WREC Aberdeen May 2005

Use of regional wind energy indices to predict long-term wind farm production and to assess portfolio effect

Authors: Keir Harman, Colin Morgan
e-mail: keir.harman@garradhassan.com
Tel: +44 1179 729 900
Company: Garrad Hassan and Partners Ltd, St Vincent's Works, Silverthorne Lane, Bristol BS2 0QD

Abstract

The long-term production estimate for a wind farm is traditionally based on historical periods of on-site wind speed or production measurements extrapolated to the long-term by correlation to measurements at a long-term wind speed reference station. Typically many years of measurements at the long-term reference station are required to define a reliable long-term. Such datasets are often unavailable. As a result, there is increasing demand for regional indices that are based on a composite of long-term wind speed measurements and/or wind farm production. The perceived benefits and drawbacks of such indices are presented with reference to particular indices for regions of Europe.

Increasingly wind farm owners are looking to mitigate wind risk by acquiring a geographical spread of wind farms. Correlation of regional indices will demonstrate how portfolio effect can be assessed. The paper will draw on Garrad Hassan's experience of assessing thousands of megawatts of operating wind farms worldwide.

Key Words: Wind energy indices, portfolio effect, wind risk, production forecast

Introduction

In the wind industry the annual variability in wind speed is often the principal risk associated with the production forecast.

This paper will examine using wind energy indices as a tool for understanding the long-term trend of a particular region with the focus on one area of increasing activity within the wind industry; the financing of geographically diversified wind farm portfolios which aim to mitigate wind risk.

The first section of this paper briefly defines what wind indices are and explains how they can be created. The second section examines the main uses for wind energy indices. This is followed by a review of what indices are currently available. The final section assesses whether when applied these indices support the beneficial portfolio effect previously described.

The main focus is on Northern Europe over which some 46% of the world's total installed wind energy capacity is located [1]. There is some brief comment on other geographical areas at the conclusion.

This paper draws upon Garrad Hassan's unique experience of assessing thousands of megawatts of operating wind farms worldwide. Due to the obvious issues of data sensitivity this paper will not use specific case studies instead it will rely on data sources available in the public domain which have been internally tested and verified using real wind farm data.

Wind energy indices and their uses

Wind energy indices are a statistical tool that provides a generalised trend over time for a particular geographical region. They are historical time series of production or wind speed data for a region normalised to a long term average and are usually produced on a monthly or annual basis. Ideally they should be based on actual production figures from wind farms. Alternatively, in the absence of such data, they can be derived using a simple model which converts wind speed measurements to a production equivalent.

There are three main reasons why one would use wind energy indices:

First, the **long-term production estimate** for a wind farm is traditionally based on short-term periods of on-site wind speed or production measurements extrapolated to the long-term through correlation to measurements at a local wind speed reference station with long-term historical records. Such reference stations are usually operated by the national weather service. Typically many years of consistent measurements at the reference station are required to define a reliable long-term forecast. Such datasets are often unavailable and in such cases a long-term production forecast may be estimated by using an appropriate wind energy index. The chosen wind energy index may be used in much the same way as a more traditional long-term wind speed reference station by correlation to measured site data and extrapolation to simulate a time series of historical resource for the particular site.

Secondly, with regards to an operational wind farm these wind energy indices can be used to **understand the production in a particular year**. As such, they can be a useful tool to aide wind farm operators. For example, an wind energy index can be referred to where turbines performance and availability are deemed to be satisfactory but the wind farm is not meeting its projected revenue due to wind speed. The relevant index may be simply used to explain low or high revenue compared to the budget.

Thirdly, wind energy indices may be used to **assess the correlation of wind speed over wide geographical regions**. It is this last point that is becoming of greater interest as there is an increase in ownership of geographically diverse portfolios which attempt to mitigate wind speed risk. Garrad Hassan has recently been involved in the financing of several large-scale portfolios in the US and Europe.

Availability of wind indices

One of the most established wind energy indices is produced for the Danish wind market. This covers the period from 1979 and is based on the production data from thousands of turbines across Denmark. This monthly index is regularly updated and publicly available [2].

Figure 1 below shows this Danish index on a monthly and annual basis.

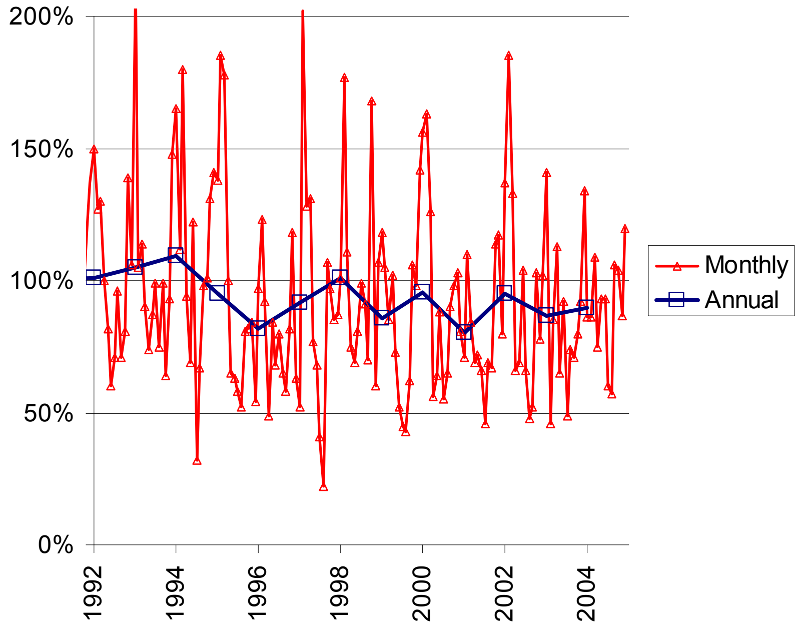

Figure 1 The Danish wind Index shown from 1992 to 2004
100% = average from 1979 to 2004

Points of note are:

- The production from each of the wind turbines are normalised to an average from 1979 to 2004.
- The monthly figures are shown in extreme cases to be double the long-term average.
- The annual figure is the average of twelve calendar months.
- Annually the index may vary by as much as 20% from the long-term mean (unity).

Another wind energy index available in the public domain is the German index provided by IWET [3]. Also available is the Dutch index provided by Wind Services Holland [4] and the wind energy index for Sweden from Elforske [5]. All of these indices are based on actual wind farm production data.

It is notable that there are currently no public or widely available wind energy indices for Spain, Italy, UK or Ireland despite very active wind energy markets in these countries.

In the absence of publicly available production data it is possible to produce wind energy indices which can be derived from wind speed measurements. Figure 2 shows wind energy indices which have been derived by Garrad Hassan for the UK and Ireland based on combined wind measurements from several meteorological masts.

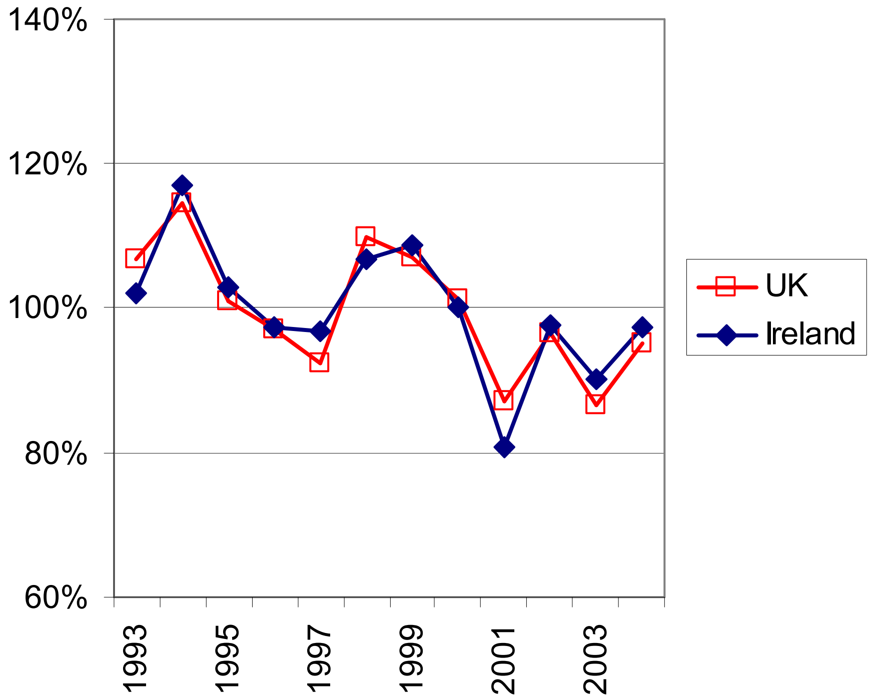

Figure 2 Wind energy indices derived for the UK and Ireland
100% - Average from 1993 to 2004

As an alternative data source to derive wind energy indices, there is increasing interest in using reanalysis datasets which are composites of many different types of wind speed measurements, including upper atmosphere measurements. [6]

Considering Europe as a whole, there is varying quality and consistency of datasets that are available. Depending on an individual country's approach to data and its confidentiality, the availability of wide spread wind farm production data may be scarce.

Acquisition of wind farm portfolios

When seeking to acquire wind farm assets, production forecast estimates are created based on historical periods of wind speed measurements. It is common sense to assume that there is a "portfolio benefit" to acquiring multiple assets in regions with apparently uncorrelated wind speed, as by doing so the long term production forecast risk is reduced.

An additional perceived portfolio benefit is a smoothing of the annual revenues with regards to regionally diverse operating wind farms.

There are other risks, in addition to wind risk that can be successfully mitigated by taking a portfolio approach. The use of a portfolio can mitigate risks by using a:

- combination of turbine types, for example reducing the risk of loss through a manufacturer going bankrupt and reducing the risk of production loss through serial mechanical defects;
- wider spread of both political and market factors such as variability in types of revenue tariffs

These latter risks although potentially substantial are not considered here. Nor is the element of wind risk relating to measurement and analysis uncertainties.

Using the indices outlined earlier it is useful to test the assumption that there is a portfolio benefit with regards to acquiring wind farm portfolios across Northern Europe.

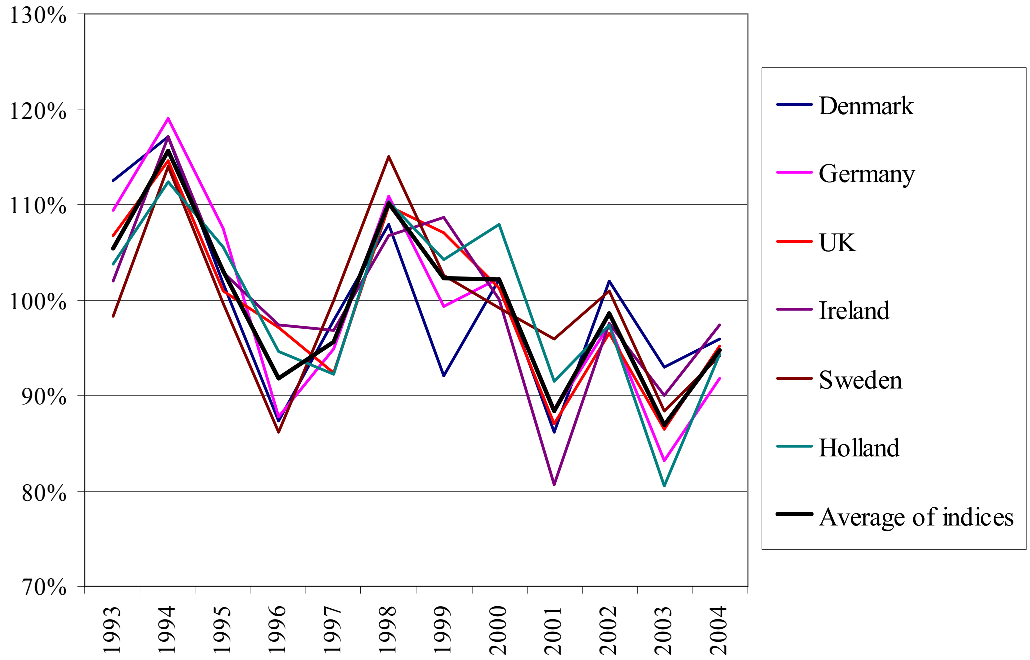

Figure 3 **Various wind energy indices for Northern Europe showing correlation on an annual basis**
100% - average from 1993 to 2004

Figure 3 shows that the wind trends across Northern Europe are strongly correlated therefore weakening the potential value of acquiring a portfolio based solely in Northern Europe.

Interestingly, the North Atlantic Oscillation (NAO) [7], a measure of pressure difference between Iceland and the Azores in the central Atlantic used by meteorologists to understand long-term weather cycles across Europe, supports this conclusion as it shows a similar trend to the average of the wind energy indices in Northern Europe. The NAO is compared to the average of the North European Indices in Figure 4 below.

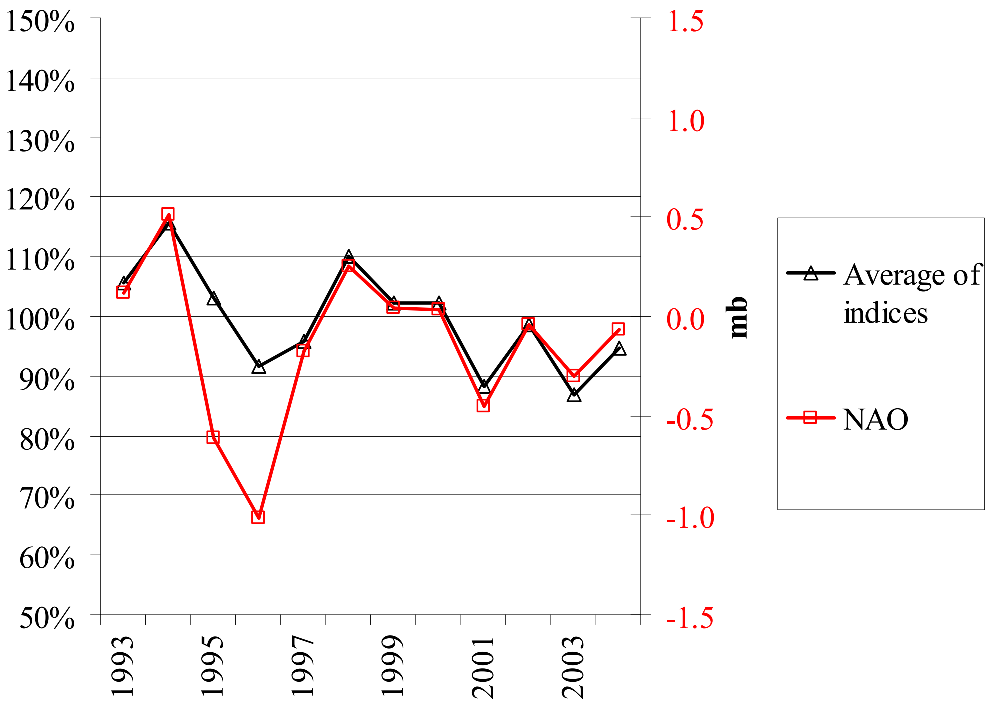

Figure 4 Comparison of the Northern European Indices to the North Atlantic Oscillation

Conclusion

This paper attempts to compliment the traditional approach of long-term wind farm production forecasting by suggesting the wider use of wind energy indices to aide the estimation of long-term production. The use of wind energy indices as a tool to explain operating wind farm production deviation is also considered. The presented wind energy indices are correlated to assess the potential for portfolio benefit from geographical diversification.

The paper has briefly reviewed what wind energy indices are and different methods of deriving them, commenting on the fact that there are areas of Europe that have no public wind energy indices despite very active markets. This paper has argued that wind energy indices can be very useful for assessing the portfolio effect. The key point that emerges when comparing Northern European indices is the strong correlation and hence there is not the level of portfolio effect benefit that one might expect. This conclusion is supported by other work in this field, for example Dunlop [8].

This conclusion would indicate that to successfully mitigate wind risk a wind energy financier must look further a field than Northern Europe when constructing a portfolio. Initial recommendations would be to seek a portfolio which covers both Northern Europe and Southern Europe bearing in mind other potential portfolio benefits briefly mentioned earlier in the paper.

References

1 BTM Consult, World Market Update 2004, March 2005

2 Danish Wind Index available from www.naturlig-energi.dk

3 German Wind Index available from IWET

4 Wind energy index for Holland available from Wind Service Holland

5 Swedish wind farm production data available from www.elforsk.se

6 Kalnay E., Kanamitsu M., Kistler R. et al, "The NCAR/NCEP 40-year reanalysis project", B. Am. Meteorol. Soc., 1996, 77, 437-471.

7 North Atlantic Oscillation, available through the climatic research group at the University of East Anglia www.cru.uea.ac.uk

8 J Dunlop, Eufinium, "Modern Portfolio Theory Meets Wind Farms", EWEC Conference, London, November 2004