COOLWinD SOLVER FOR
OFF-SHORE WIND FARM SIMULATIONS

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Over the years, Computational Fluid Dynamics is becoming more and more important in the simulation of wind farm flows. Despite the higher computational cost with respect to simpler analytical models, it remains appealing thanks to the possibility of introducing more sophisticated and accurate physical models. In the industry, analytical models are still vastly used for their simplicity and low computational costs but their usage is limited to simple cases and case-specific tuning of parameters are often required. In the last few years the investments are focusing on the development of large off-shore wind farms where the effect of the wakes on the other turbines becomes crucial. For such cases, the simple analytical models are not the right answer and CFD models become important tools to predict the efficiency of the wind farm.

In the present work, we present the result of the collaboration between VKI, the university VUB and the company 3E on the development of a package for off-shore wind farms simulations. In particular, we make a comparison between the newly developed CFD solver called COOLWinD and several other software on the same off-shore test-cases. This solver is written within COOLFluiD framework and uses a finite elements technique to solve the k-epsilon RANS equations. The solver COOLWinD has already been applied to on-shore atmospheric flows.

The wind turbines are modeled by uniform actuator discs. This solution is suitable for large wind farm computations as, compared to full rotor modeling, it drastically reduces the number of required degrees of freedom, retaining a sufficient accuracy.

The development of this tool involved several tasks. The solver itself has been developed and adapted to atmospheric flows simulation by introducing a suitable formulation of the wall functions for the simulation of atmospheric boundary layers. Subsequently, wind turbine models have been developed. They make use of the actuator disc principle. The turbulence model has also been adapted, to take into account the interaction of different turbulence scales that takes place within the wind turbine wake region. In other words, additional terms had to be added to the k-epsilon equations to take into account the overproduction of turbulence intensity in the wake region. Eventually, to generate the meshes for all the cases simulated, an ad-hoc mesh generator has been developed.

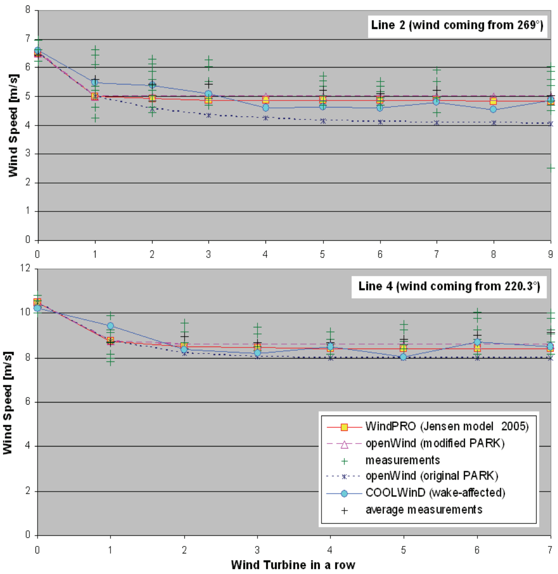

Figure 1 : Comparison between COOLWinD and other commercially available software on Horns-Rev

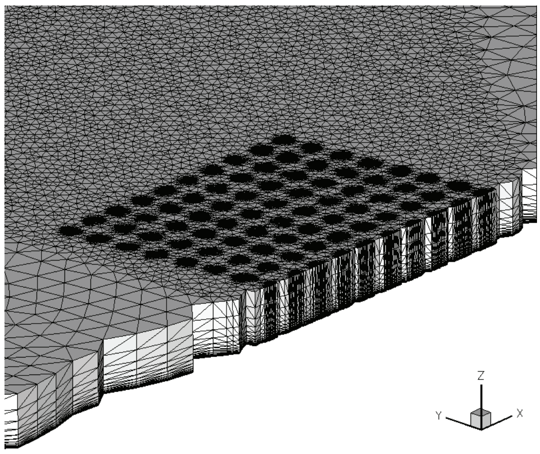

Figure 2 : Mesh used for the simulation of the Off-shore wind farm Horns-Rev