Advanced Numerical Site Calibration Using Commercial Software

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Summary. The objective of this paper is to check the influence of different parameters as stability and wind shear on the numerical site calibration performed by using commercial software. With this aim in mind, the results of site calibration obtained by using commercial software will be compared to those obtained by means of met-mast measurements. The models results have been compared with results using standardized site calibration procedures based on measurements according to IEC 61400-12-1 and the MEASNET Procedure. The conclusion is that wind profile measurements, not required by IEC-61400-12-1, adds useful information necessary for improving the results of numerical site calibration.

Introduction

Even in short distances, orography and obstacles cause systematic differences between measured wind at met-masts and incident wind over wind turbines. For this reason, it is necessary to carry out site calibration in order to perform the correct evaluation of the performance of wind turbines. Site calibration is typically used for power curve measurement. However, this process requires the installation of meteorological masts before wind turbine generators are installed and, when dealing with an already-built wind farm case, site calibration is not possible in any this way.

The numerical site calibration, in most of the cases, is a valid procedure and its results remain within the acceptable error margins given by the met-mast measurements site calibration [1]. As far as some commercial CFD, like Meteodyn WT, allows using atmospheric stability as an input, it will be tested if the use of parameters as stability and wind shear improve the results of the numeric site calibration.

Work undertaken

Vertical profile and wind direction standard deviation can be measured without difficulty at a reference site, giving these parameters information about then atmospherics stability. Extra measuring levels were installed for establishing the vertical profile in standardized site calibration procedures based on measurements.

Two sites have been considered from calibrations performed by Barlovento according to IEC 61400-12-1 [2] and the MEASNET procedure. For every site the site calibration has been carried out for several direction 10º bins, having different orographical characteristics each.

Site modelling

The CFD models define a grid and boundaries conditions to solve the flow equations. The inputs used for the model have the following characteristics:

- Orography and roughness: the maps considered are the typically used for energy evaluation, with altitude lines every 10 meters.

- Grid characteristics:

  Minimum Horizontal Resolution: 25m
  Minimum Vertical Resolution: 4m
  Horizontal Expansion coefficient: 1.1

- The model has been run for several values of atmospheric stability (varying from very stable to very unstable).

More information about how the model calculates the grid and solves the flow equations can be found in [3].

Assigning measured data to CFD atmospheric stability classes

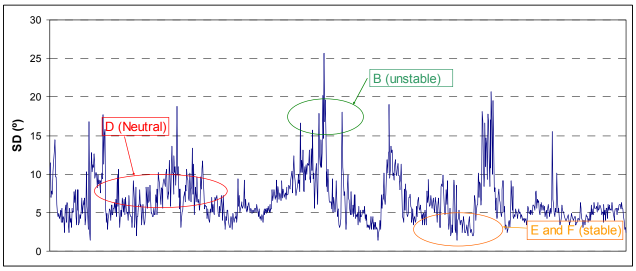
A classification of atmospheric stability has been defined according to wind direction standard deviation as follows:

STABILITY CLASS	WIND DIRECTION STANDARD DEVIATION
A (Very unstable)	25
B	20
C	15
D (Neutral)	10
E	5
F (Very stable)	2.5

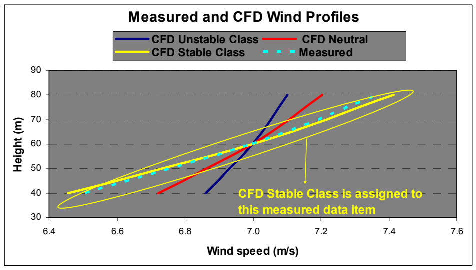
Table 1. Defined Stability classes according to wind direction standard deviation

Each measured data item of the reference site (ten minutes averaged data) has been assigned to a CFD atmospheric stability class in two different ways (Figure 1):

i) The class determined by the wind direction standard deviation
ii) The CFD class that better estimates the measured vertical profile at the reference site



Assigning Stability class via Wind Direction Standard Deviation



Assigning Stability class via the best vertical profile estimation

Figure 1. Assigning stability classes

After this process, each data item has a distortion factor assigned that depends on the direction and on the stability class.

Comparison between measurements and models results

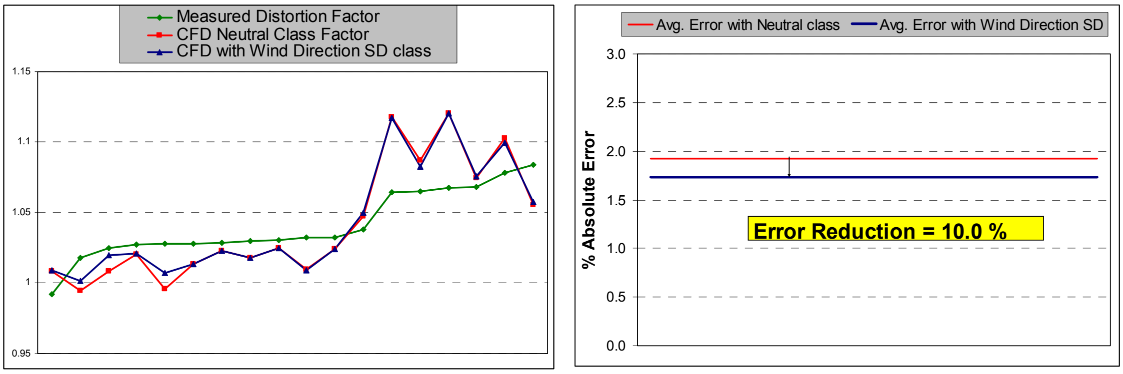
For each site and direction bin, the results of the flow distortion factors calculated by the CFD model have been compared with those obtained with the standardized site calibration procedure (IEC 61400-12-1 and MEASNET procedure). So, the comparison has been carried out with three model results:

- Using always the neutral class
- Using the class determined by the wind direction standard deviation
- Using the class determined by the vertical profile

An analysis has been carried out to see if the use of atmospheric stability improves the results of the CFD results.

Results

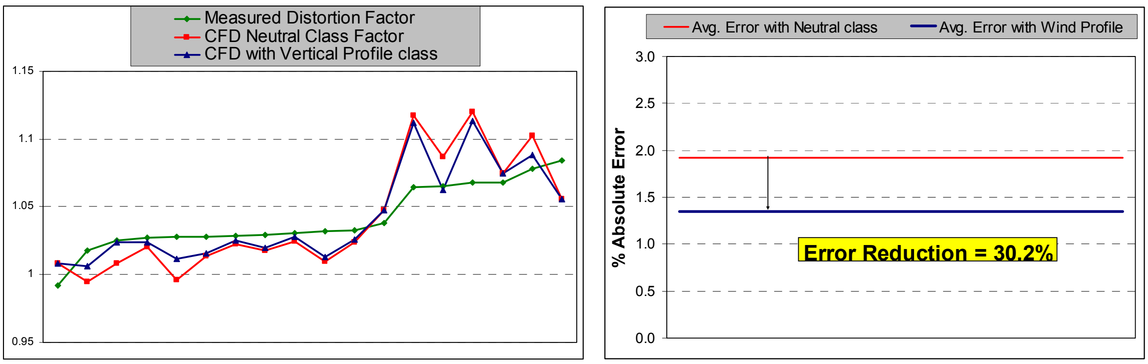
The next figures show the results obtained. The distortion factors have been ordered in the increasing order according to the standardized measurements.



61400-12 + MEASTET and CFD Flow Distortion factors

Mean absolute error using Neutral and Adjusted CFD Class

Figure 2. Distortion factors using neutral and assigned class via wind direction standard deviation



61400-12 + MEASTET and CFD Flow Distortion factors

Mean absolute error using Neutral and Adjusted CFD Class

Figure 3. Distortion factors using neutral and assigned class via the best vertical profile estimation

As can be observed, both methods of using CFD stability classes (assigned using wind direction standard deviation and measured vertical profile) leads to an error reduction on the estimation of the distortion factors. The measured vertical profile method shows a better result, and a 30% of error reduction has been obtained.

Conclusions

Wind profile measurements, not required by IEC-61400-12-1, adds useful information necessary for improving the results of numerical site calibration.

Errors are bellow 3% for most of the cases, with default settings and no specific input parameters for the CFD model, and in the analyzed cases, considering stability classes always improve the results of calculated flow distortion factors.

Additional improvements could be obtained considering other parameters, such turbulence.

References

1. Checking The Capabilities Of Commercial Software For Numerical Site Calibration, Barrios, A.; Zubiaur, R.; Cordón, R., EWEC 2007 poster and full paper.
2. IEC 61400-12-1 Power performance measurements of electricity producing wind turbines.
3. Meteodyn WT users's manual and help. http://www.meteodyn.com