Experimental Study of Turbulence Influence on Wind Turbine Performance and Wake Recovery

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Introduction

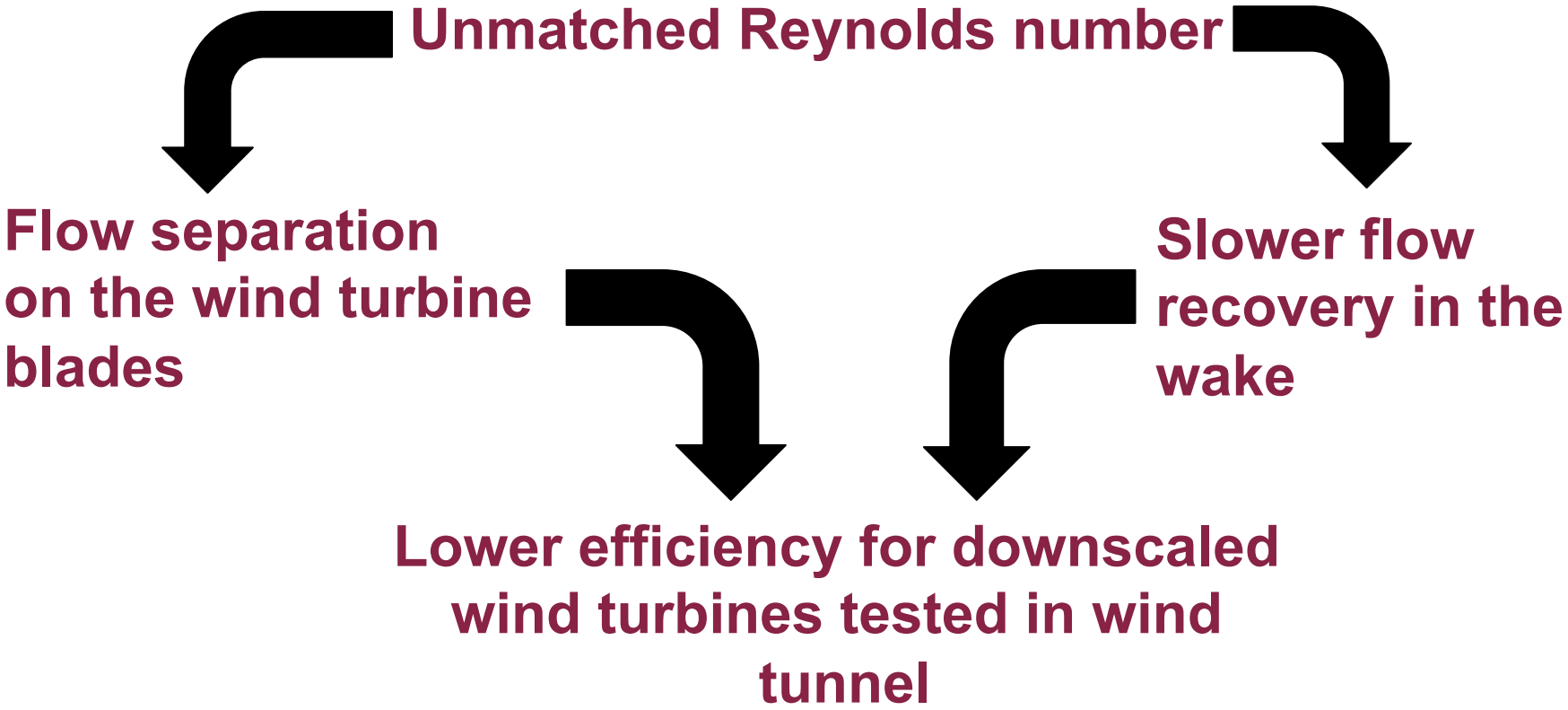
The used of downscaled wind turbine models represents a limitation for wind tunnel testing.

vs.

Outline

- Introduction
- Problem statement
- Approach
- Methodology
- Results
- Conclusions

Problem statement



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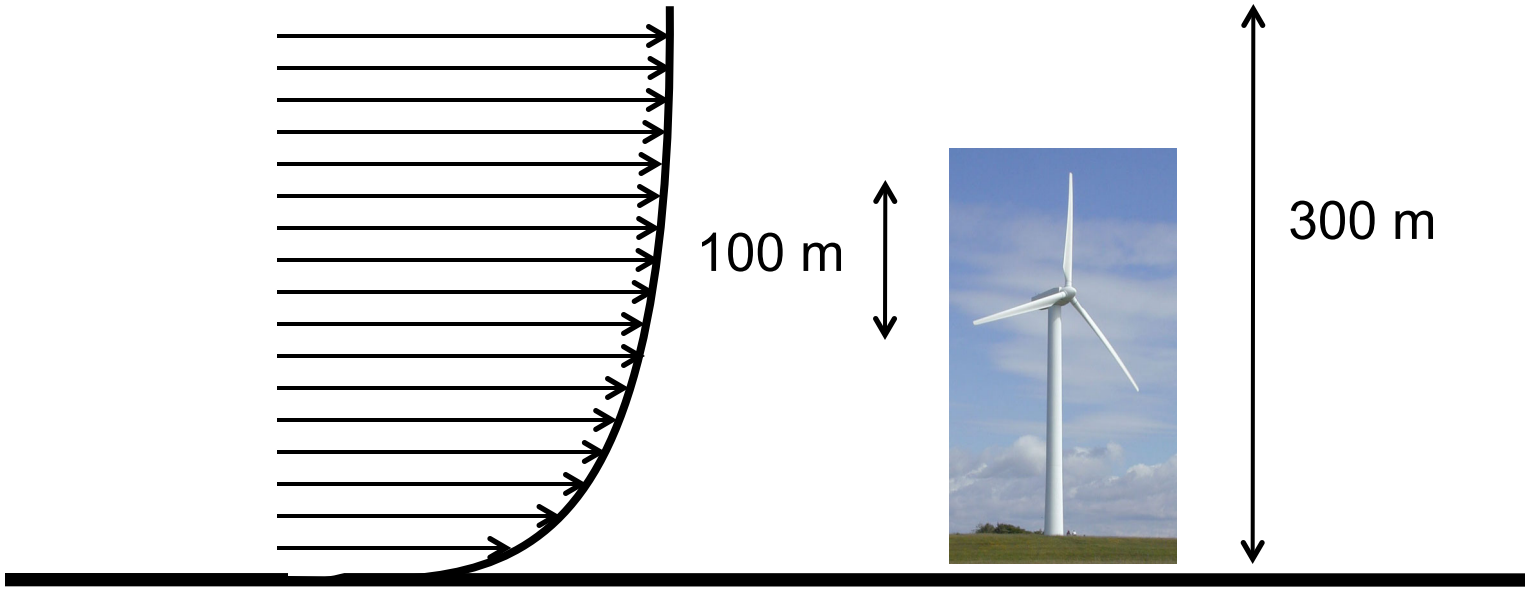
Approach

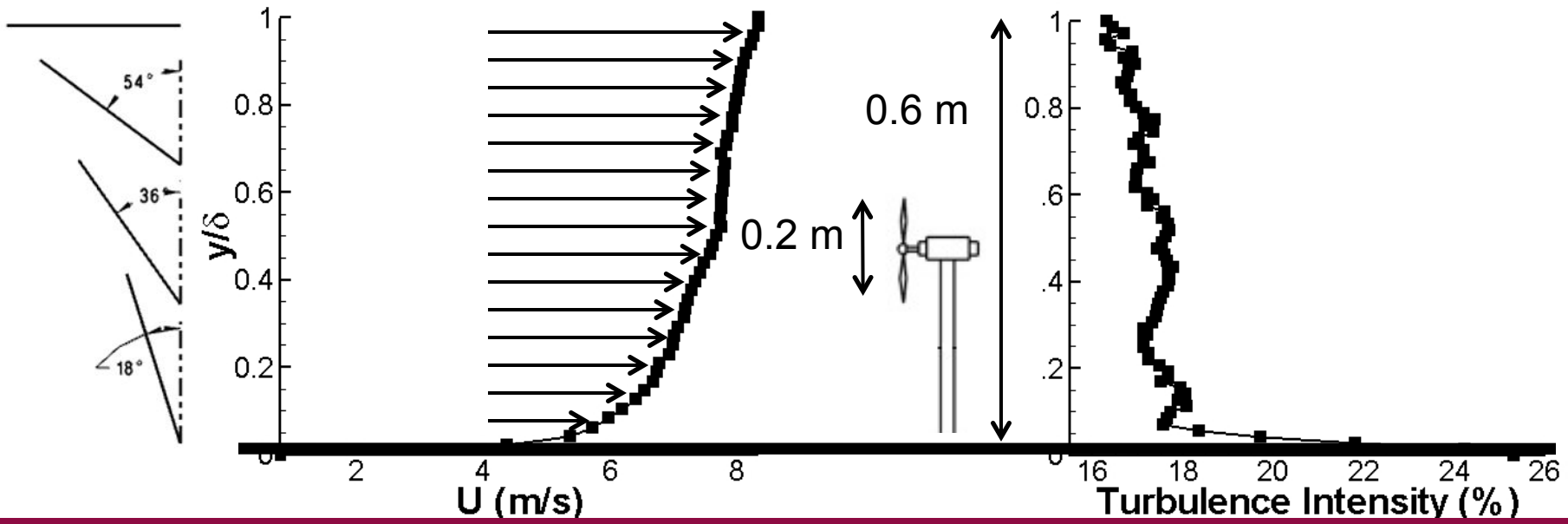
- Create turbulence in the flow with the help of an active grid system installed at the beginning of the wind tunnel

Atmospheric Boundary Layer

Wind turbines in the field work inside the boundary layer, therefore this has to be mimic



Scaled Atmospheric Boundary Layer



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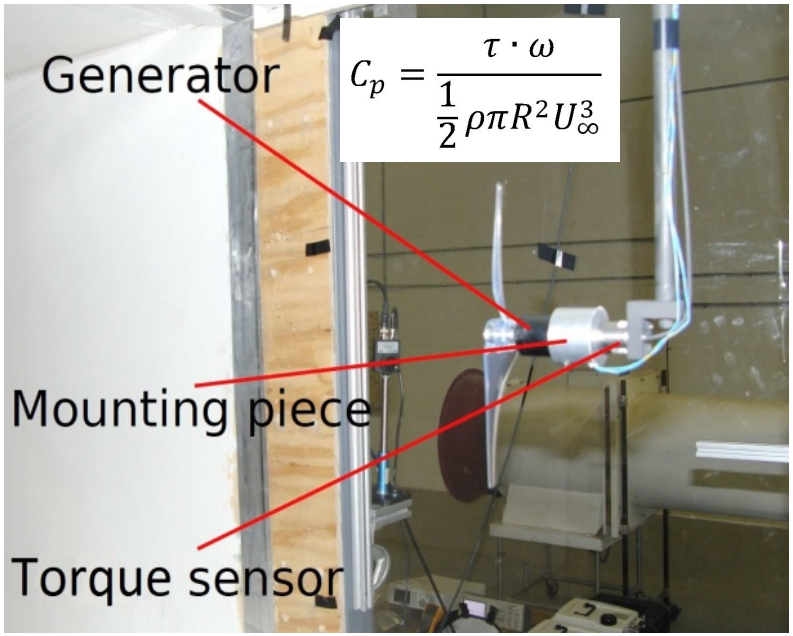
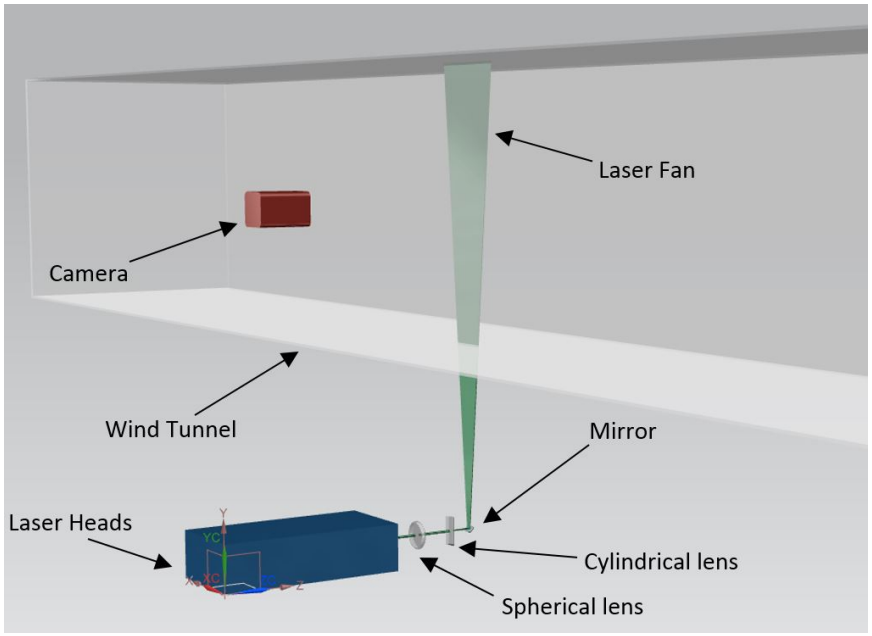
Methodology

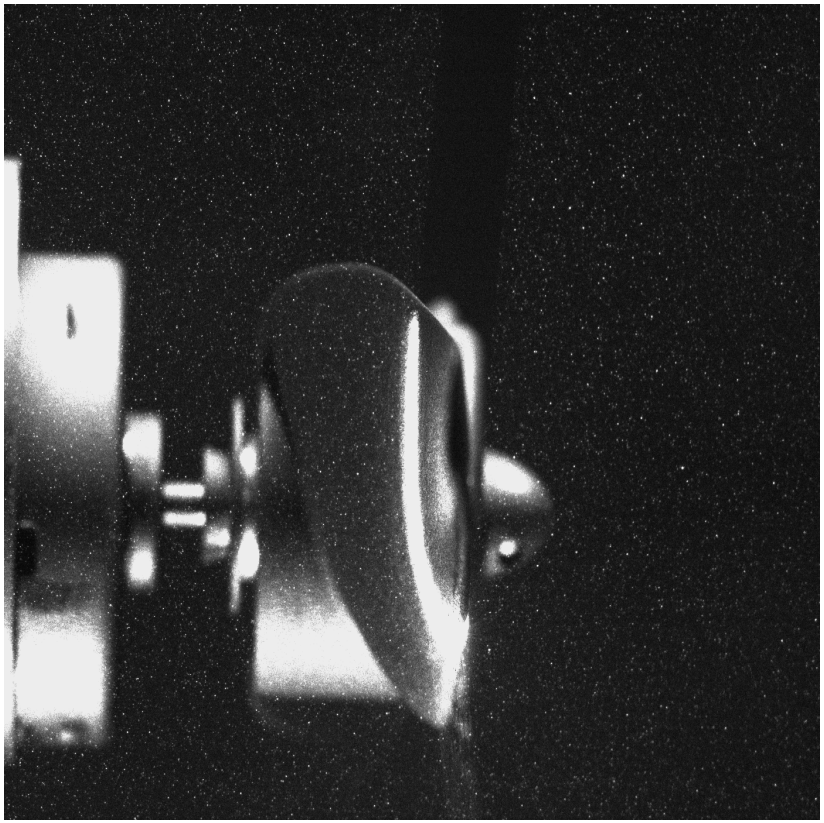
Torque measurements to calculate the efficiency



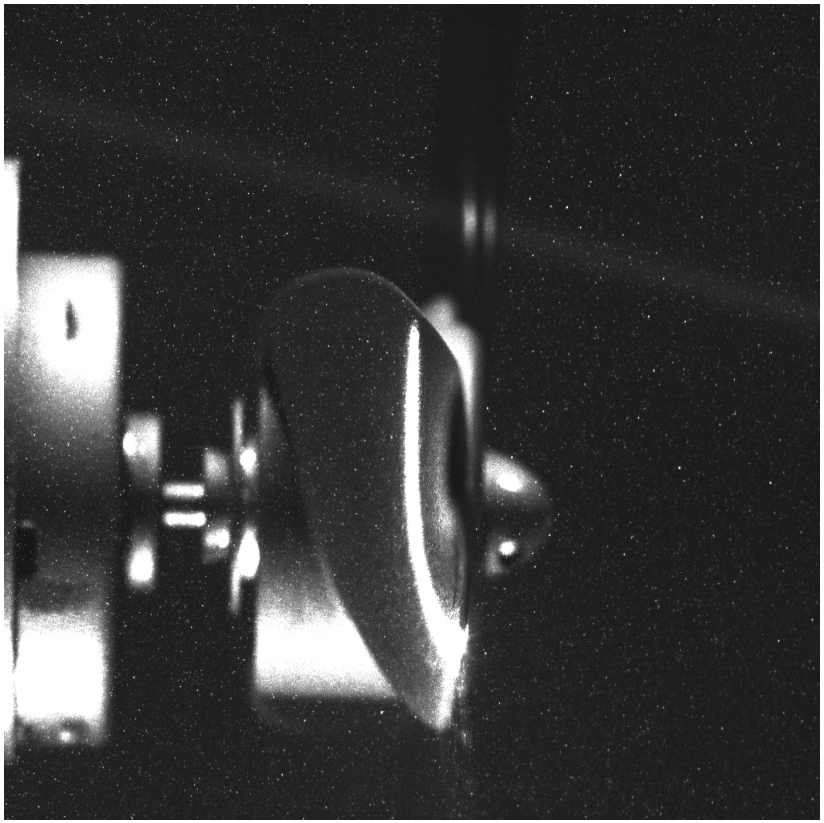
PIV measurements to investigate the velocity profiles



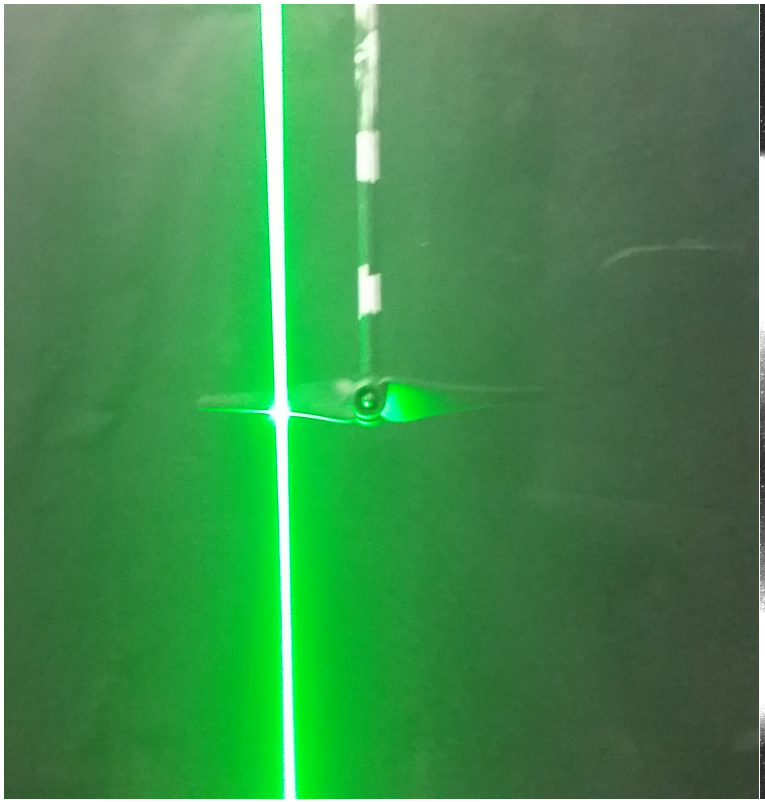
PIV image pair example. Image A

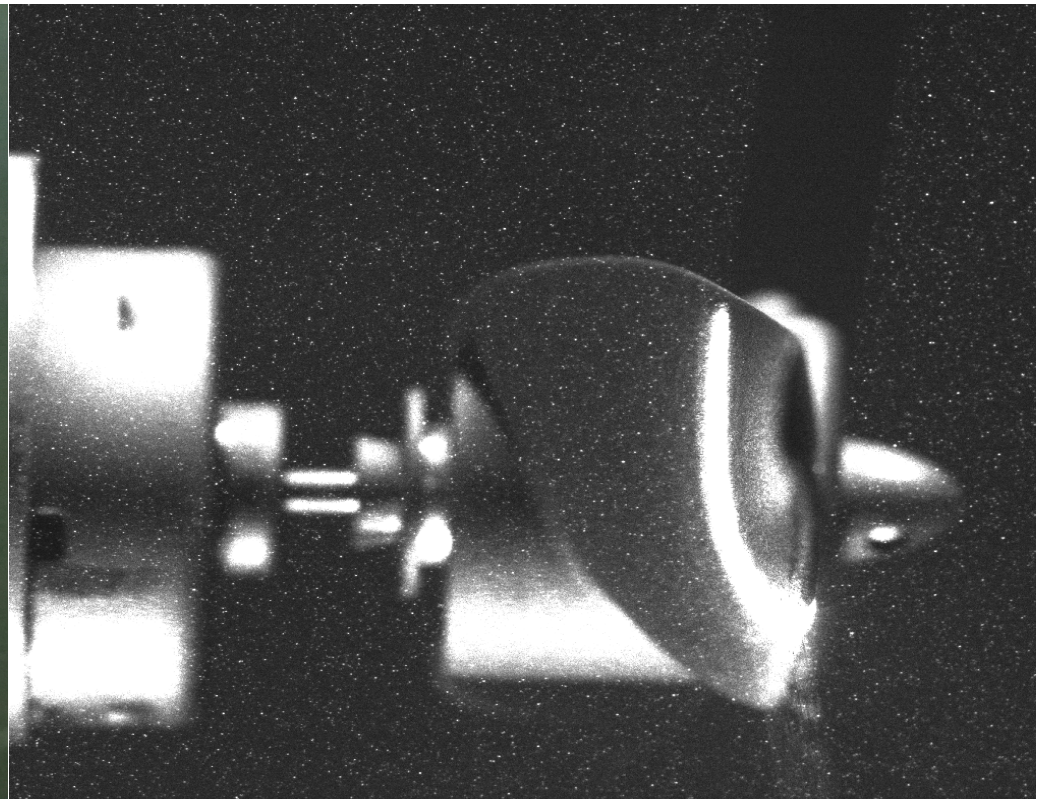


PIV image pair example. Image B



Flow separation around the wind turbine blade





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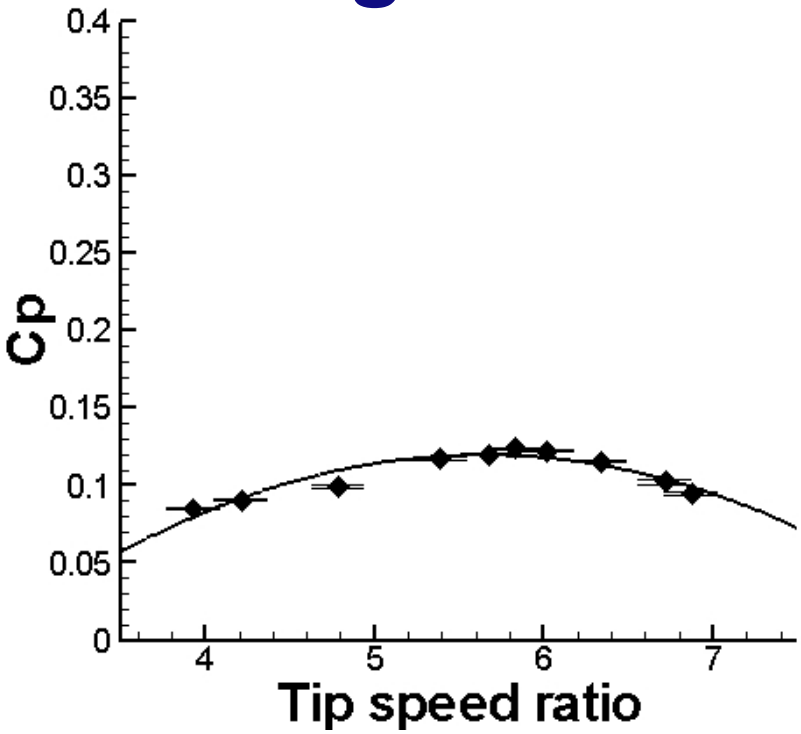
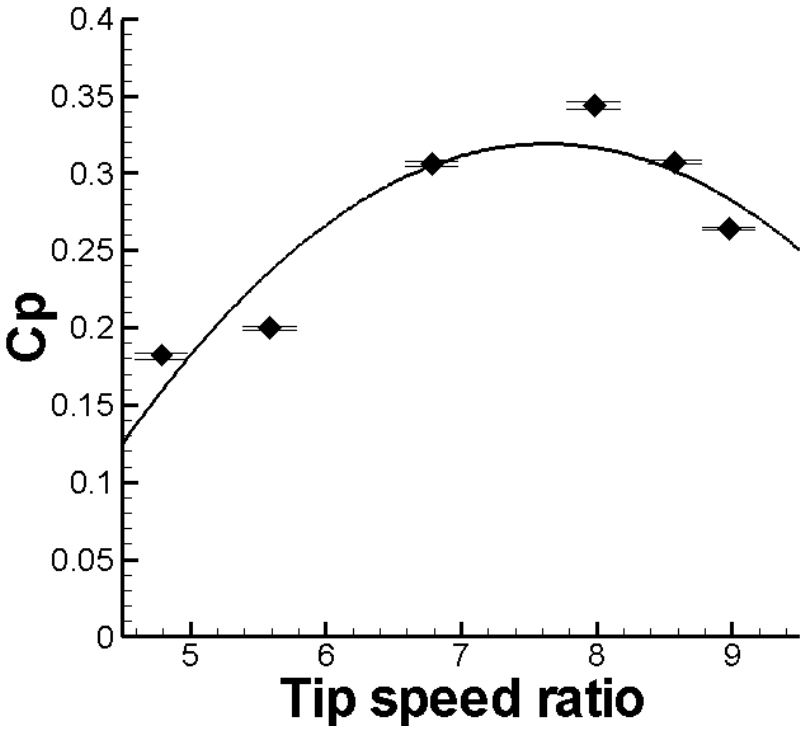
Turbulence intensity influence to C_p of a single turbine

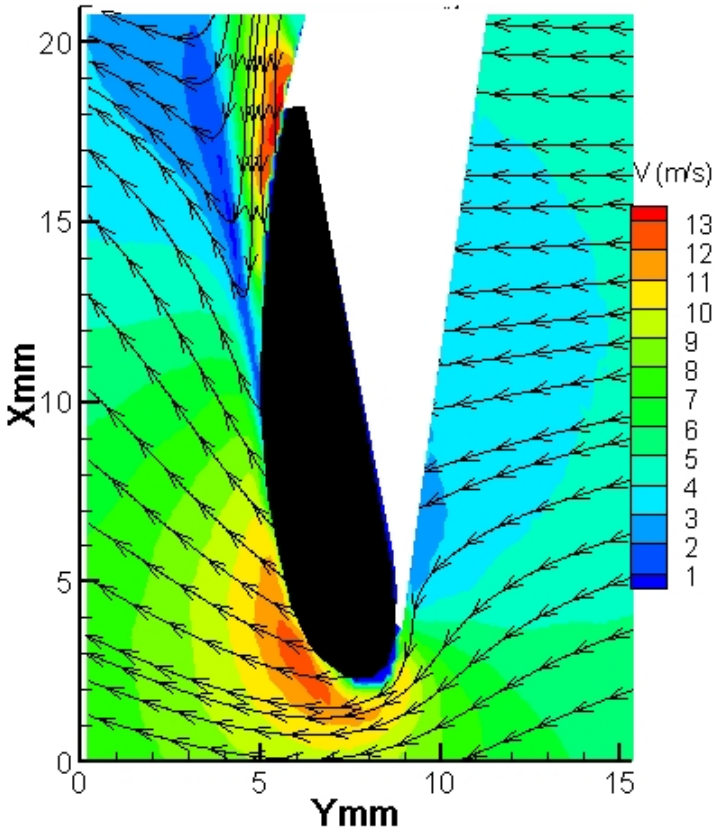


Laminar Inflow

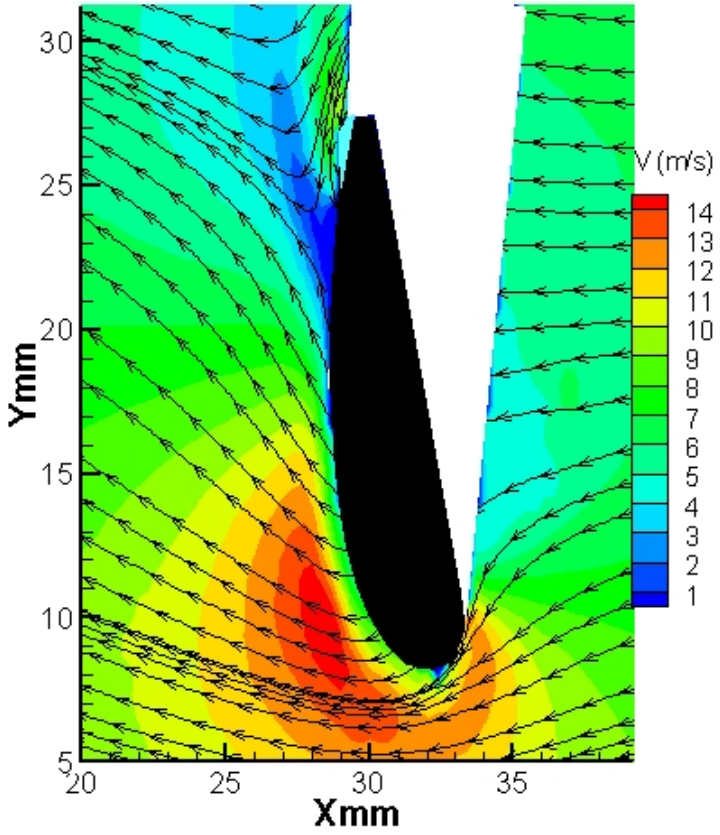


Turbulent Inflow

Flow separation around the wind turbine blade

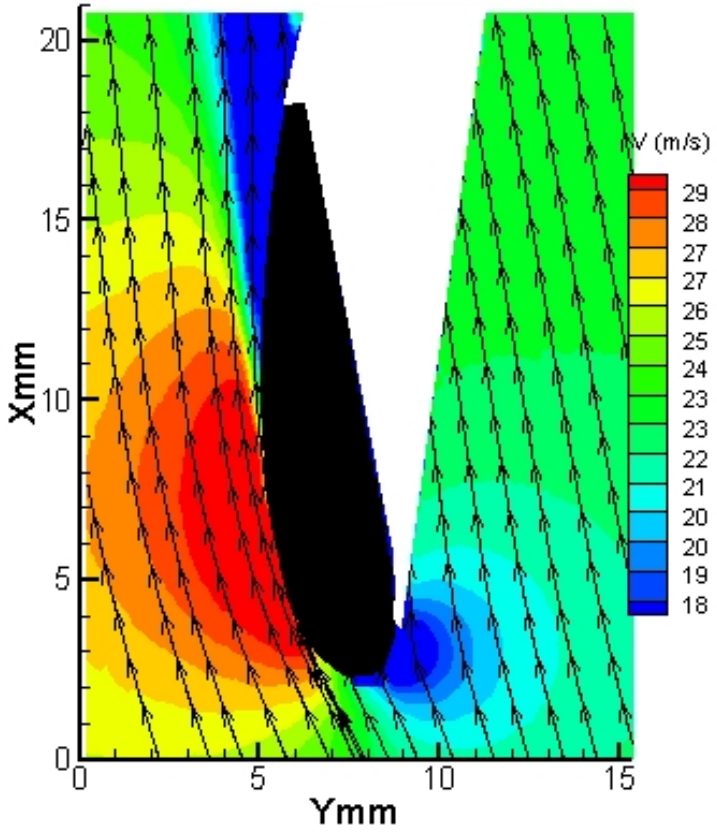


Laminar Inflow

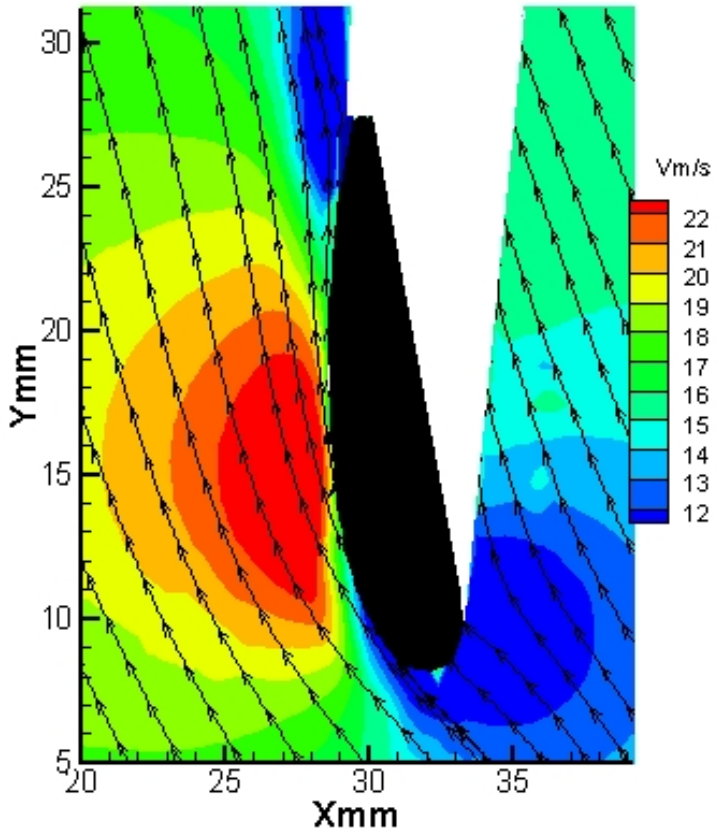


Turbulent Inflow

Including the relative velocity due to the angular velocity of the blade



Laminar Inflow



Turbulent Inflow

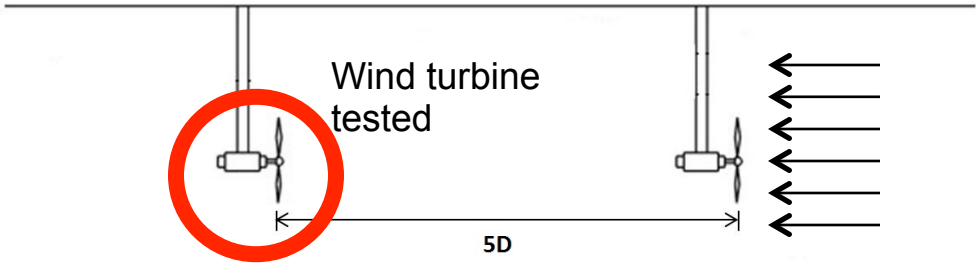
Influence of turbulence intensity to wind turbine array

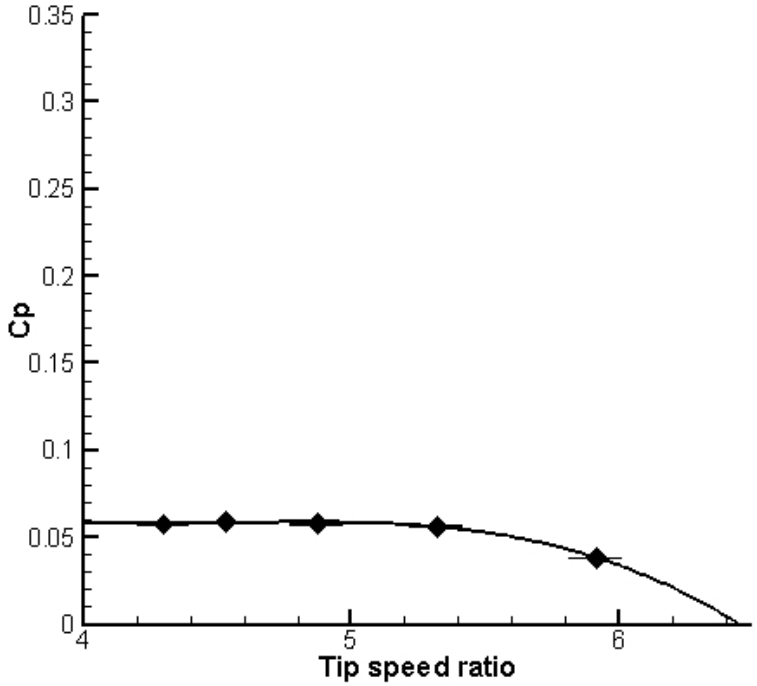
Wind turbine tested

Results

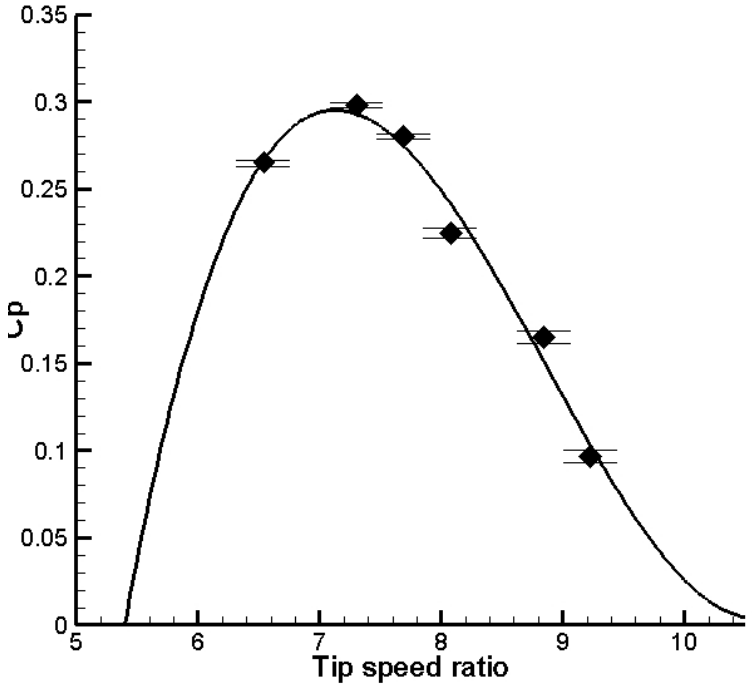
Torque measurements

5 diameters



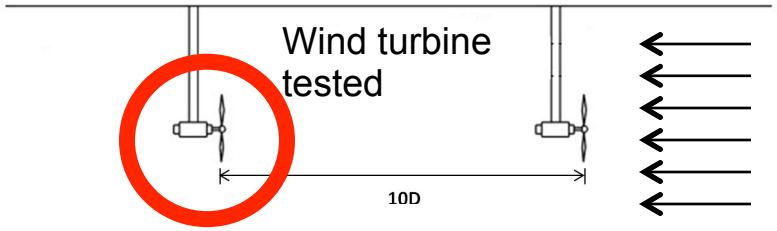


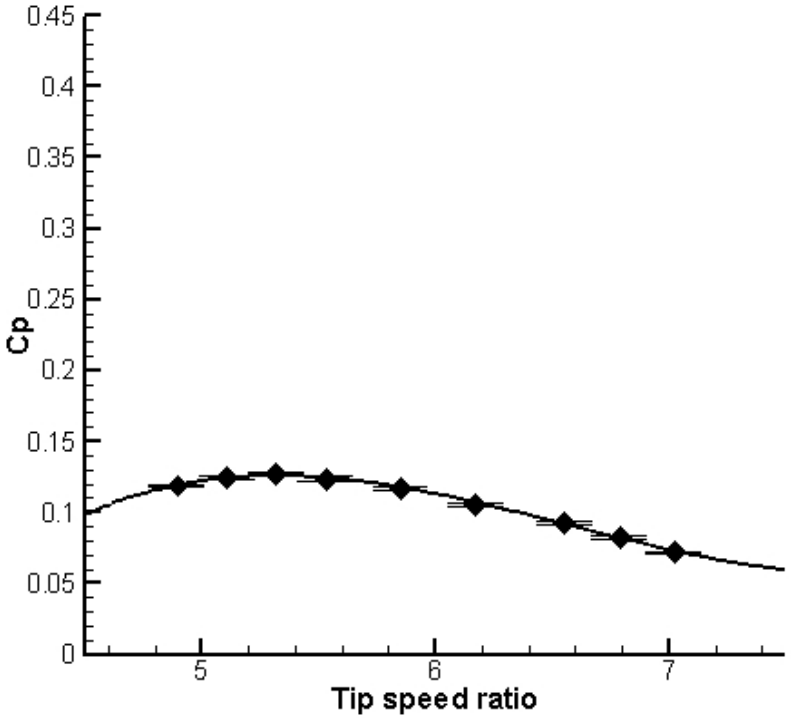
Laminar Flow

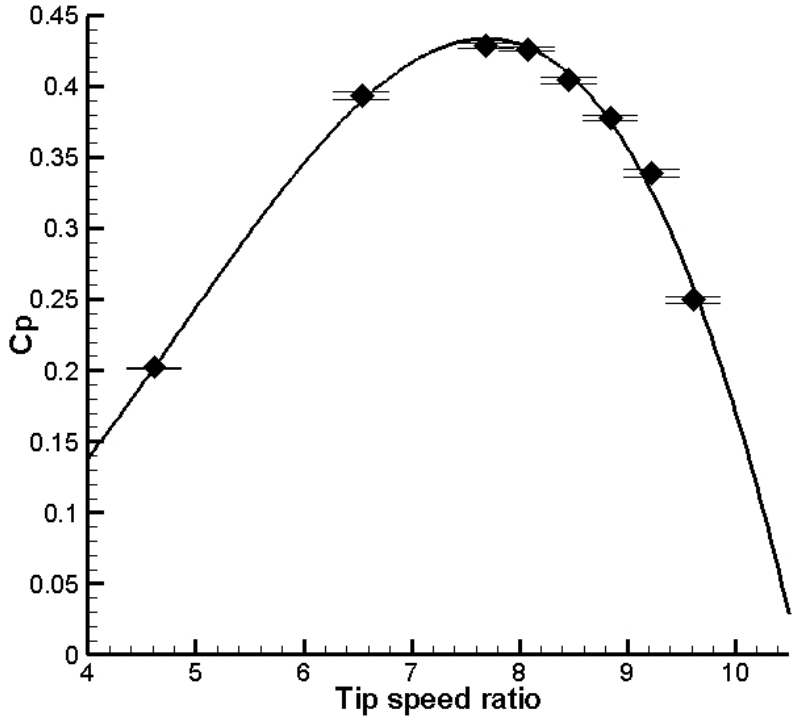


Turbulent Flow

10 diameters



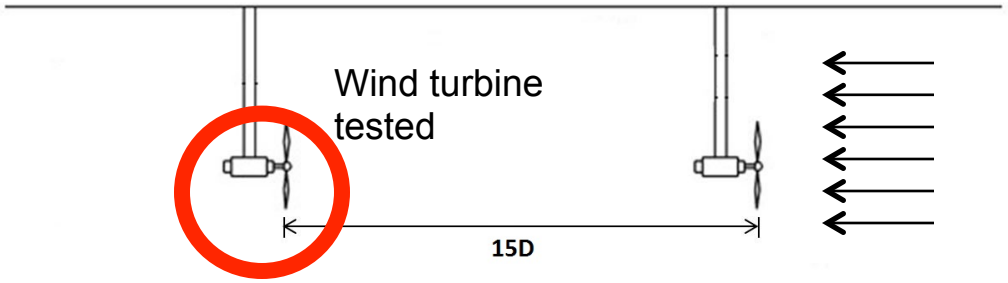


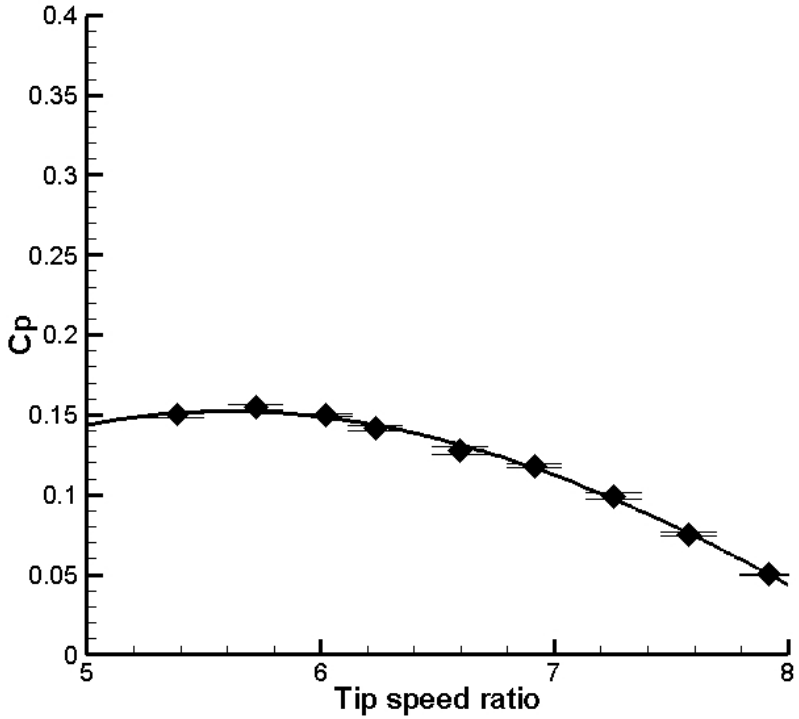


Laminar Flow

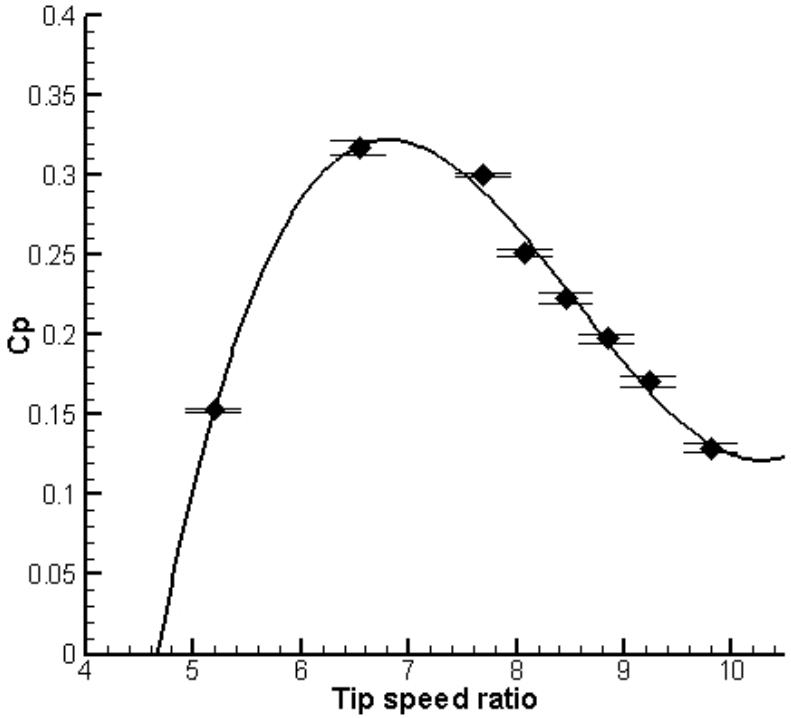
Turbulent Flow

15 diameters





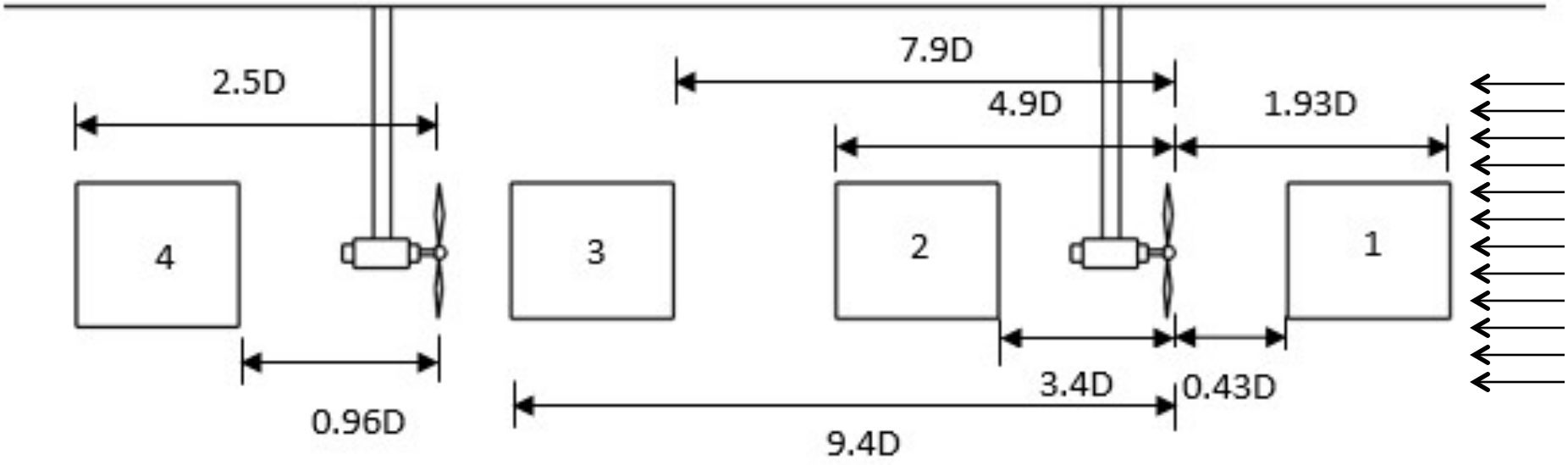
Laminar Flow



Turbulent Flow

Influence of turbulence intensity to wake recovery

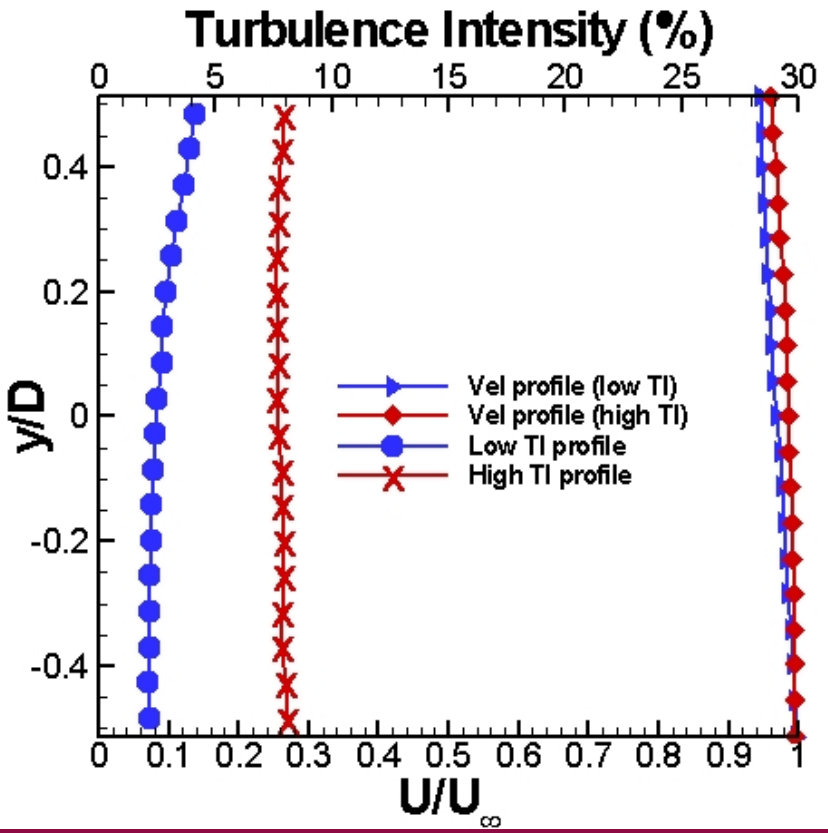
PIV test sections



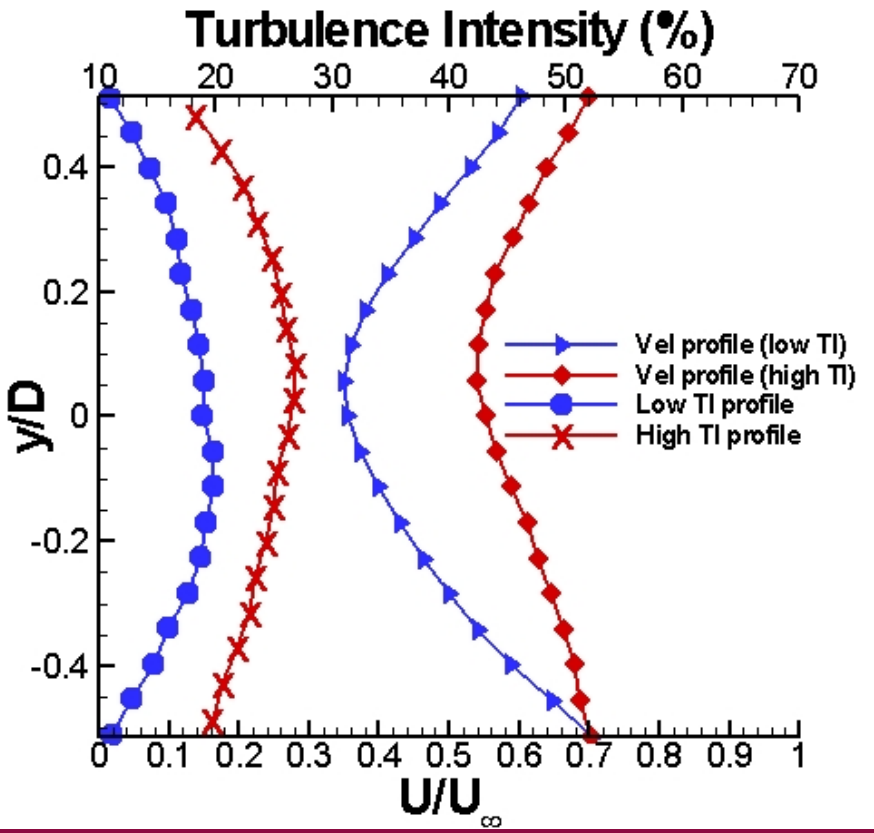
PIV Results

FWT= First Wind Turbine
SWT= Second Wind Turbine

Section 1. x/D=-0.93 to FWT

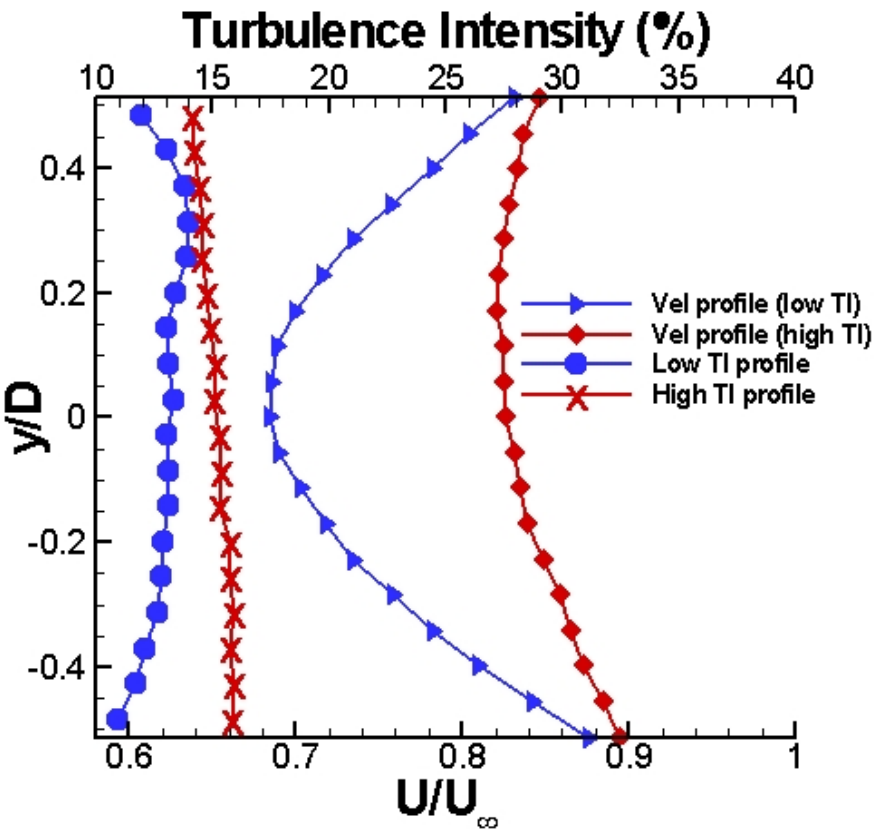


Section 2. x/D=3.65 to FWT

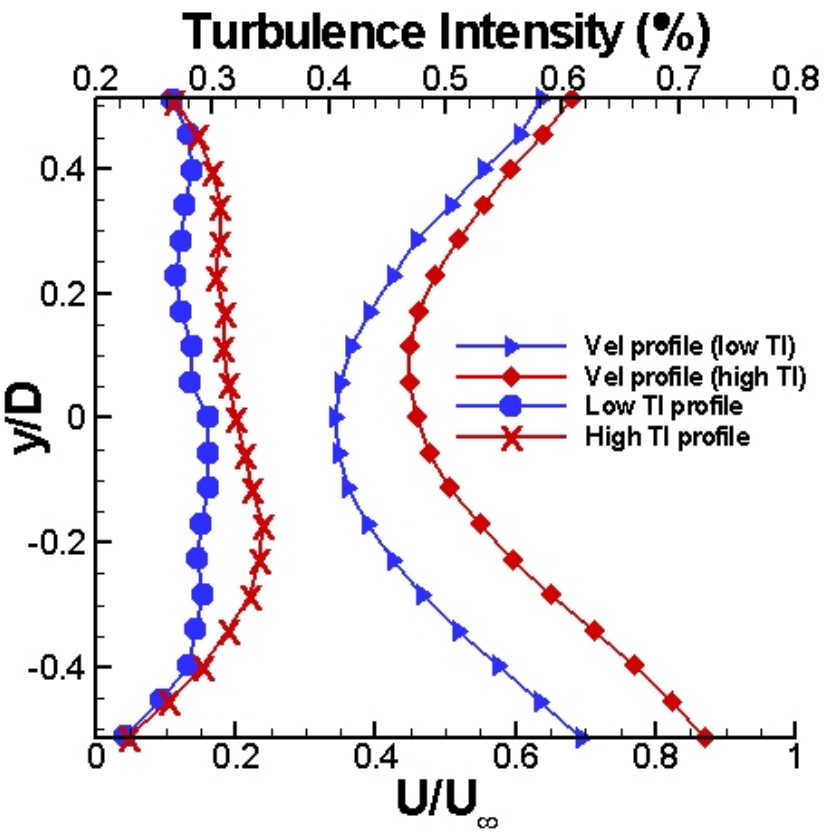


FWT= First Wind Turbine
SWT= Second Wind Turbine

Section 3. x/D=8.4 to FWT



Section 4. x/D= 1.46 to SWT



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Conclusions

- Wind turbines tested in laminar wind tunnels does not mimic the field situation, since a lower performance is presented.
- Wind turbines tested with turbulent inflow have a more realistic efficiency, even though the unmatched Re number.
- Using of an active grid system is effective way to generate controllable turbulence intensity and get realistic wind turbine test results in wind tunnels.
- Flow separation in the suction side of the wind turbine blades highly depends on the inflow turbulence intensity.
- The flow recovery in the wake highly depends on the turbulence intensity.
- Wind turbine performance highly depends on the flow separation of the wind turbine and the flow recovery on the wake, therefore on the turbulence intensity.

Questions???