

Assessing Wind Turbines Potential Thanks to CFD

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The energy provided by a wind farm is a function of local wind parameters (velocity, direction, variations). An accurate knowledge of these parameters could bring a substantial increase in the power output of a wind farm, thereby improving its viability and effectiveness. Usually, the assessment of the local wind parameters is carried out by on-site measurements during at least one year, since wind conditions can vary significantly depending on the seasons. However, this is often insufficient because of year-to-year variations. Then, long term records are required. These experimental measurements can be fastidious and expensive. Moreover, they provide only a local information. Therefore, numerical simulation tools prove to be valuable and accurate, provided that the wind field and local turbulence are correctly reproduced.

Rather new in the field of environment, but used for quite some time in aeronautics and industrial applications, computational fluid dynamics (CFD) methods can provide a very elegant and efficient solution. It will help for a quick assessment of wind turbines potential and for an optimised turbine location, thus offering to turbine developers a reliable and high-precision tool capable of generating a wind field atlas for any wind turbine siting. A CFD tool, *fluidyn*-PANEOLE, developed by TRANSOFT International, dedicated to mesoscale and microscale analysis of a site for wind turbines energy potential prediction is presented here through an example of a wind farm located in Corsica.

The numerical model of the terrain (topography and land usage) is created thanks to Ordnance Survey maps, as well as imported GIS files. The curvilinear computational mesh is generated automatically and follows closely the terrain so that the boundary layer is correctly represented. Then, meteorological conditions obtained from the nearest meteorological station are used for the wind initialisation. The Navier-Stokes equations are solved taking into account 3D terrain features, atmospheric stability and possible inversion layers, including practical turbulence models. The generated wind field atlas includes local boundary-layer effects such as flow detachment, Venturi effects between hills or large buildings, surface-roughness-generated turbulence, or sea breeze. Finally, the energy potential of the site for various kinds of turbines is calculated. Results are visualised as wind-power-density contours on the imported map or in a tabular format. In this particular example, the results have helped finding an efficient location for wind turbines in a very hilly region of the island of Corsica.

Knowledge of local wind parameters could bring an increase in the power output of a wind farm, thereby improving its viability. The classical method, on-site measurements, is very limited both spatially and temporally. A numerical tool using CFD, *fluidyn*-PANEOLE, is presented based on the example of a wind farm in Corsica. Based on topography, land-usage, and meteorological data from the nearest meteorological station, the software computes the energy potential of the site for various kind of turbines. Results have shown the best location for wind turbines. CFD offers a reliable and precise tool to generate a wind field atlas for any wind turbine siting.

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Assessing wind turbines potential thanks to CFD

The energy provided by a wind farm is a function of local wind parameters (velocity, direction, variations). An accurate knowledge of these parameters could bring a substantial increase in the power output of a wind farm, thereby improving its viability and effectiveness. Usually, the assessment of the local wind parameters is carried out by on-site measures during at least one year, since wind conditions can vary significantly depending on the seasons. However, this is often insufficient because of year-to-year variations. Then, long term record are required. These experimental measures can be fastidious and expensive. Moreover, they will provide only a local measurement.

Therefore, the numerical tool proves itself to be a valuable and accurate tool, provided that the wind field and local turbulence are correctly reproduced.

Rather new in the field of Environment, but used for quite some time in aeronautics and industrial applications, the computational fluid dynamics (CFD) methods can provide a very elegant and efficient solution. It will help for a quick assessment of wind turbines potential and for a optimised wind turbines location, thus offering, to the wind turbines developers, a reliable and high precision tool capable of generating a wind field atlas for any wind turbine sitting.

A CFD tool, *fluidyn-PANEOLE* developed by TRANSOFT **International**, dedicated to meso and micro scale analysis of a site for wind turbines energy potential prediction can be a decision tool to choose the best site to set up a wind farm.

The 3D numerical model of terrain representing the potential wind farm site is created based on Ordnance Survey maps or GIS files. It takes into account the land usage and the topography of the site, that will control the local wind field and then the wind turbines potential. A 3D curvilinear mesh is generated over the terrain, following closely the altitudes contours so that the boundary layer is correctly represented. This mesh is refined near the potential wind turbine placements in order to get a fine description of the wind field closed to them.

Figures 1 and 2 show a numerical model of terrain and the associated body fitted mesh.

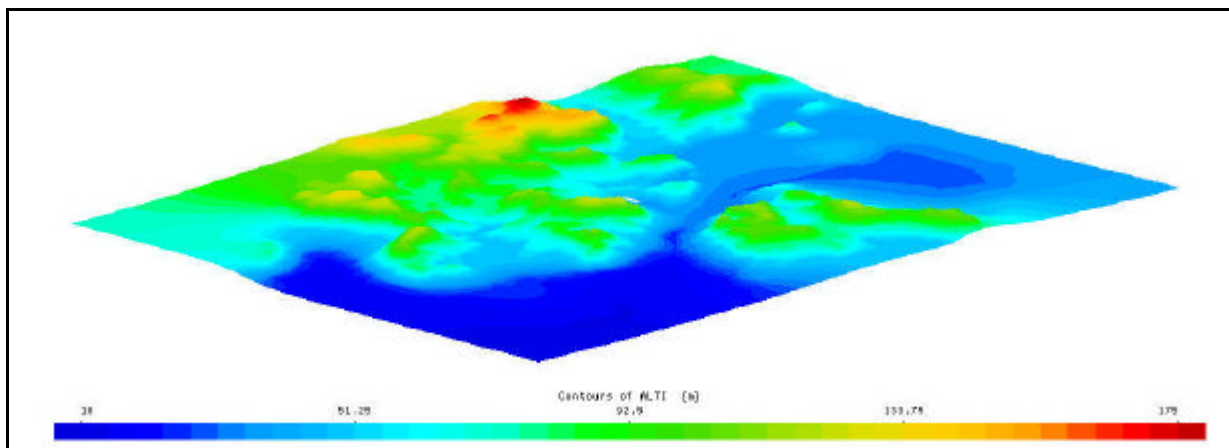


Figure 1 : Altitude contours on the numerical model of terrain

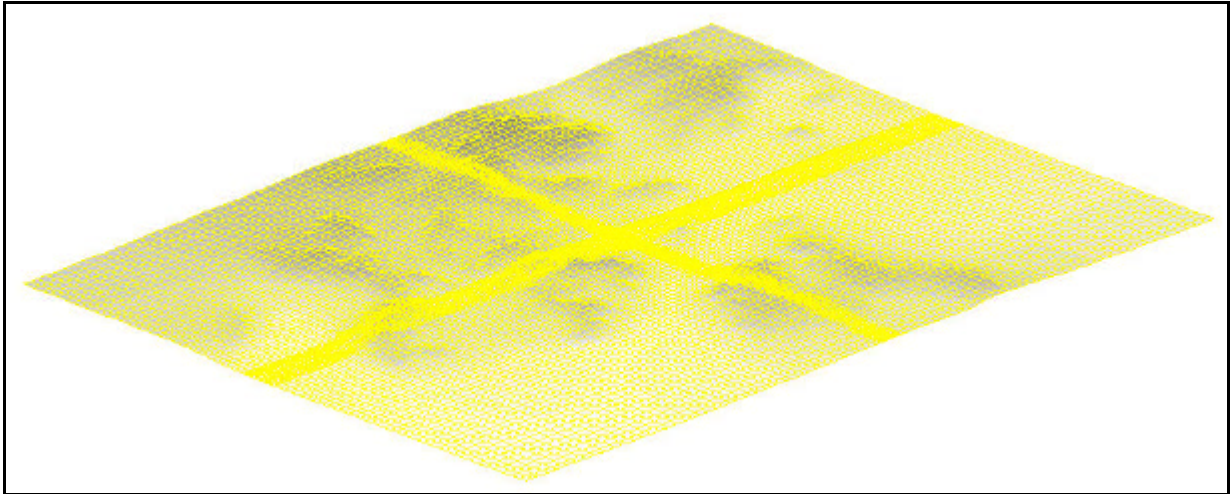


Figure 2 : Curvilinear body fitted mesh

Meteorological conditions coming from the nearest meteorological station are used for the wind initialisation. Initial wind conditions are put at the domain limits far from the wind turbines emplacements. Then, Navier-Stokes equations are solved taking into account the 3D terrain features and atmospheric stability and possible inversion layers with the well-known k-e turbulence models. The generated wind field atlas includes local boundary layers effects such as flow detachment, Venturi effects between hills or large building, surface roughness generated turbulence or sea breeze.

Once, the wind field calculation is done, it is possible to visualize its physical parameters, like the wind speed, direction, turbulent energy in all the domain, as shown by the figures 3 and 4.

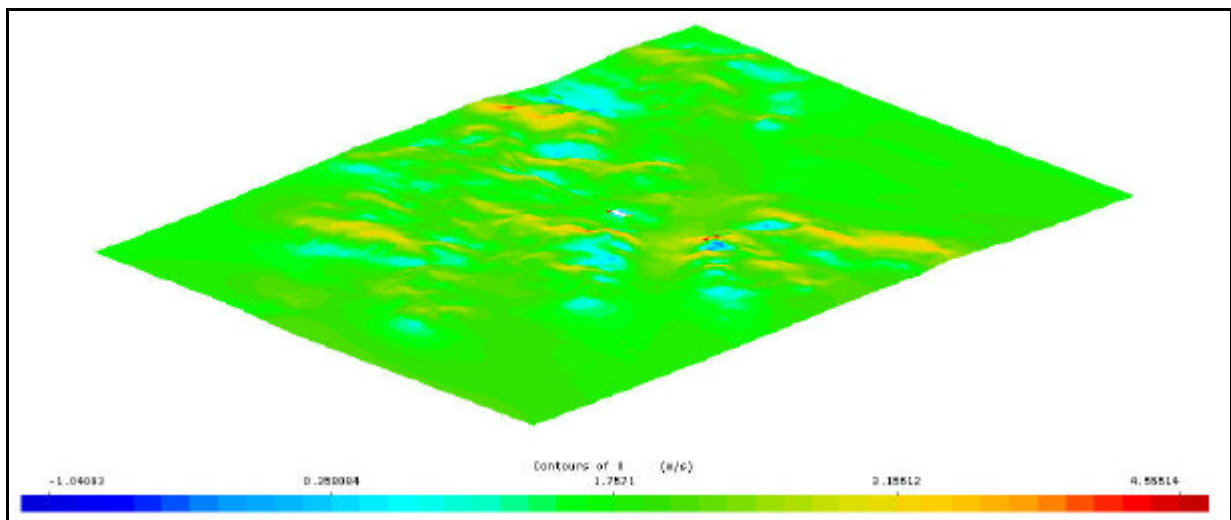


Figure 3 : Contours of wind speed

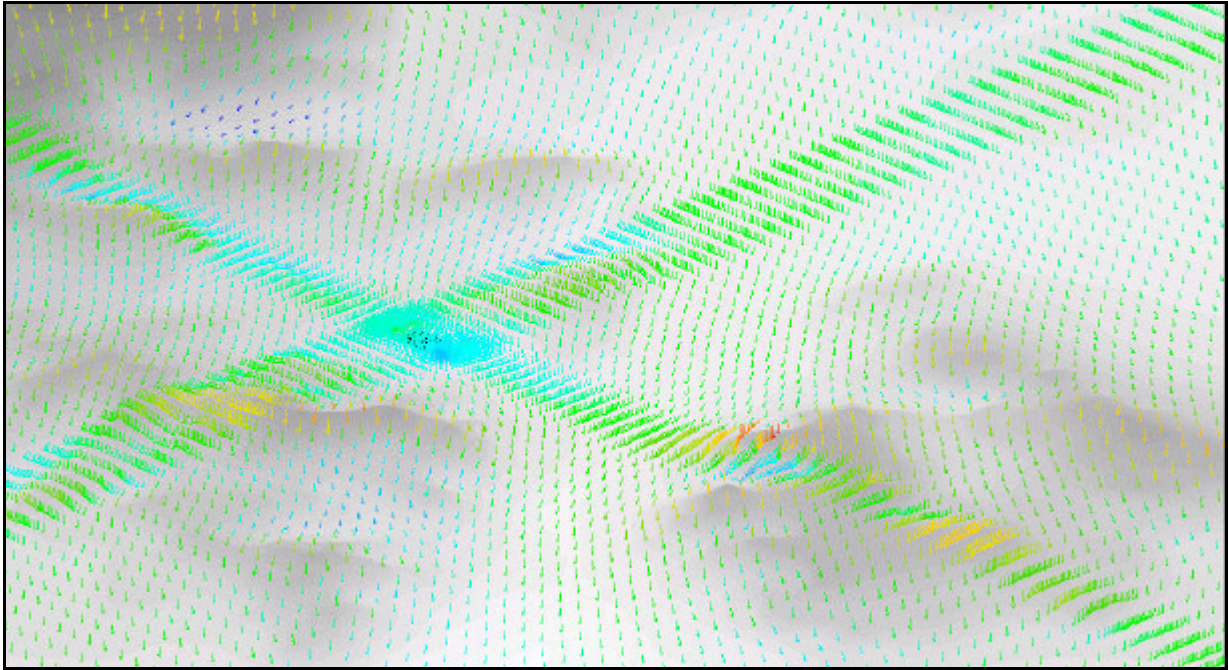


Figure 4 : Wind velocity vectors on the near the ground

Finally, it calculates the energy potential of the site for various kind of turbines. Results are visualised as wind power density contours on the imported map as shown by the following figure, or in a tabular format.

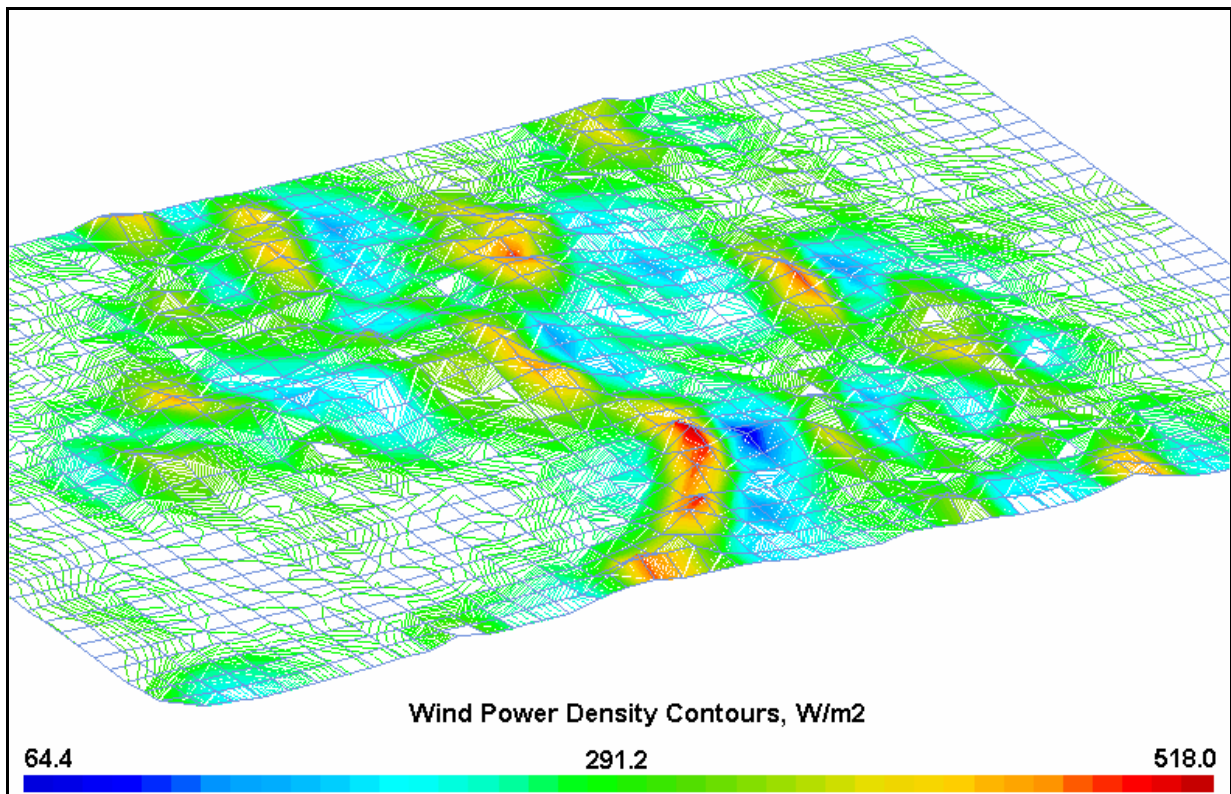


Figure 5 : Wind power density contours at 32 m in W/m^2

Knowledge of local wind parameters could bring an increase in the power output of a wind farm, thereby improving its viability. The classical method, on-site measurements, is very limited both spatially and temporally. A numerical tool using Computational Fluid Dynamics,

like fluidyn-PANEOLE, can be a really efficient alternative to assess the wind turbines potential of the site.

Based on topography, land-usage and meteorological data from the nearest meteorological station, the software computes the energy potential of the site for various kind of turbines. Results have shown the best location for wind turbines. CFD offers a reliable and precise tool to generate a wind field atlas for any wind turbine sitting.