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Wind turbine performance under the influence of wind characteristics: a case study

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Abstract

The influence of air density to the performance of wind turbine has been known for a long time and has been introduced by several manufacturers as different power curve for each level of air density. In 2013, IEC proposed a correction of the air density in the standard of the industry IEC 61400-12-2.

The influence of other wind characteristics, such as: turbulence intensity, shear, veer or inflow angle… has also been investigated in several researches. But how to apply this theoretical knowledge to better estimate the wind turbine output power is still an open question. The main obstacle is the difficulty to obtain these variables in practice.

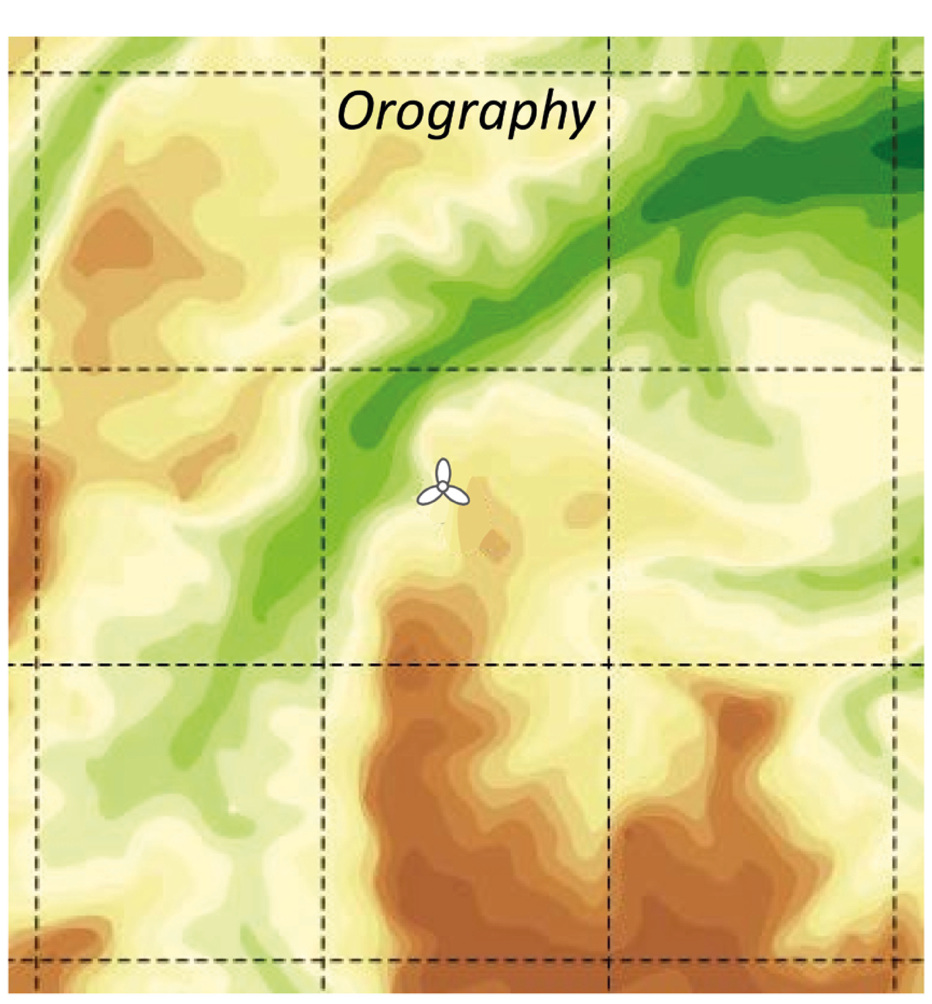
Objectives

Nowadays, as an industry standards, Power Curves are given depending on different levels of air density. Our objectives is to obtain, similarly, different power curves depending on different levels of wind shear and inflow angle.

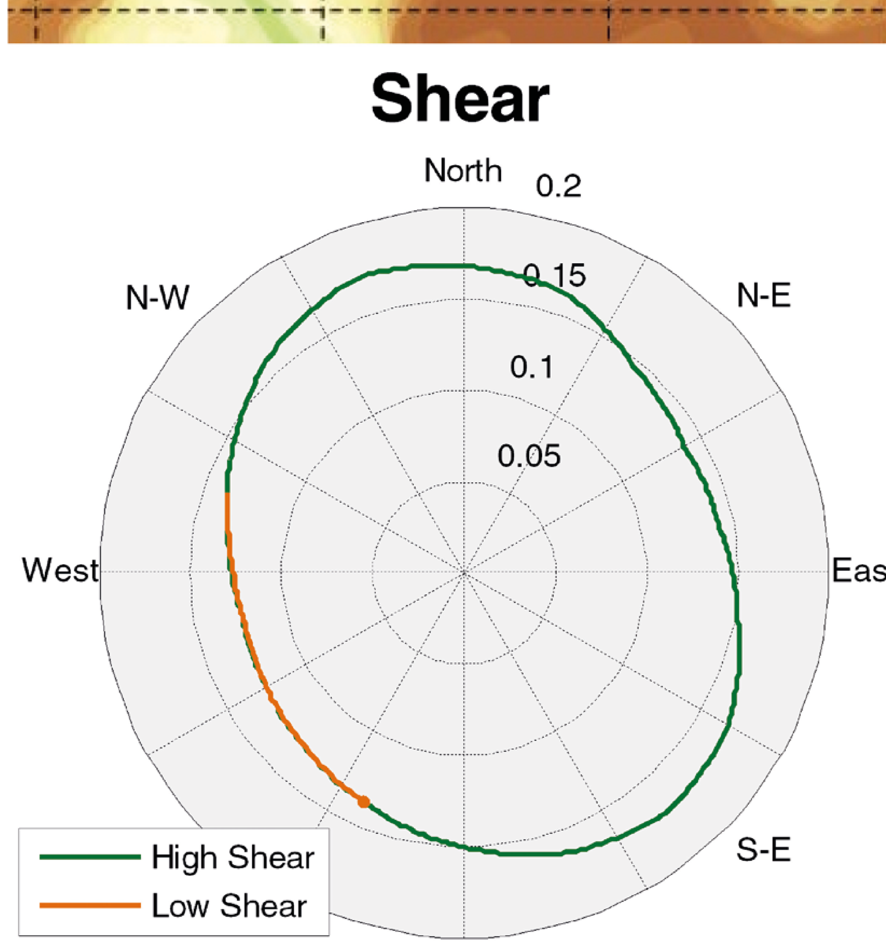
Our approach proposes to estimate these wind characteristics (shear and inflow angle) from the measured wind direction and a look-up table obtained from a pre-processed CFD simulation (**MeteodynWT**).

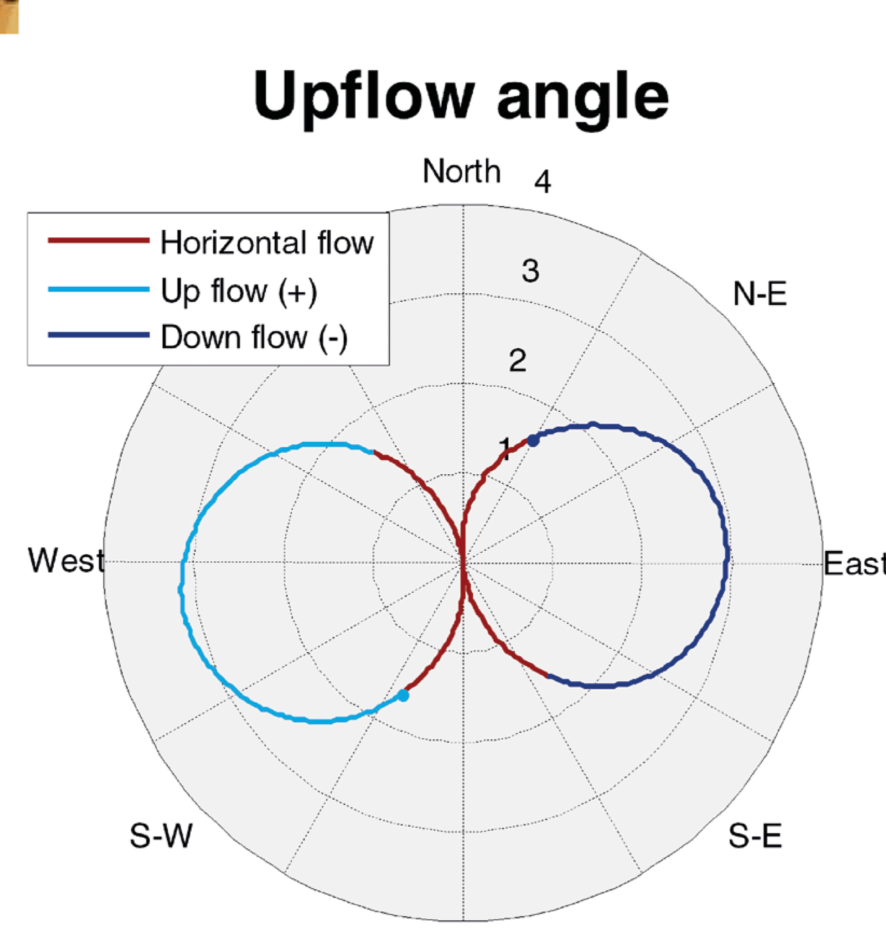
Methods: CFD calculations

Wind flows over the terrain are calculated using a Computational Fluid Dynamics software dedicated to atmospheric boundary layer. Results are depending on the orography (ground level) and the roughness (land use) of the site. The mean shear exponent on the swept area is then computed, for each direction, as well as the inflow angle at the hub location.



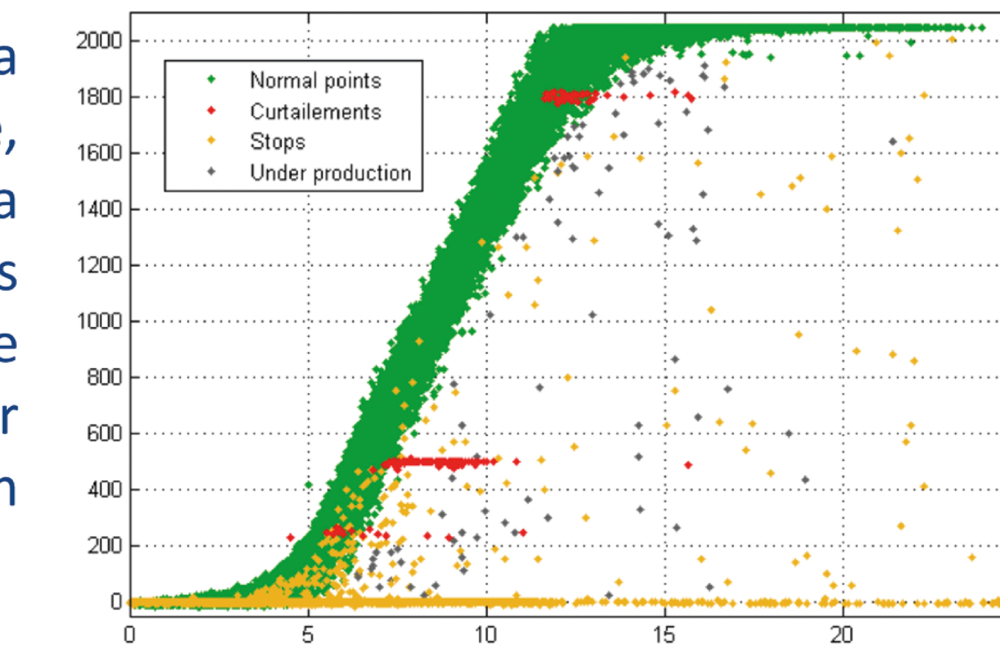
Results from this CFD simulation shows that Shear varies from 0,12 up to 0,17, while the Vertical Angle spans from -2,9° to +3,1°. Hence, shear is binned into 2 classes (above and below 0,14) and inflow angle is binned into 3 classes (below -1,6°, between -1,6° and +1,6°, and above +1,6°).





Methods: SCADA Data analysis

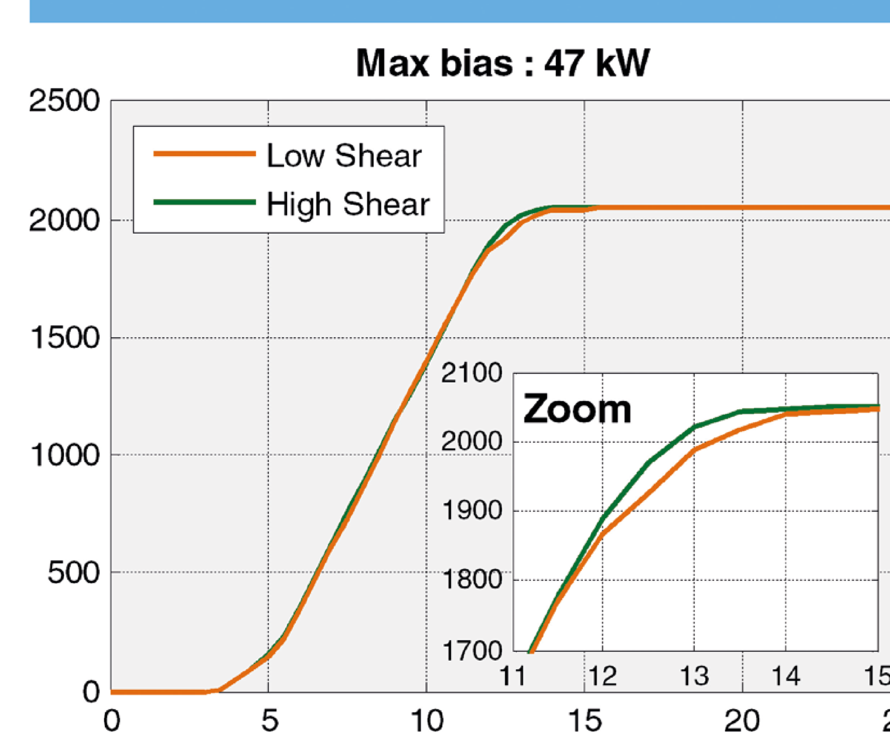
A 2-years period of Scada Data, from a 2 MW machine, is used in this study. First, a classification algorithm is performed in order to remove stops, curtailments and other measurement failures from the data set.

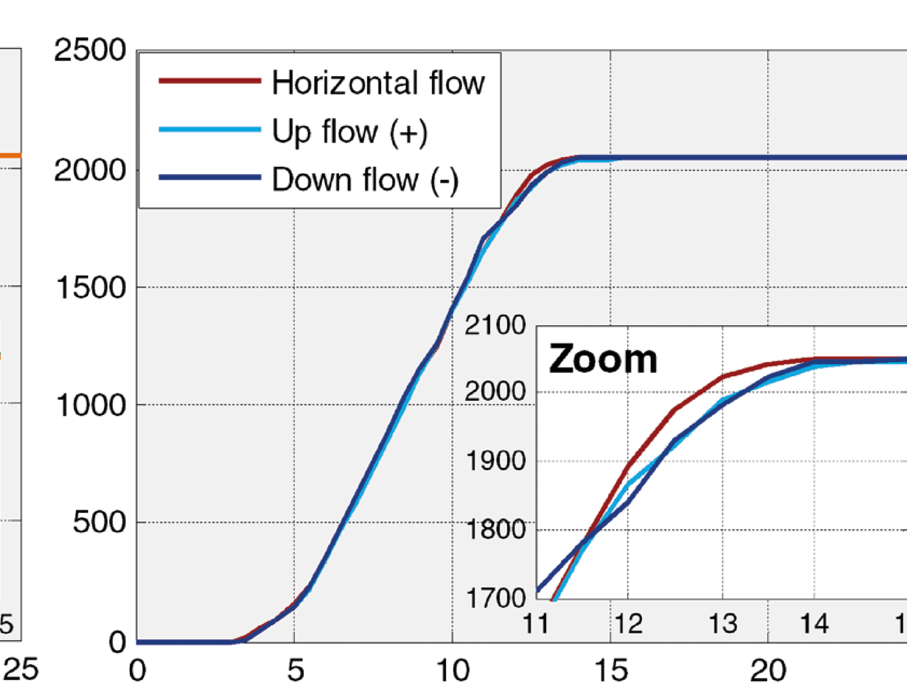


Then, data points are binned by directions, according to the shear rose (resp. the inflow angle rose). Thus, this is equivalent to bin the data points by Shear (below or above 0,14) or by inflow angle (downflow, horizontal flow, up flow).

Last, an iterative median based algorithm is performed on each bin in order to construct a specific power curve. This leads to 5 different power curves.

Results





Results show small difference in the power curves: High Shear (–) and Horizontal Flow (–) exhibit higher performance than Low Shear (–) and Inclined Flow (positive (–) or negative (–)), in the region of nominal wind speed event. The difference reaches 47 kW.

Conclusions

The wind flow characteristics (inflow angle, wind shear) seems to have an impact on power curves, only close to the nominal power. This suggests that this could be overcome by a modification of the controller parameters in this region.

A limitation of this study is the high correlation between variables (direction, shear and inflow angle). A wider data set, including different machines in different terrains (with other links between the 3 variables), is necessary to establish independent power curves. Nevertheless, this study shows the impact of wind flow is only second-order of the global power generation.

References

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