WIND RESOURCE ASSESSMENT BY PHYSICAL MODELLING IN THE WIND TUNNEL

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In the fast development of wind energy, wind resource assessment is a major concern. The evaluation of the wind potential of a site is needed for the prediction of the annual energy production, the calculation of the wind farm profitability and the choice of the wind turbine design. The decrease of the uncertainty on long-term annual energy production forecasting and on the local wind conditions forecasting are important targets of the EU program. The difficulty of the prediction depends on the complexity of the terrain where the wind farm is situated.
This challenge comes together with the fact that lots of high wind potential sites with good accessibility are exploited or under project. Therefore, the expansion of wind energy capacity goes through the development of reliable tools for wind assessment in complex terrains like hills, mountains, forests, ridges, cliffs or even cities.

For the prediction of the flow over very complex terrain, like slopes greater than 15%, linear models fail and CFD is at a research state. For complex sites, wind tunnel has its rule to play. Physical modelling of atmospheric flows is a common tool in pollution dispersion, for the study of the wind over forests or on simplified geometry but it is still a confined tool in wind resource assessment. As for numerical modelling, the physical modelling needs to satisfy modelling assumptions, to meet similarity requirements, and to reproduce inflow conditions.

The aim of this work is to demonstrate the suitability of wind tunnel tests for wind assessment in mountainous terrains and to discuss important modelling issues encountered.

The reproduction in the wind tunnel of atmospheric inflow conditions is one of the main subject; in function of the type of terrain to model (open sea, landscape, forest or city) and the scaling factor in the wind tunnel, roughness elements have to be placed in the test section to develop velocity and turbulent profiles that model the type of terrain desired (fig. 1). Additionally, the turbulent spectrum has to be matched.
Other modelling parameters like the choice of the scaling of the terrain, the choice of the modelled area, the roughness of the model or, more specifically related to physical modelling, the relaxation of the Reynolds number, are crucial questions tackled.
A measurement strategy in three steps is also proposed in the wind tunnel to measure the wind resource on a complex terrain: qualitative assessment of the high wind area with a sand erosion technique, then 2D2C planar measurements with Particle Image Velocimetry (PIV, fig. 2) and finally punctual time resolved measurements of the three components of the velocity by hot-wire anemometry.

Figure 1 : Modelling of atmospheric inflow conditions

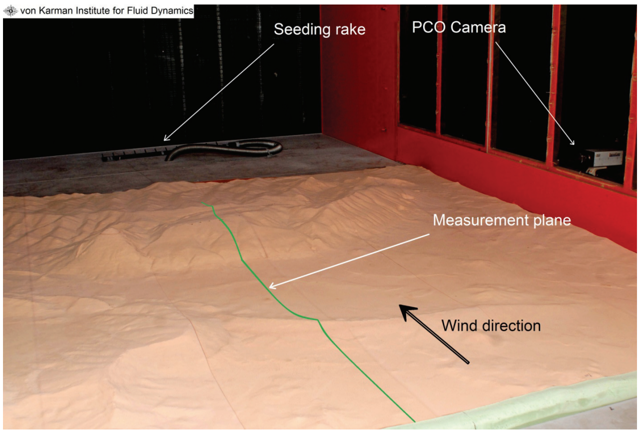

Figure 2 : Mountain model in the test section with PIV set-up