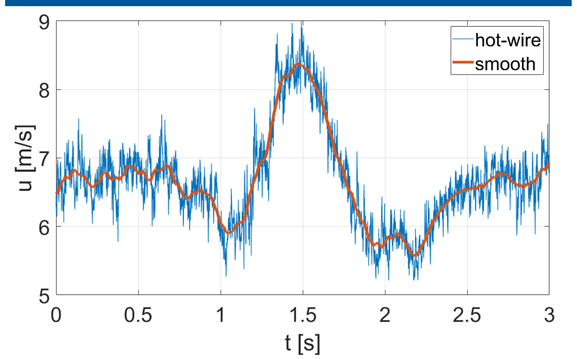
- Flow excitation by active grid & wind tunnel fans
- Wide velocity range
- Turbulence intensity (TI) independent of mean velocity



- Spectra for wide frequency range



Gust generation



Rotor coherent inflow:

- Mexican hat like gusts
- Sinusoidal changes in the wind speed
- Step-like changes in the wind speed

Model wind turbine Oldenburg (MoWiTO)

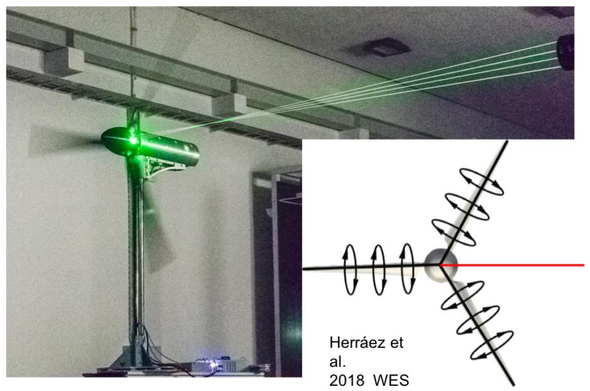
MoWiTO 1.8 (D = 1.8 m) [2] :

- Scaled 5 MW wind turbine
- TSR 7.5
- Baseline pitch and torque control
- Individual pitch control (IPC)
- Realistic aerodynamics

MoWiTO 0.6 (D = 0.58 m) [3] :

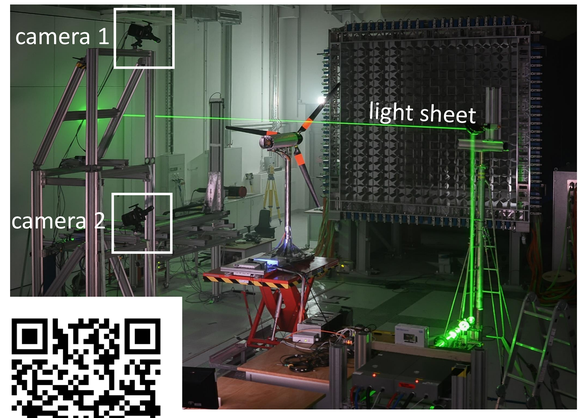
- TSR 6
- Baseline pitch and torque control
- Collective pitch control (CPC)
- Wake/wind farm investigations

Radius resolved induction distribution



- Application of method by Herráez et al. [4]
- 1-point measurement with 2-D LDA in bisectrix of blades
- Axial- / tangential induction by axial- / tangential velocity in rotor plane

Local aerodynamics in rotating system



← VIDEO + MORE INFO

- High speed 2D3C PIV system (max 10 kHz)
- Cyclic triggered measurements
- Stall by dynamic pitching (IPC) / turbulent inflow planned
- Measure/visualize dynamic stall in rotating system

Conclusions

The experimental setup enables fast testing of different control algorithms and rotor concepts in realistic and repeatable inflow conditions and with realistic model wind turbine behaviour.

References

[1] L Kröger et al. 2018 *J.Phys.: Conference Series* 1037
[2] F Berger et al. 2018 *J.Phys.: Conference Series* 1104
[3] J Schottler et al. 2016 *J.Phys.: Conference Series* 753
[4] I Herráez et al. 2018 *Wind Energy Science* 3(1)

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