

Abstract

Wind resource assessment requires nowadays more efficient tools to provide an accurate evaluation of production in order to reduce costs.

As onshore wind farms are built in more complex terrains, it is necessary to find a new method to provide a fine evaluation of energy which reduces the error during the data extrapolation process. This explains why CFD models have become a standard for WRA in specific conditions.

This presentation is focused on the wind speed and energy yield prediction carried out for a 29MW wind farm project. The accuracy of the wind modeling is investigated by the cross validation between the different met masts around the site. The net energy prediction P50 is compared against real wind farm performance data during a blind test organized by EWEA in 2013. More than 50 companies have been involved in order to compare methods results.

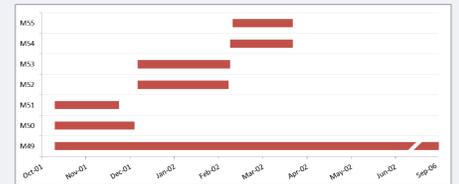
Project characteristics and methods

The site is located in Scotland. The area of interest is approximately 8km by 8km.

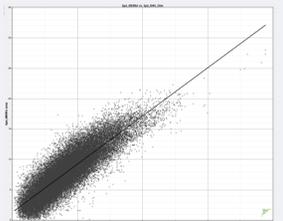
Elevation data are 50m resolution, with a difference of more than 400 meters in altitude. Roughness data (roughness length z_0) and obstacles (height and porosity) are defined. All other areas are assumed uniform according to EWEA requirements. A total of 22 turbines is installed in the mapping area.

7 met masts have collected data at several heights: mean wind speed, standard deviation of wind speed and direction on a 10 minute time base. However, most of them (6/7) have only 3 months of data which is not representative of long term meteorological conditions on site (because of fluctuations of the annual wind). One mast (M49) has 6 years data and was used in a "Measure-Correlate-Predict" method with a regional station and with MERRA data.

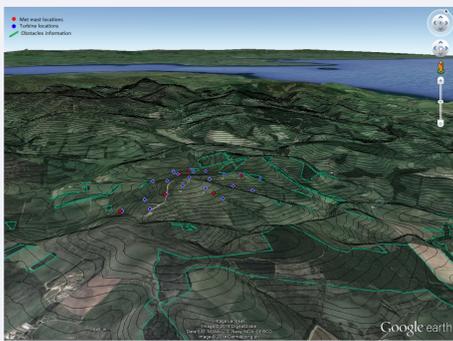
CFD modeling was performed to extrapolate the wind characteristics to all masts and turbines. Uncertainties are deduced by cross comparison.



Site assessment measurement campaign



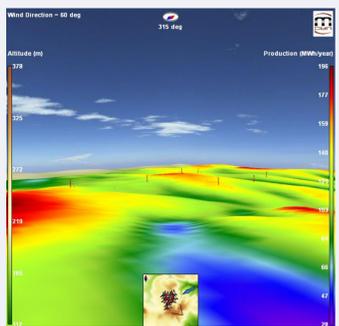
Correlation between mast M49 and MERRA data



Site characteristics: turbines layout, masts location, obstacle information

Modeling

Metedyn WT solves the steady isotherm incompressible averaged Navier Stokes equations. The non linear Reynolds stress tensor is modeled by one equation closure scheme dedicated to atmospheric boundary layer. The turbulent length scale is computed at the beginning of the calculation according to a model based on Yamada and Arritt [1], [2]. Wind flow simulations on the site have been computed with a directional step of 10 degrees. The horizontal and vertical spatial resolution of the computation grid is 20m and 4m respectively. The computational domain area has been extended to a zone of 9km x 9km in order to minimize boundary effects. All these constraints lead to a computational grid of about 5 Million cells.



Computed map of production at hub height (47m)

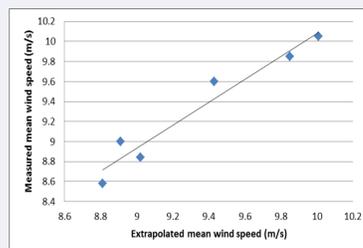
Results

Mean wind speed and turbulence intensity uncertainties

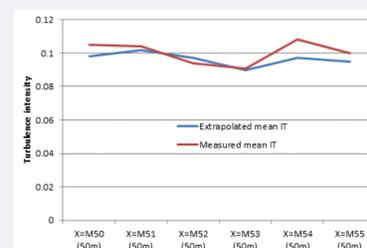
The better correlation between measurements and long-term reference data was obtained with MERRA data. The MCP results are used as a reference climatology data on site. Mean wind speed is equal to 8.07m/s at 40m high and most of the wind comes from south west direction.

Met masts are well distributed over the site, and the distance between M49 and turbines is less than 700 meters. Hence, error in the horizontal extrapolation can be considered as homogeneous. The vertical extrapolation is low due to the fact that measurements are collected at 50m and turbines hub is at 47m high.

To evaluate the uncertainties regarding the turbulence intensity, computed values have been compared to measured ones for the same time period. As CFD technology tends to overestimate the turbulence intensity, a scale correction was applied to better fit the measurements.



Correlation between measured and computed wind speed



Comparison between measured and extrapolated turbulence intensity

Production estimation

The provided power curve and thrust curve were used to compute the production and evaluate the wake effect. Local air density at each hub height (47m) was taken into account to correct the power curve according to IEC 61400-12.

The reference yield (before evaluation of topographical and wake effects, respectively 8,7% and 9,5% losses) was equal to 104GWh. Main losses categories have been estimated to deduce the net energy P50: turbine availability, grid availability, electrical transmission loss, turbine performance, high wind speed hysteresis, ... Finally, the net energy yield estimated by metedyn WT P50 was equal to 76.4 GWh.

Conclusion

After analyzing meteorological data, metedyn WT has been used to model the site and perform a wind resource assessment in complex terrain and performed really accurately compared to measurements:

"Observed long-term energy yield based on 5 years of production data; corrected for windiness, as well as an overall plant availability of 96.8%. This produces an observed yield of 76.25 GWh/year." [3]

References

- [1] : Yamada, T, (1983), *Simulations of nocturnal drainage flows by a q2l turbulence closure model*, *Journal of Atmospheric Sciences*, vol. 40, Issue 1, pp.91-10
- [2] : P. J. Hurley (1997) *An evaluation of several turbulence schemes for the prediction of mean and turbulent fields in complex terrain*
- [3] : N.G.Mortensen – H.E. Jørgensen (2013) - *Comparative Resource and Energy Yield Assessment Procedures (CREYAP) Pt. II – EWEA Workshop*