Title:
Long term wind expectations in Northern Europe

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Summary/Conclusion

After a period with really good wind conditions from 1985 to 1995, the last decade has shown a constant decrease in the wind in Northern Europe, although the winter 2006/07 for first time in a decade gave a wind index level above 100%. Where it previously has been accepted to use a 10 year period as a sufficiently good long term representative this seems far too short a period. Wind index reliability has been brought in focus especially in Denmark and Germany, where the constant change in turbine technology and hub heights challenge the way of calculating wind index from WTG production data. Also establishment of new turbines around existing “index generating” turbines seems to be a problem especially in Germany. Based on numerous analyses performed by EMD, an expected long term variation of wind energy index for Denmark has been established and the knowledge has been coupled to the German wind energy index leading to some criticism of the German IWET index. Wind energy index is especially in Denmark and Germany used for verification and scaling of the wind data used in calculation of production for new wind turbine projects. In that way the wind energy index directly influence the energy yield predictions. An error of 10% in wind energy index for a given period leads to a prediction error of 10% for a new project. This error seems to be the major single error component in energy yield predictions in the relevant countries with existing long term WTG operational experience. Inclusion of NAO index (North Atlantic Oscillation) in the wind index analyses tell us that around 50 year is necessary as long term basis if slow climate oscillations shall be taken into account. Even with 20 years data, the very long term level could be +/-7% off, which also tell that the next 20 years could differ in same magnitude from the very long term level – or the coming 20 year could differ 2 x 7% = 14% from the previous 20 years. To minimize possible errors in energy yield predictions the very long term level should be known.

Introduction

The constantly decreasing wind from 1995 – 2006 in Northern Europe, especially seen in Denmark and Germany in the production figures from a large number of wind turbines, has given rise to concern among investors in turbines in these regions. It is not unusual in recent years to see investors getting less than 80% of expected production. How much is based on less wind and how much is based on less accuracy of the wind index? The German as well as the Danish wind index was revised in 2003. A second revision was made to the Danish Wind index in 2006, in part based on new information (from EWEA 2004 presentations, [1] and [2]) on very long term wind expectations where among other sources the North Atlantic Oscillation (NAO) index available from 1864 till now has been used. But also development of new tools at EMD for analyzing the long-term wind in combination with turbine production has been included in the latest wind index revisions.

EMD who has performed the Danish wind index revisions has criticized the German wind index for being too low based on problems with the adoption of the changes in WTG technology. Older smaller stall regulated turbines is a major source for the wind index calculation, while all new turbines are large pitch regulated, often with essential lower specific power (kW/Rotor area). This in combination with a constantly decrease in wind speeds seem not to be handled properly. A too low wind index level leads to too high production estimates, which makes it a critical issue in Germany, where more than 1000 MW wind capacity has been installed annually in recent years. Many investors must admit that their investment has failed. EMD has like some other German consultants tried to repair the German wind index in order not to mislead new investors, but unfortunately the majority of projects are still sold based on what EMD considers as far too high production estimates based on a wrong wind index assumption.

In the beginning of 2007 IWET introduced a new revision, the IWET 2006. In this paper we give an evaluation of this revision as well.

What the future will bring, nobody knows, but assuming that historic wind variations repeat themselves, higher wind speeds should return. Estimating when and how much though is an issue with large uncertainties. Based on long-term experiences we will try to give our best opinion.

The long term wind variations in Northern Europe

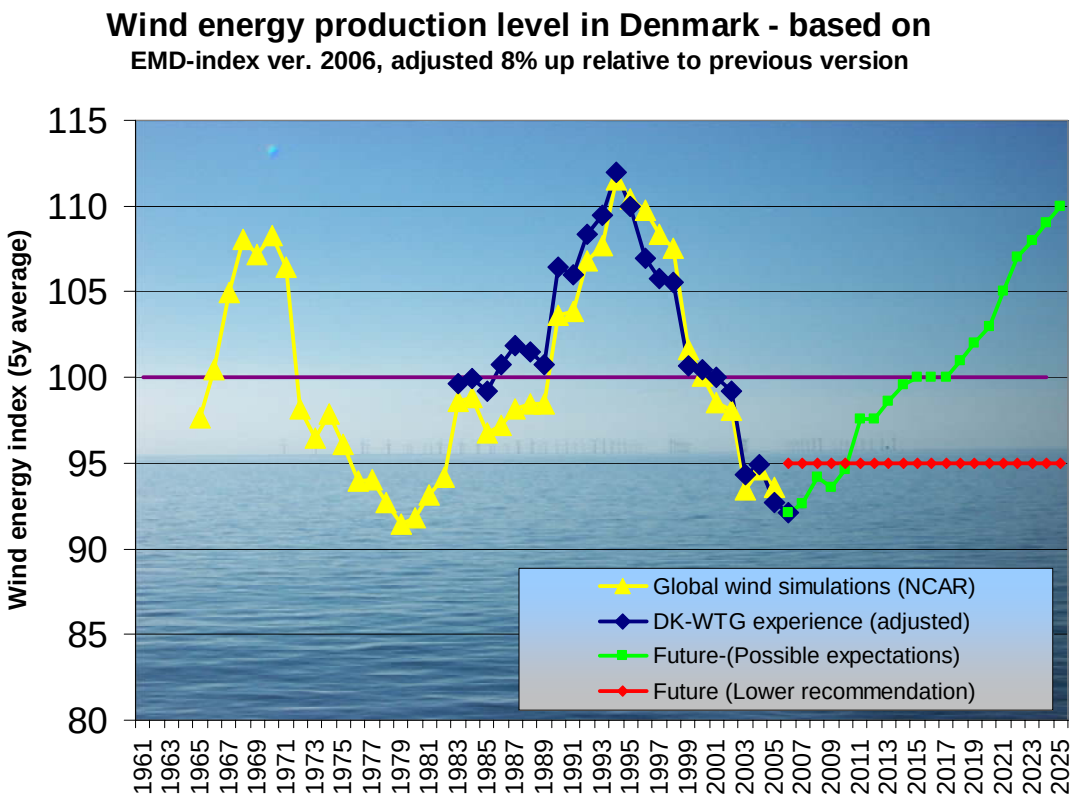

Figure 1. Based on energy production data from 2500 turbines geographically well distributed in all parts of Denmark, the ver. 2006 Danish wind index is calculated from 1998 to now. Before 1998 fewer turbines are used for the wind index calculations combined with technology change corrections.

In figure 1 turbine production figures match well to NCAR wind data simulations giving the wind turbine production variations during the past 25 years. With the NCAR data extrapolations is made back to 1961. The data show a periodic variation of around 25-30 years of period length. If and how this will continue, no one knows, but a best guess would be that the periodic variations will continue, meaning that next decade will bring more wind.

Below the winter NAO index variations do tell much about the wind index variations in Northern Europe. Note the high value in winter 2006/07, where we for first time in many years had very good wind conditions in Northern Europe. Also 1985-95 show very high values, the years with the extreme good wind conditions. In general the winter index is above 0 in average, like the wind index for winter months in general is above 100%.

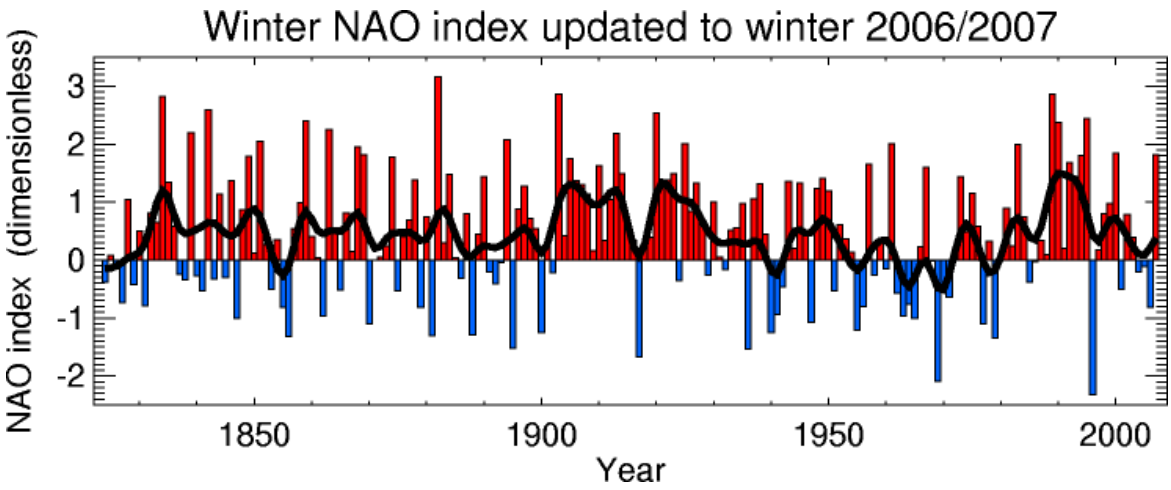

Figure 2. The NAO (North Atlantic Oscillation) index from http://www.cru.uea.ac.uk/~timo/projpages/nao_update.htm

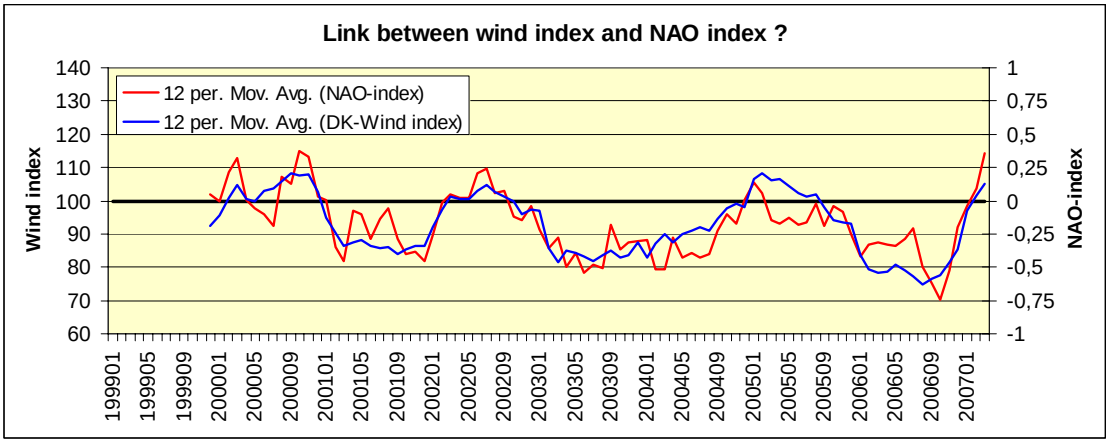

Figure 3. The monthly NAO index from the same web page as mentioned previously show extremely well correlations with the Danish Wind index based on 12 month average. Note the lowest level for the Danish Wind energy index ever based on 12 month average around 75% were reached August 2006.

The comparison of the Danish Wind index and the NAO index not only show that there is a good correlation, but also that the level of the Danish Wind Energy Index seem to be correct seen on a very long term perspective, as the very long term NAO index in average is zero.

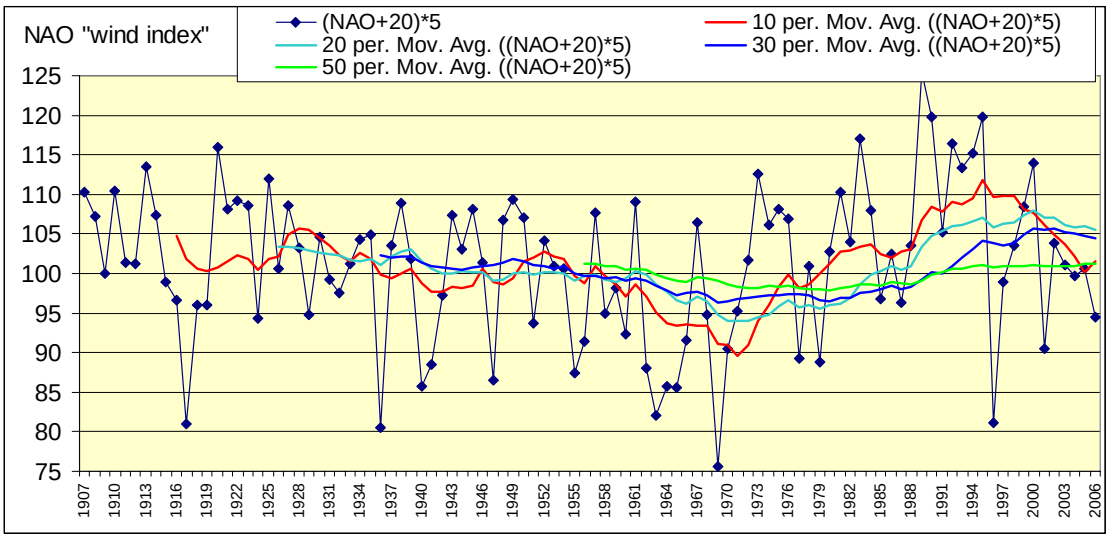

Figure 4 How long data period will be required to get a real long-term representation? The graphic above where the past 100 years NAO index is converted to a wind energy index based on a simple approach indicate that a10 year averaging period can be more than 10% off (1986-95) and even a 30 year averaging can be more than 5% off (1971-2000). With around 50 year, the long term index level stabilizes with maximum a few percent off from the very long term index level. With 20 year averaging period the worst case deviation is 6% below long term average.

Important lessons learned regarding long-term wind variations in Northern Europe is that there is a very tight link to the NAO index and that this show that around 50 years of averaging is required in order to establish a very long term average wind energy level (figure 4). With a base period of 20 years , the wind energy level in the worst case is seen to be 6% below the very long term level based on the NAO index. This is a risk the investor in wind power projects in Northern Europe have to deal with. But an even more important message is that if the very long term level is not included in the analyses of the expected energy production, but maybe only the recent 10 years of data, there might be more than 10% bias in the production estimate. This would then lead to a risk of 16% error on the expected energy production, just from the long-term wind energy expectations. This is a far larger risk than most other risk elements in energy production estimates.

German wind index problems

While we at EMD believe that we have established a real long term based wind index (Version 2006) AND we believe in that there are no faulty trends due to change of technology etc., one way to test the German Wind energy index is to compare along the Danish – German border. The wind energy index along this simply should not differ, at least not when looking through longer periods, while monthly variations will be reasonable.

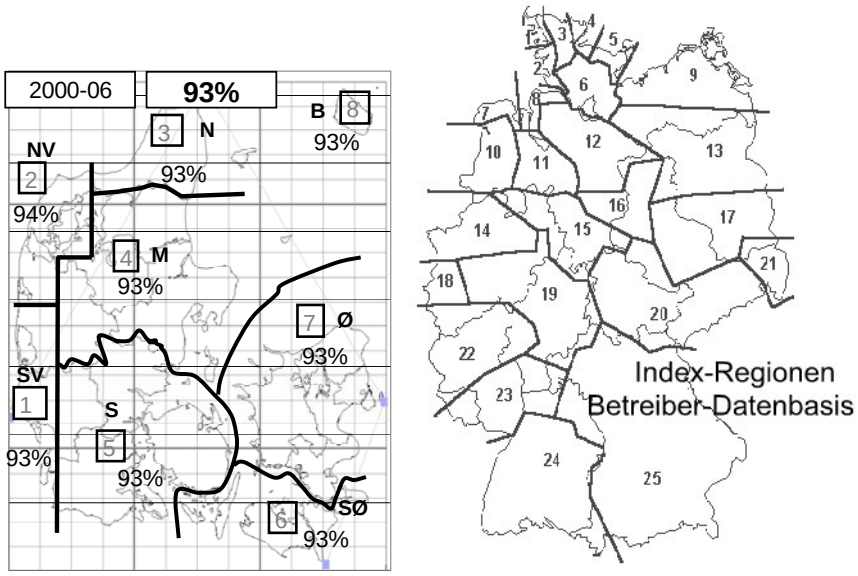

Figure 5. The Danish (left) and German index regions. The Danish region 5 is neighbor to German region 3 & 4 and should have comparable wind index levels. Later we take a look at the 2000-06 index level, which in the DK-map graphic is seen to be around 93%.

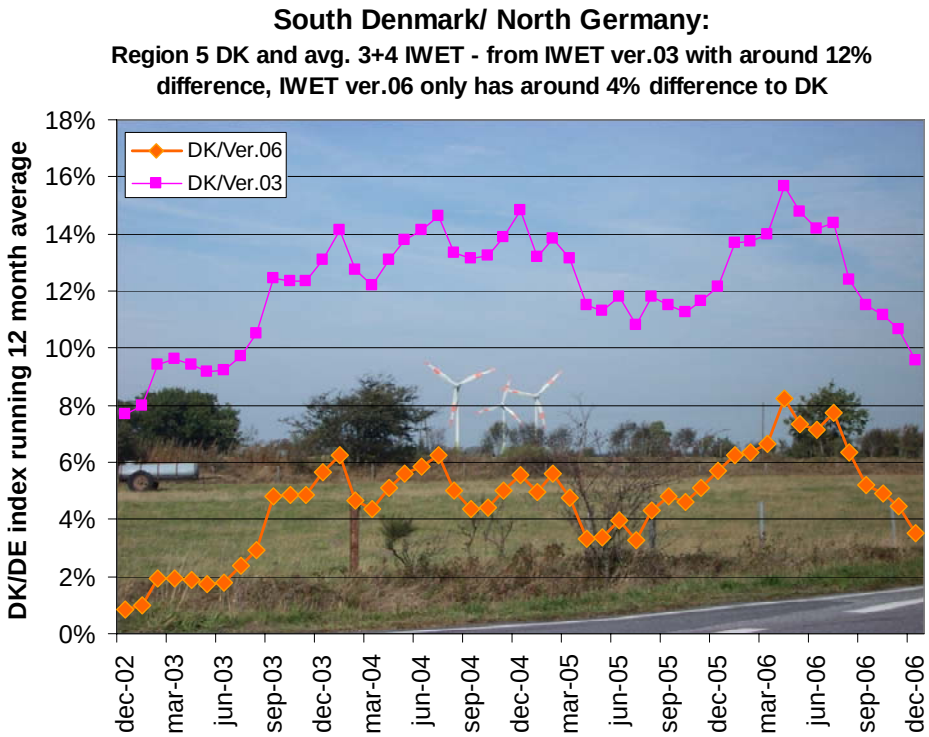

Figure 6 Comparing DK region 5 and German region 4 & 5 (average) – values shown is DK/DE – 1(%)

The comparison between Danish and German index levels show that based on the old IWET version 2003, the Danish index level is around 12% higher. Based on IWET version 2006, the difference is lowered to around 4%. It indicates that there is still around 4% too low a level in the new IWET 2006 version, which leads to a 4% overestimation when calculating new projects based on the IWET 2006 index for this region.

Based on Danish long term experiences, the 7 years from 2000-06 should have a wind energy index level around 93%. How the IWET 2006 match this is seen in figure 7. If the assumption that the past 7 years on average had a similar relative wind climate to long term average is correct, the problematic regions in the new IWET 06 version will be the regions 9, 13, 16 and 17 (all former DDR), with around 5% error plus the southern German regions 22-25 with up to 9% error.

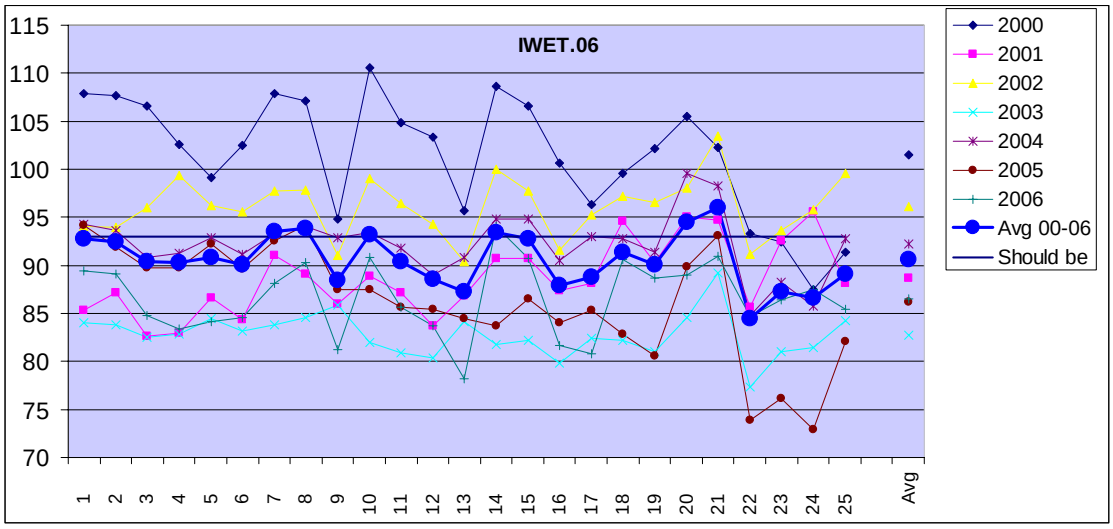

Figure 7. Progression of IWET 06 index for individual years through the German IWET sectors. The fat blue line is the average of 2000 to 2006, which in Denmark is 93%.

To understand the importance of a correct wind energy index level, it has to be mentioned that most energy calculations for new wind farms in Germany is based on the reference turbine method. Basically the wind data basis is calibrated to predict existing turbines in the region of the new project correctly. The correct actual production of the existing turbines is obtained by adjusting the actual production with the wind index for the production period. If the wind energy index level is 10% too low, a 10% too high actual production for existing turbines is assumed and thereby the new turbines also is calculated 10% too high.

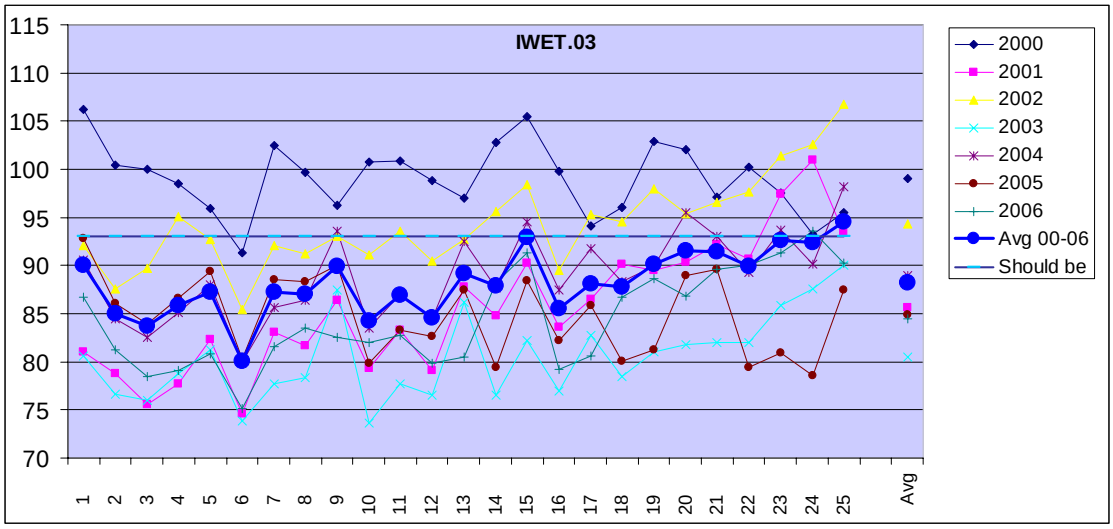

Figure 8. Same story as figure 7, but based on the IWET 03 version. Up to 14% error (reg.6) on the basis of 7 years, including many of the important regions (North, 2-4 and Northwest, 10-12) with errors as high as 8-10%.

The expected possible error in energy production estimates just due to wind index error based on the IWET 03 version could be as high as 14% in one region but around 8-10% in several of the regions rich in turbines **This is with 7 years of production data for existing turbines. With fewer years, the error can be significantly higher.**

The reason for the probably wrong levels in German wind index is partly to find in the used reference period 1989-2002 for version 03, but this is not the only reason. Technology change in time not handled consistent is one - new wind farms build up around the index giving turbines another. But basically there probably are methodical problems – how the index is calculated, we do not know.

Referenses

[1] A. Albers Deutsche WindGuard Consulting GmbH, Germany; Long Term Variation of Wind Potential: Are we Moving into a Low NAO-Cycle Period? EWEC 2004, London.

[2] Cecilia Johansson & Hans Bergström Uppsala University, Sweden; Variability in the energy content of the wind over Scandinavia a 101-year perspective. EWEC 2004, London.