# Experimental study of the effects of topography on wind turbine wakes and power output.

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Due to the need to develop renewable energies, there has been a growing interest in wind power in the past two decades. Various types of equipment exist to harvest energy from the wind, however at present the sector is dominated by horizontal axis wind turbines. The performances of such wind turbines are known to be affected by the characteristics of the incoming flow. In particular the power production has been shown to be related to the mean wind speed and the fatigue of the blades to the turbulence intensity. The atmospheric boundary layer, in which the turbines operate, is also known to be affected by the surface of the earth, and yet little is known on the interaction between topography and wind turbines.

To investigate this matter, experiments are being carried out in the wind tunnel of the WIRE laboratory at EPFL, Switzerland. It is a suck-down wind tunnel with a test section of dimensions 28m x 2.5m x 2m and running with a free stream velocity of up to 8m/s. A stand-alone three-blade turbine with a rotor diameter D=127mm on a 107mm mast is mounted on a cliff-like forward facing step 1D-high. The step and the turbine are placed in an incoming boundary layer 700mm thick with a turbulent intensity of 6.5%. The angular velocity (RPM) of the blades was measured with a laser tachometer and the three components of instantaneous velocity were measured at various locations downstream using multi-hole pressure probes.

The angular velocity measurements with the turbine at various streamwise positions show a peak in RPM at 1D behind the front of the step. This peak represents an increase of about 50% compared to the minimum found with the turbine 5D further downstream. Preliminary measurements of the flow above the step without turbine show that the mean flow at turbine height is accelerated at that location due to the constriction of the step. Velocity measurements in the turbine wake were consequently carried out with the turbine 1D behind the front of the step. Two regions can here be distinguished. In the near wake (up to 2D downstream the turbine) the velocity deficit remains fairly symmetrical (once the incoming flow is subtracted) despite the strong vertical inhomogeneity of the incoming flow. The turbine has here an enhancing effect on the turbulent intensity in the top half, and a dampening effect in the bottom half. In the far wake however, whereas wind turbines are typically considered to have an enhancing effect on turbulence levels, the turbulence intensity is clearly dampened throughout the wake. The recovery of the wake is here faster in the upper part and the maximum velocity deficit is shifted toward the height of the bottom tip of the turbine blades. Overall, the recovery proves to be faster than that of a turbine in a similar boundary layer but without step.

These preliminary results show the complexity of the interaction of topography and wind turbines in the case of a forward-facing step. Different types of ramps from the wind tunnel floor to the top of the step are now being tested and the latest results will be presented during the course of the conference.

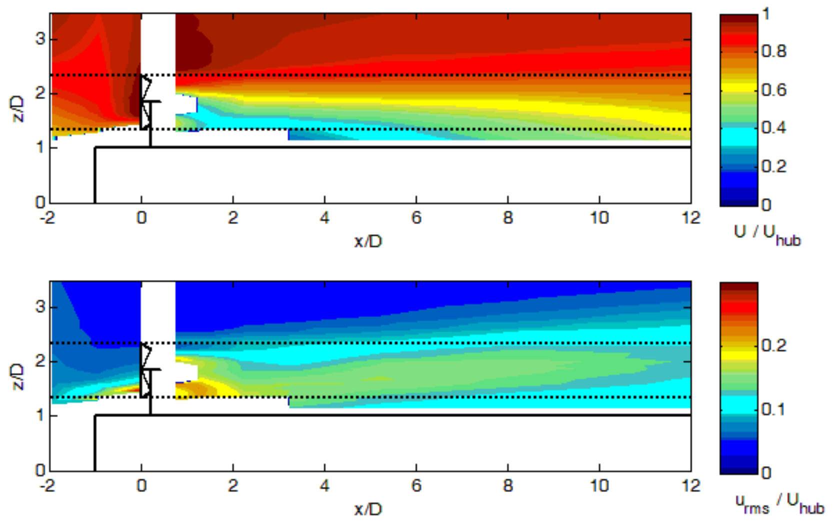


Fig. 1: Normalised mean velocity and turbulence intensity in the streamwise direction.