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Wind resources requirements by wind farm developers

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Contents

1 Introduction

Based on recent experience in projects for the wind industry and received requirements of wind farm developers to determine the wind resources for offshore wind farms, the reasoning and requirements for the determination of wind resources are listed in this document.

To stress the importance of the wind resources, the following. *Wind-resource assessments (**WRA**) have a direct impact whether or not projects are financed and constructed and which ones are not. The primary result of the WRA is the Annual Energy Production (**AEP**) estimate, which in turn is the most important factor to determine the viability of a wind farm project. A reduction in uncertainty also improves financial terms for developers. In addition, when wind projects perform closer to expectations, it strengthens the trust between consultants, developers, the financial community, policymakers, and the general public.*[1]

The most commonly used method to determine the WRA at a site, where there is no onsite long term wind measurements available, is to apply a method called Measure – Correlate – Predict, or **MCP** in short.
In this MCP method the measurements are split in two different sets, first a usually short term wind data set measured in the proximity of the location of the wind farm for which the wind resource assessment is determined and secondly a long term data set measured at a greater distance of the location of interest (**LOI**). The short term measurements are correlated with the long term wind measurements (more than 10 years but preferably more than 25 years). There are no “definitive” requirements with respect to the distances of the short and long term measurement and also not strict requirements with respect to the duration of the measurements however the shorter the measurement periods the higher the uncertainty of the resulting AEP. The requirement is most often described as to use the best data available.
When there are no reliable long term wind resources available in the wide area around the LOI it is quite common to apply long term hind cast data from numerical meteorological models supplied by the meteorological institutes around the world and correlate those with the short term measurements in the proximity of the location of interest.
When there are no measurements available in the proximity of the LOI the hind cast data is correlated with actually measurements at several location and it is investigated whether the correlation factor is uniform or there is a trend in the correlation with respect to location, directional sector and/or e.g. distance to shore.
The advantage of using the modelled data from forecasts made in the past, thus using it as hind cast data, is that, that data is often available at a relative high spatial resolution and can be evaluated at several heights and locations based on model based interpolation techniques. While data measured at a meteorological measurement location are often measurements at a relatively low altitude and often on shore, or in the coastal region, with varying disturbances over time and in direction.
Wind farm project developers are relying on accurate wind resource analysis for several reasons. An accurate wind resource prediction is required to make an optimal

[1] Asian development bank, *Guidelines for wind resource assessment – Best practices for countries initiating wind development*. https://www.adb.org/sites/default/files/publication/42032/guidelines-wind-resource-assessment.pdf, assessed June 27, 2018.

wind farm lay-out to determine the wind farm efficiency, i.e. determine the wake losses of wind turbines in the wind farm as a function of the wind speed and wind direction. Next to that the wind farm production estimate has to be determined where it is of the utmost importance to know the probability distribution of the wind farm yield. This is required to be able to negotiate the financial terms with investors, lenders and financiers. Usually the financial world does not look at the P_{50} but the P_{90} or P_{95} or even P_{99} to determine the willingness and size of their financial involvement. The uncertainty is sometimes also denoted as the ratio of P_{50} over the P_{90}. The closer that value is to 1 the less uncertain the annual energy production is.

2 Requirements of project developers for the wind resource analysis

As mentioned the main objective for project developers with a WRA is to predict the AEP in a reliable way. Due to the fact that the WRA is the largest uncertainty in the determination of the AEP and that the reliability of the AEP prediction is valuable in financial terms some qualitatively requirements are described. It is required that the wind resource analysis is founded on local measurements, preferably for a minimum period of a year in combination with long term wind measurements or hind cast data that is available within a reasonable distance to the LOI, usually where the new wind farm will be developed. The wind resources should be available as a spatial distribution of at least in a few locations in the area the wind farm will be developed. The spatial distribution can be based on local measurements that are performed at two or more locations or based on the hind cast data of a meteorological model that can provide data at a grid of points in between which the wind resources can be interpolated.

Next to the average wind resource the wind farm developers require to have the uncertainty in the wind resources as part of the uncertainty in the energy yield estimate. In most situations the uncertainty of the wind distribution is the largest factor in the formulation of the distribution of energy yield in time. The wind farm developers usually require to have the following statistical distribution figures of the yield P_{75}, P_{90}, P_{95} and sometimes the P_{99}) for several duration periods e.g. for 1, 10, 15 and 20 yrs.

In the past it was quite common to determine a wind index for each year and the distribution of the wind index. Figure 1, below shows the variation in the wind over the period 1990 – 2008 in standard deviations. As can be seen the wind index fluctuates quit strong on year to year basis and the profitability of a wind farm project is strongly influenced by the yield of the first years of operation.

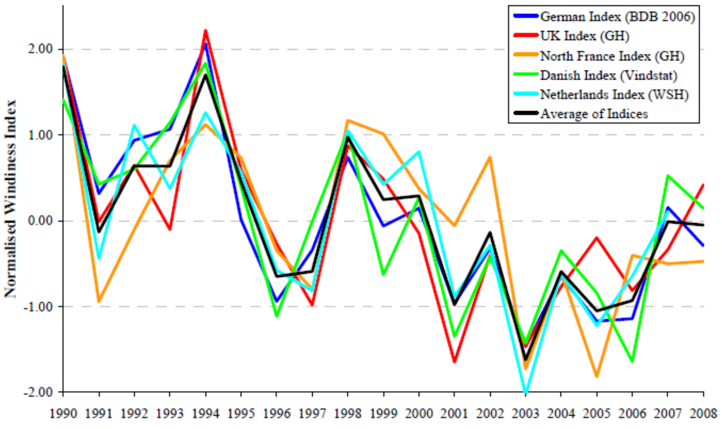

Figure 1 The normalized wind index of several north European countries 1990 – 2008, copied from [2]

[2] Peter Thomas, Simon Cox, Andrew Tindal, Long term wind speed trends in north western Europe.

Next to the long term average wind data it will be required to determine

- year to year variations of the average wind speed and,
- seasonal or monthly variations and
- diurnal or daily variations of the wind speed.

3 The MCP method

The MCP method can be divided in several different correlation methods and different source of long term wind resources. In [Rogers, Rogers and Manwell[3]] a description is given of 4 methods ranging from correlating the annual average wind speed to correlating the energy content to correlating the wind speed and direction distributions. Several other descriptions can be found how the MCP method can be applied.
The two most often used methods are correlating short term wind measurement on site with long term measurement at a meteorological station a greater distance, see Figure 2 the other is correlating hind cast data as the source of the long term data with short term measurements on site, see Figure 3. The short term measurements are or performed with a met mast with measurements of wind speed, direction, temperature and air pressure and humidity at several heights or performed with a floating LiDAR which measures the wind speed and direction at several altitudes. The hind cast data is available on a grid, e.g. see Figure 3 where the model is capable to interpolate between grid points.

In both cases the period of the short term wind measurements at the LOI is correlated with the long term measurement on shore or the hind cast data. Correlation is performed per wind direction sector, usually per sector of 30º. The correlation that is found for the short term period that both measurements or measurements and hind cast data are available and assume that this is valid for the entire period the long term measurements / hind cast data is available.

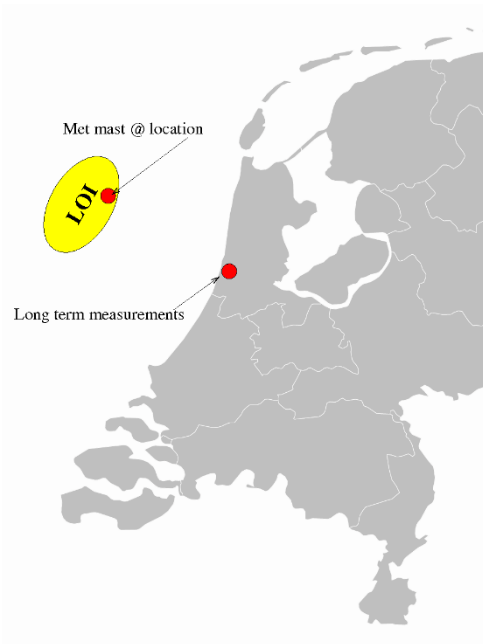

Figure 2, Correlation between short term measurements on site and long term measurements on shore

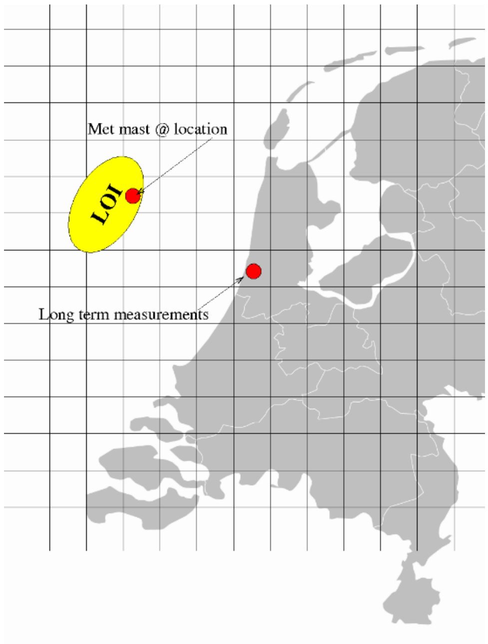

Figure 3, Correlation between hind cast data and short term measurements on site and long term measurements on shore.

[3] Anthony L. Rogers, John W. Rogers, James F. Manwell, Comparison of the Performance of Four Measure-Correlate-Predict Algorithms.

4 Specifications of the requirements for the DOWA

The requirements towards the new offshore wind atlas based on the considerations indicated above are that the DOWA is based on:

- long term hind cast data, more than 25 years, in combination with:
- as many locations with measured wind data that is of high quality and not disturbed by local situation;
- the actual measurements should have a high availability, preferably close to 100%;
- The measurements should be available at an altitude as close as possible to the hub height of the wind farm due to the fact that the height extrapolation has a large uncertainty;
- It will be required to be able to also determine the air density via direct measurements or otherwise by measuring the temperature and pressure;
- The uncertainty of the WRA should be known by indicating the uncertainty of the measurements and measurement equipment and or the model uncertainties of the hind cast date. The overall uncertainty should be low as low as possible preferably less than 2%.
- The wind atlas data should be corrected for location and wind directional effects if that results from the validation.