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VALIDATING CFD VALUE FOR ANNUAL ENERGY PRODUCTION ASSESSMENT USING THE PERFORMANCE MATRIX METHOD

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Abstract

In order to compare modeled and measured AEP, it is required to have two comparable values. Real production data includes losses that are not part of the calculation method for potential AEP assessment. For example, wind turbine availability should be estimated and used to obtain measured production figures with 100% availability.

Measuring the power curve of a wind farm by direction (performance matrix) allows you to check its power performance. This process enables you to obtain potential AEP figures (including only wake losses) which can be used as a reference for model validation.

Objectives

- To calculate a performance matrix from SCADA data and reference wind measurements
- To use the CFD orographic speed-ups and declared power curve to convert measured wind data time series into power time series including wake losses, and derive a modeled performance matrix
- Validate AEP assessment by comparing measured and modeled performance matrices

Methods

The performance matrix is the relationship between the wind farm active power output and reference wind observations (speed and direction). The process of creating a PM is very similar to the method of bin in the determination of a wind turbine power curve (IEC61400-12-1)

$$PM(i,j) = \frac{\sum_{k=1}^{N_{i,j}} P(i,j,k)}{N_{i,j}}$$

Where:
$PM(i,j)$ is the average P for U bin i and D bin j dataset
$P(i,j,k)$ is the observed P for dataset record k in U bin i and Dbin j dataset
$N_{i,j}$ is the number of data records un U bin and i and D bin j dataset

SCADA production data from a well performing wind farm in Northern Norway were binned by wind speed and direction from the measurement masts available at the site (fig.1).

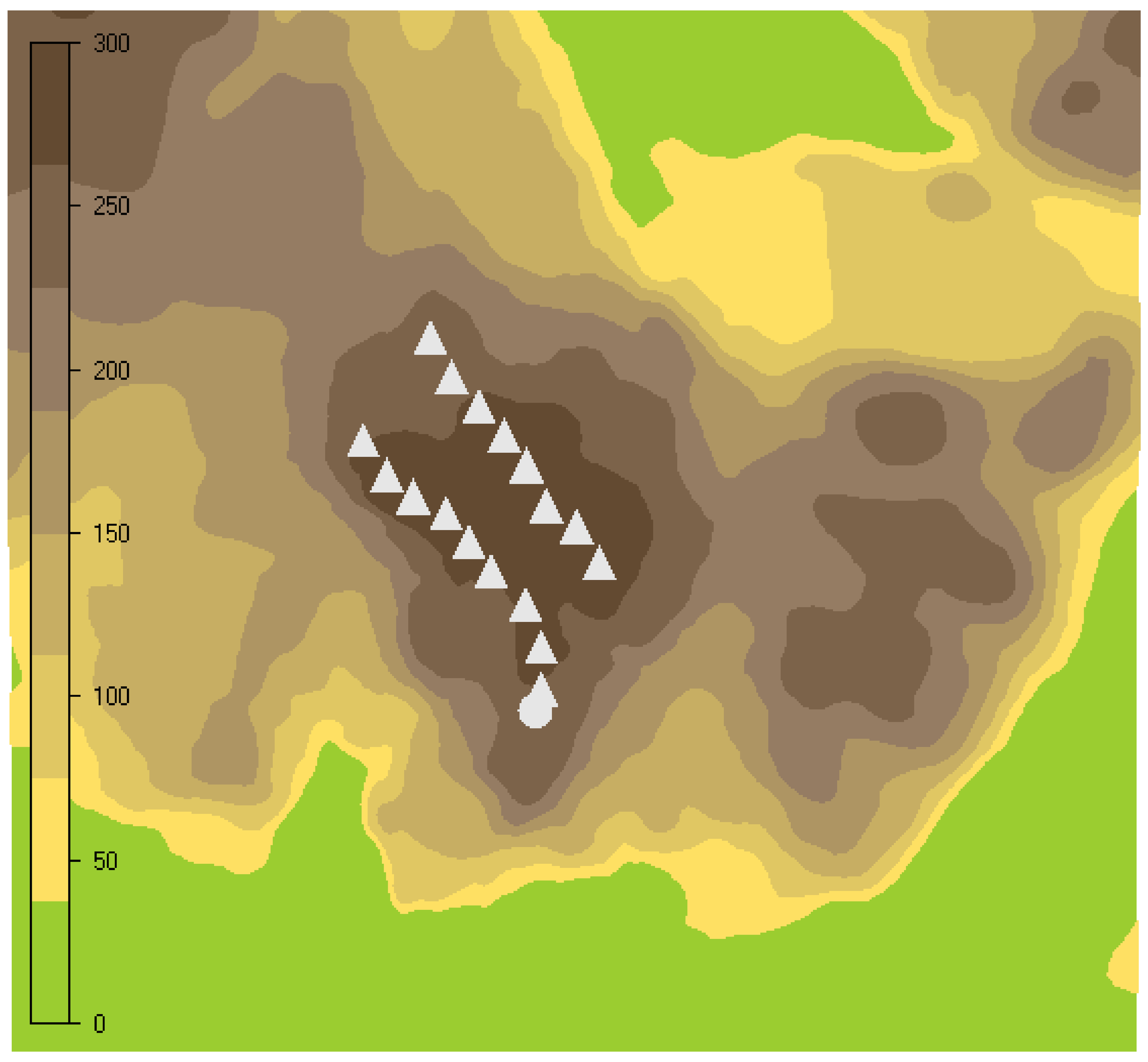

Fig. 1: Wind farm layout and site elevation

The estimated production time series were obtained by; modeling the orographic speed-ups between the wind measurement point and the hub of the turbines, applying such speed-ups to the wind time series, and calculating power time series using the declared power curve, and subtracting eventual wake losses. CFD based software has been used for the scope.

A measured performance matrix (fig. 2) was obtained and the same procedure was used to derive a modeled performance matrix (fig.3) out from estimated production data.

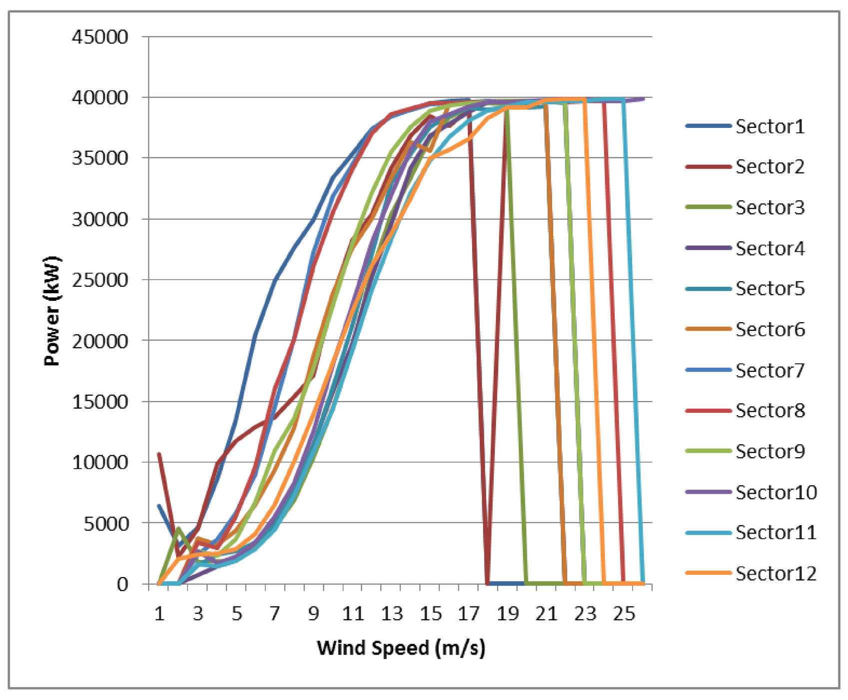

Fig.2: Measured PM

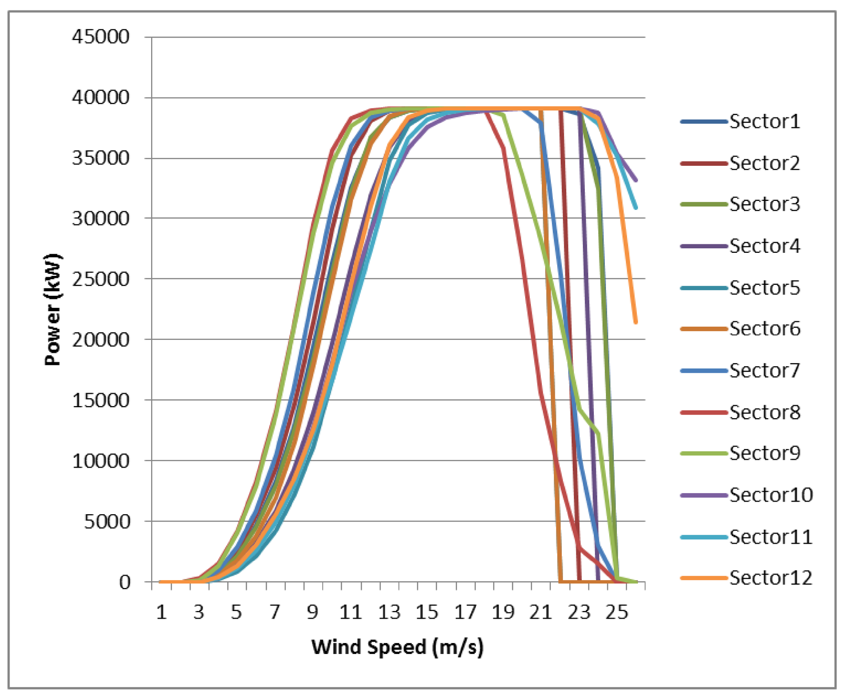

Fig.3: Modelled PM

The frequency distribution was derived from the concurrent wind measurements. The wind statistics are disturbed by the wakes of the turbine in operation. Wake disturbed sectors are calculated according to the annex A of the IEC 6140-12-1 (fig. 4)

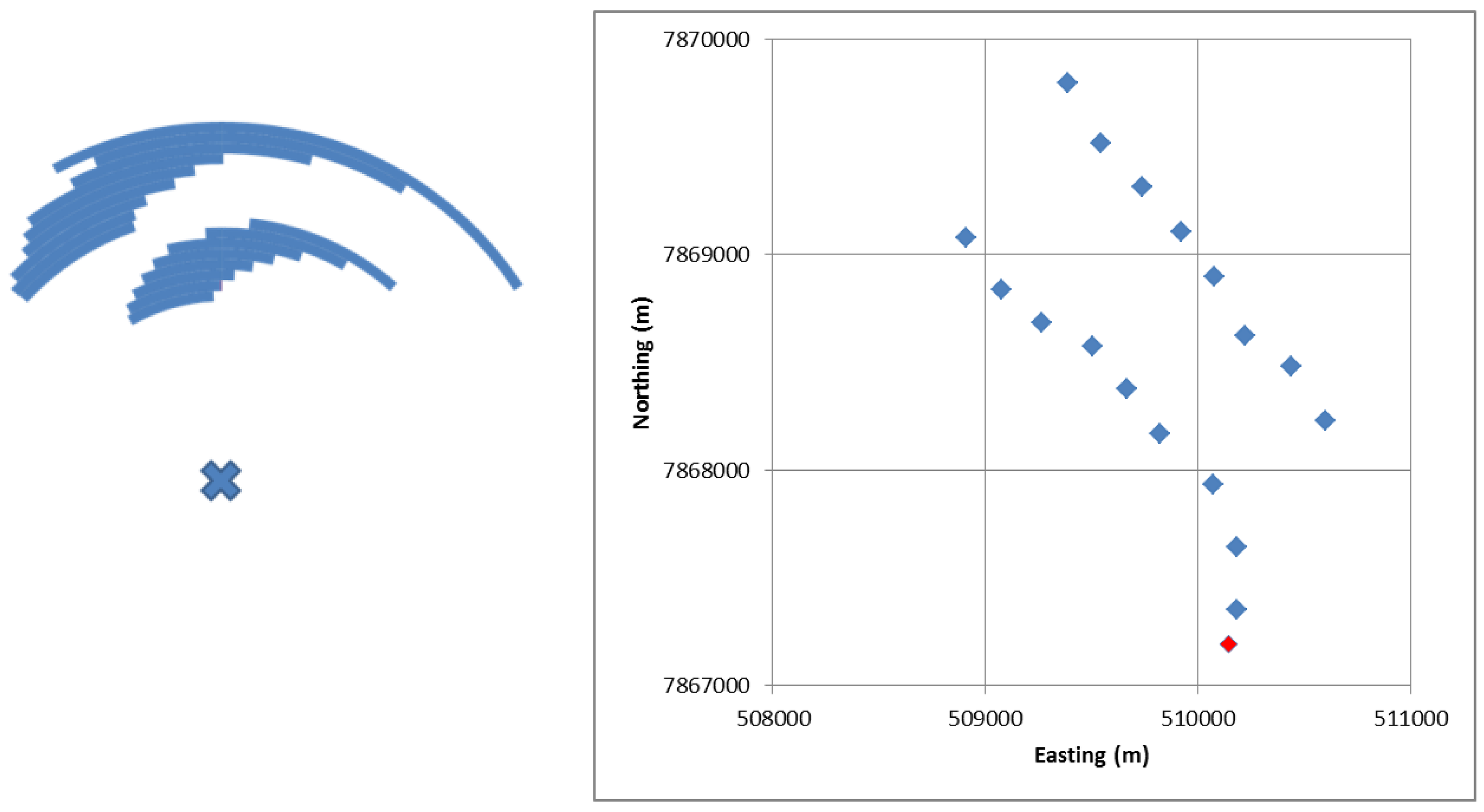

Fig. 4: IEC wake disturbed sectors

Results

Modeled and measured AEP figures were obtained by multiplying the two matrixes by a wind speed and direction frequency table representative of the average wind conditions at the reference point and compared for undisturbed direction sectors (fig.5).

$$Freq\ (V,D) * (P.M._{meas} - P.M._{modelled}) = Error$$

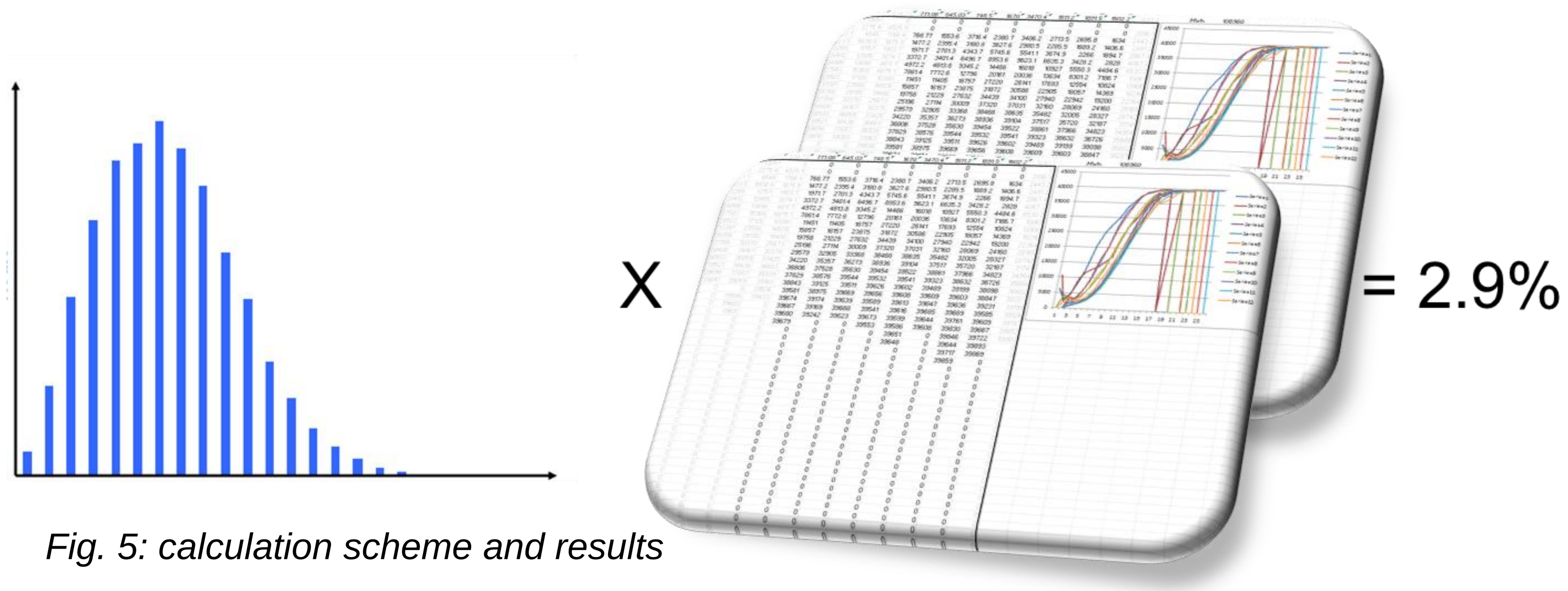

Fig. 5: calculation scheme and results

Conclusions

This study represents a validation case for CFD-aided energy yield calculation. The comparison between modelled and measured AEP was conducted using the performance matrix method. This technique was introduced as a method for assessing the performances of a wind power plant especially in complex terrain. However, the study confirms also the suitability of such technique also for AEP calculation.

The main results of the study is a very small difference between measured and modelled AEP. These results confirm the accuracy of CFD for energy yield assessment of wind farm in complex terrain.

Acknowledgement

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