CREATING A WIND ENERGY INDEX

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ABSTRACT

The wind energy index we can provide you with will be a "historic" overview of how much wind could have been utilized by a WTG on the location in question. Index 100 indicates a completely average month or year based on e.g. 10 years of wind data, whereas an index of 90 will indicate 10% below average. The index will be based on detailed studies of the shape of the landscape (the height contours) in a radius of 5 km around the Met mast and a study of how the nature of the landscape (the "roughness" and local obstacles) will affect the Met mast. Roughness is evaluated in a radius of min. 20 km and local obstacles in a radius of 1000m.

In addition to that the monthly average temperature, based on long-term measurements is taken into account and finally the data is filtered through a generic power curve.

In a spread-sheet (MS Excel) which can be delivered it is also possible to enter new wind data from the Met masts in question and get an index number out e.g. for May 2001.

In Denmark it is very common to base **production guarantees** on calculated/predicted production - 10% IN A NORMAL WIND YEAR. In many of the big wind energy countries like Denmark and Germany, literally thousands of WTG owners are using such an index every month in order to get an indication of how well their single WTG or wind farm is performing.

In this lecture I will present our experiences with the calculation and creation of wind energy index's evaluation of wind measurement with emphasis on the following subjects:

1 INTRODUCTION: WHY MAKING A WIND ENERGY INDEX

1. It makes it possible to estimate whether the measurement period was typical compared to long-term data.
2. It makes it possible to make a general correction of the production estimate of a windfarm in the region.
3. Gives investors the option to incorporate the wind energy index as "risk-parameters" in their cash flow analyses. Based to the regional wind energy index a worst-case financial scenario can be made e.g. for the first three years of operation.
4. Provides the operator or the owner of a wind farm with a tool for follow-up on the windpark. Is the production this month above or below the expected production?
5. Provides part of the basis for insurance covering losses due to errors in the calculated energy production of the wind farm.
6. If you can get an insurance giving a production guarantee for the first five years of production, financing of the wind farm becomes much easier. In short your project becomes bankable.

An example from Denmark:

The WTG cooperative which I'm chairman of owns a NEG Micon 600 kW machine with hubheight 50m and 48m rotor. An insurance covering losses due to wrong estimation of the wind energy production with a duration of five years was app. US $3,200 for all five years. But the production is always converted to A NORMAL WIND YEAR.

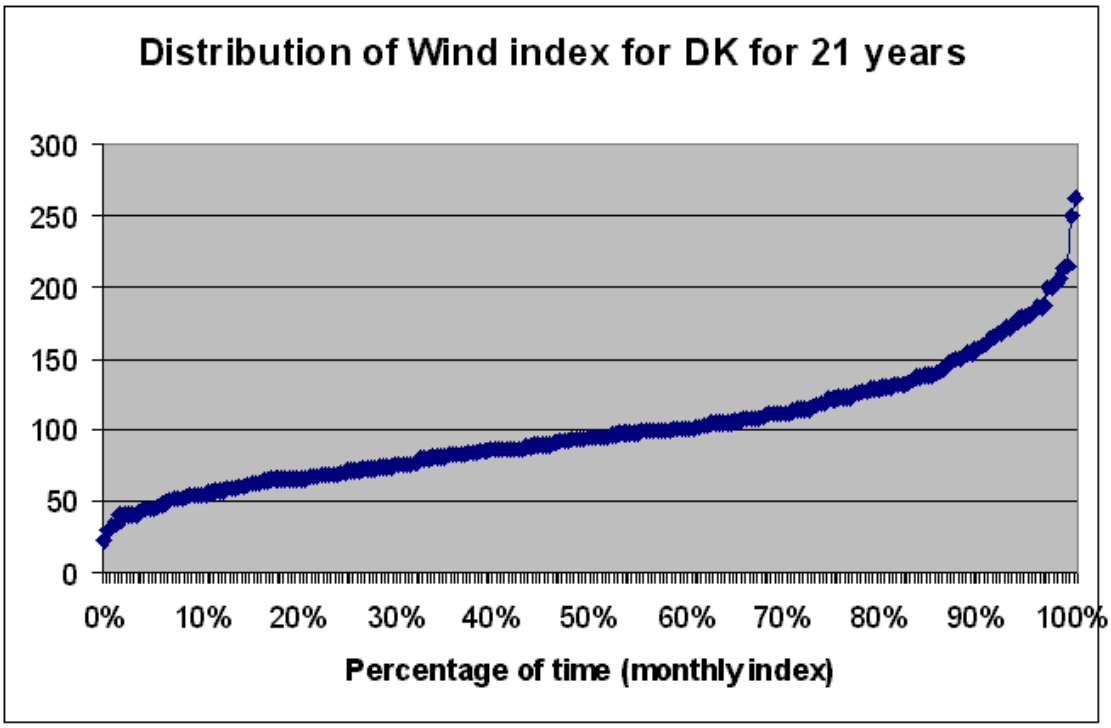
2 GENERAL REMARKS ON WIND INDEX – EXPERIENCE FROM DENMARK

A wind energy index is a tool to use to analyse actual energy production from a given WTG or Wind Farm. Especially to correct actual energy production to "long term normalized wind conditions" and thereby evaluate if the calculated energy production could be expected over a long time operation period.

But it is also a tool to analyse the past, and get useful input for cash flow analyses for wind energy project in the planning phase.

The energy production from a WTG or wind farm varies quite much from time to time due to changes in the wind.

A few figures is following presented, primary based on WTG's in Denmark, but as also probably will be reality in the most European countries:



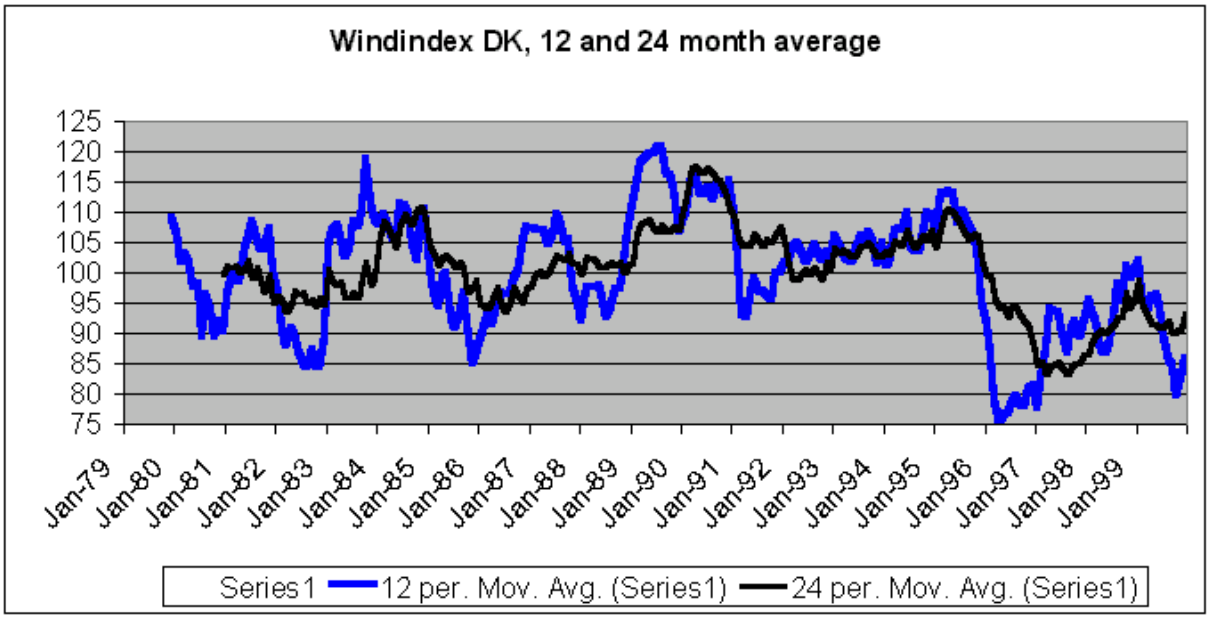
80% of the months, the WTG production will be in-between 50% and 150% of the mean monthly production.

10% of the months, it will be below 50%, down to 25%

10% of the months it will be above 150%, up to 250%.

The critical part for an investor will often be, if too many months in a row has a very low wind energy index, and by that following low WTG-production and income.

The following graph shows the variation in time.



The figure shows the 12 and 24 months mean values of wind energy index. From this can be seen:

Within a 12 months period, the lowest mean index value is 75% - this means, that a WTG installed at that time (12 month before the moving average value is 75%), should produce 25% less than calculated, but will still reach the calculated energy production during a long period.

Within 24 months period, the lowest index value during the 21-year long index period from Denmark is around 85%.

So these figures could be, what investors should incorporate as “risk-parameters” in their cash flow analyses:

25% less production during the first year.

15% less production during the first two years of operation.

10% less production during the first 10 years of operation.

Important notice:
This is only the possible reduction due to the actual wind climate.
Uncertainty in calculation model etc. is another reason to reduce expected energy production in cash flow analysis.

3 DESCRIPTION OF THE USAGE OF THE WIND ENERGY INDEX

The **wind energy index** will typically be presented on monthly basis, and have a value of 100 if the month is a normal month (the wind energy corresponds a mean month and the expected energy production for a WTG will be 1/12 of the expected annual energy production).

When the wind index is available, following formula correct actual energy production to a normal wind energy year, also called Wind Corrected Production (WCP):

WCP = ΣActual production * 1200 / Σ Wind index

Σ - Summing up for a given range of months.
1200 corrects to 12 months and for the mean value of the wind index on 100.

When WCP is found, this might be divided with the calculated production, to find how well a given WTG or Wind Farm has performed relative to calculation. The "index" found, we name the Goodness factor:

Goodness factor = WCP / Calculated annual production.

If the primary goal is to follow up on how precise the calculation method is, months with major downtime (low availability) should be taken out of the calculation of WCP.

4 HOW CAN RELIABLE WIND INDEX BE CREATED?

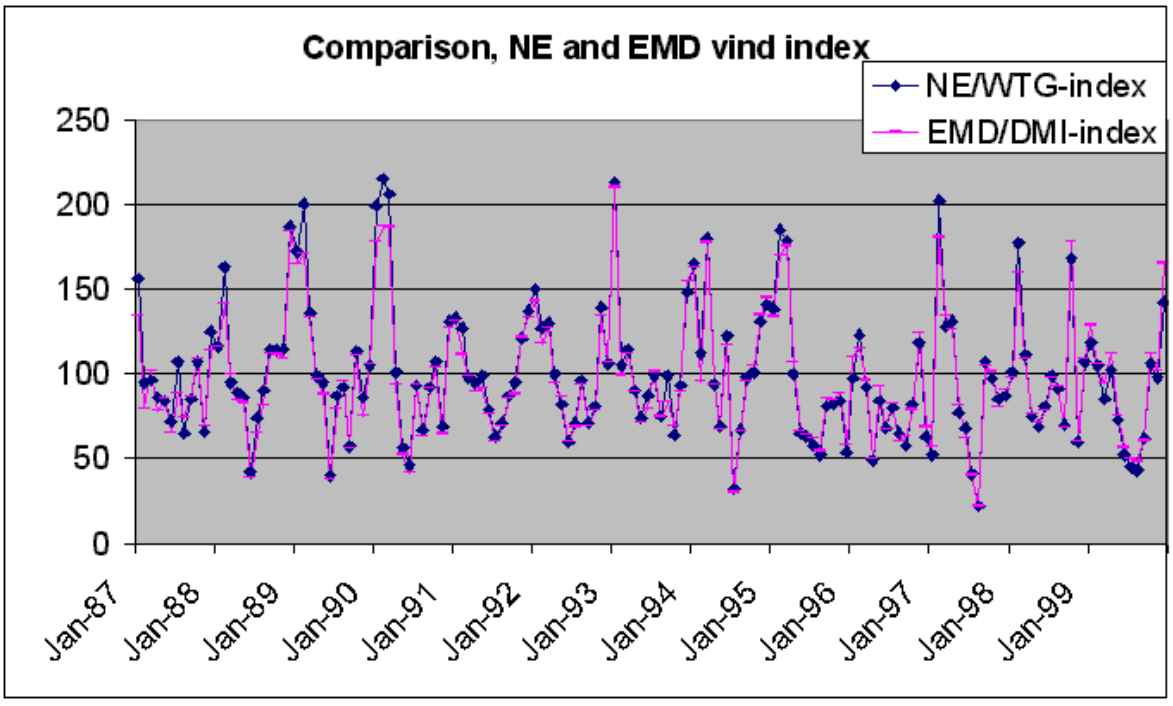
There are 2 different ways to create wind index:

a) Based on a large amount of geographically distributed WTG's (the NE/WTG-index).
b) Based on measured wind data (the EMD/DMI-index).

In Denmark, method a) has been used since 1979 – with quite few WTG's the first years, but from mid 80'es based on a large number.

In 1992 EMD developed a method to create wind index based on wind measurements. This has been developed in environments, where we had a large number of WTG's and an existing wind index to test it up against.

The result is shown in the below figure:



As it can be seen, the NE/WTG-index, based on a large number of WTG's mean energy production and the EMD/DMI-index based on wind measurements, fits very well together. This documents, that it is possible to create very precise wind index based alone on wind measurements.

The method is:

a) Wind Speed is corrected to "neutralized" terrain conditions, for each wind direction sector. In order to use the index as a regional wind energy index this is very important. If it's not done the wind energy index will be site specific and cannot be moved.
b) Measured wind speed is corrected to "typically" WTG hub height. This is done to take the shape of the wind profile into account when calculating the index.
c) Wind speed is filtered through a typical/generic WTG power curve. This is done to take the possible utilisation of the total energy content of the wind into account.
d) Wind speed is then filtered through monthly average temperatures based on long-term measurements. This is done to take the density of the air into account. The air density has a direct influence to the output of the WTG. During a summer and a winter day with the exact same wind speed, the output of the WTG can easily be 20% higher during a winter day because of the higher air density (cold air is more heavy).
e) The index is calculated for small time steps. There must at least be 4 diurnal measurements and preferably 24 diurnal measurements or in other words hourly values.
f) All calculated energy values is summed up and normalized based on the sum, so that the mean monthly value over a long period (min. 10 year) gives the value 100.
g) By summing normalised energy up month-by-month, the wind index for each month is found.

Especially part a) requires some effort, because the local terrain conditions around the measure mast must be known very precise. The influence of roughness, topography and local obstacles is taken into account according to the Wind Atlas methodology developed by the Risoe National Laboratory Denmark.

5 BASIC DATA, SPECIFIC PROJECT

To realise the present analysis, the following wind data of the nearest meteorological site with data of a sufficient period of time, are used as a basis.

They are:

- The observatory of the Airport of Demo

The airport provided 8 daily observations of the speed and direction of wind during a period of 10 years, from January 1989 to December 1999.

Furthermore, digital topography was used in a radius of 5 km near the metrological station according to maps with a scale of 1:5000 and digital roughness in a radius of 20 km near the metrological station according to maps with a scale of 1:5000 and 1:50000.

In addition to that, photographs were taken describing a full circle of 360º around the metrological stations in order to assess the possible effects caused by close/local obstacles within 1000m's.

6 RESULTS OF THE CALCULATIONS OF THE WIND INDEX FOR DEMO WIND FARM

The results of Demo, according to the wind data of the nearest and most representable metrological station from the Airport of Demo, indicate that the **wind energy index** of the period of measurement (May 1991 to June 1995) was equal to 94. Therefore, the actual production by the wind farm of Demo can be expected to be 6% higher in the long run, than in the given period.

7 WHO IS EMD?

The Danish institution EMD is an independent Member Association with a board of directors appointed by a number of organizations within the energy sector. EMD participates in various ongoing research and development activities. The software WindPRO developed by EMD for wind energy projection is used by several hundred users including all major wind turbine manufactures. EMD is widely respected as an independent consultant.

EMD has performed similar studies in Denmark, Norway, Sweden, Great Britain and Spain in order to define contractual, correcting factors. The correction factors define the modifications needed for the production estimate of a location in order to predict the energy output of a certain wind farm on a long-term basis.

ABOUT THE WRITER

Lars-Bo Albinus has performed complex energy calculations for big WTG projects in numerous countries e.g. Turkey, Denmark, Sweden, Norway, United Kingdom, Germany, Spain, France, Italy, Greece, The Philippines, Latvia, the USA and more. Many of the studies have included site inspections performed on foot, by car, plane, boat and helicopter. This has often included detailed wind data analysis, long-term wind data correlation (MCP) in many cases and detailed roughness evaluation and height contour treatment. He has also performed a large number of visualizations. He has played a major role in developing a new and very detailed Wind Resource Map of Denmark using the latest computer data handling technology. He is responsible for the WindPRO Windturbine Catalogue. Through his work he is always up-to-date with the latest WTG-technology. Finally he has given many tailor-made and open courses in the software program WindPRO in which he is a super-user.