Geographical Distribution and Wind Power Smoothing 2009

Observations from Denmark, Germany and Ireland

Previous studies have demonstrated that there is a considerable synchronism in variations of wind power in Denmark and Germany. The smoothing effect of considering the two Danish and the four German control areas as on wind power system is poor. Even the electricity market performance reflects the close relationship between the two countries.

It has been suggested that aggregating wind power along an east-west axis could give a much better wind power smoothing. The establishment of a time series for Irish wind power in 2009 has allowed an east-west comparison.

Data sources

In most European countries time series on the electricity market are not conveniently available.

Denmark was a frontrunner in publishing hourly data. The data are available at the Energinet.dk web site[1]. The data from Energinet.dk includes spot prices from the European Energy Exchange (EEX) in Frankfurt. Wind power output in Germany is available at the web sites of the four German transmission system operators[2].

Irish market and system data can be downloaded from Eirgrid's web site[3].

The formats are different. Therefore different conversion procedures are required for the establishment of comparable time series.

Statistics

The comparison between Germany and Denmark in previous studies was based on energy units. This is reasonable due to the strong interconnections and the close operational relationship between the two countries. The results demonstrated that the two countries responded to the variations of wind power as one power system.

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[1] http://www.energinet.dk/en/menu/Market/Download+of+Market+Data/Download+of+Market+Data.htm

[2] http://www.transpower.de/pages/tso_en/Transparency/Publications/Network_figures/Actual_and_forecast_wind_energy_feed-in/index.htm
http://www.50hertz-transmission.net/cps/rde/xchg/trm_de/hs.xsl/SetWebsiteLanguage.xml?languagevariantid=ENG&lang=en&targetPage=153.htm
http://www.amprion.de/en/wind-data-according-to-17-stromnzv
http://www.enbw.com/content/de/netznutzer/strom/download_center/eeg/windprognose/index.jsp

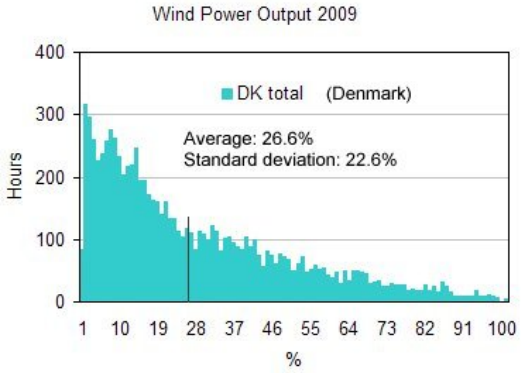
[3] http://www.eirgrid.com/operations/systemperformancedata/downloadcentre/

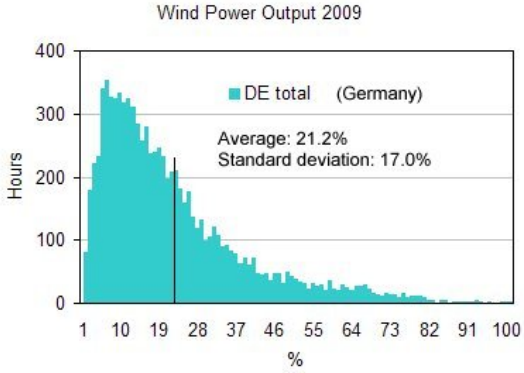
The purpose of analyzing time series for wind power in Denmark, Germany and Ireland is to compare smoothing effects north-south and east west. The three locations should have the same weight. Therefore the time series have been converted into percent of the maximum value of the year.

The following overview has been extracted from the time series:

		Denmark	Germany	Ireland
Wind	GWh	6,708	37,738	2,886
Max	MW	2,877	20,353	1,043
Duration	Hours	2,331	1,854	2,741
Load	factor	0.27	0.21	0.31

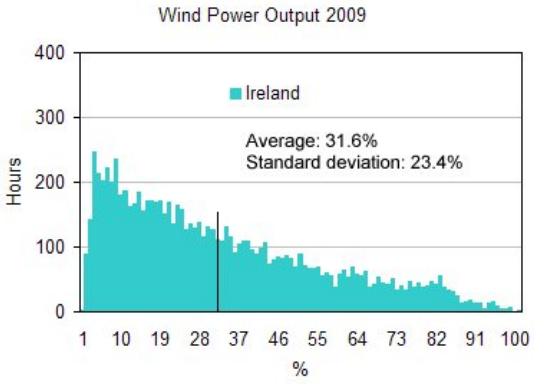
The three wind power systems are different in size and wind intensity. The differences can be further explored by considering the distribution functions:



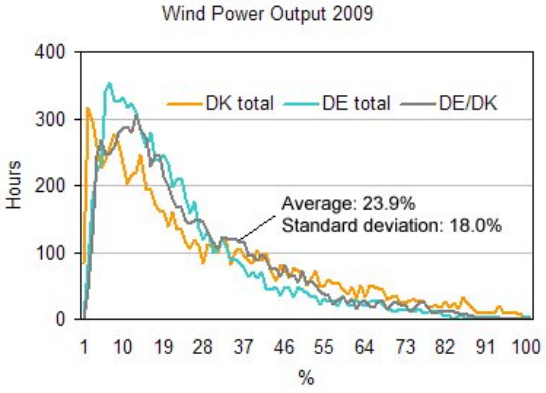


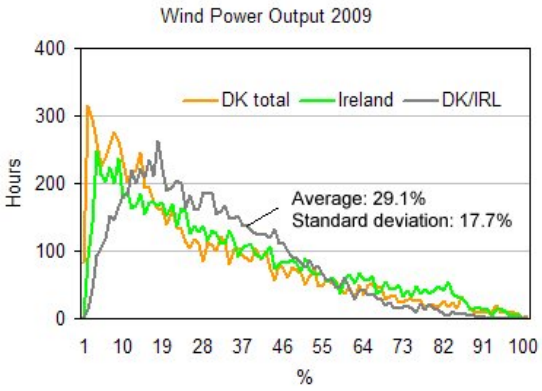
The average in Germany reflects the lower average wind intensity at the wind power sites. The standard deviation depends on the size of the country. It is obvious from the chart that Germany has a lower number of hours with very low and very high total output.

The wind intensity at the wind power sites in Ireland is higher than in Denmark and Germany. A high standard deviation reflects the size and extension of the Irish wind power parks.



Average time series for Denmark and Germany and for Denmark and Ireland have been established in order to quantify smoothing effects north-south and east-west. The use of simple averages implies that the three locations have the same weight.





The left hand chart shows that only modest improvements have been obtained in a combination of Denmark and Germany. By combining Denmark and Ireland a different distribution function appears. The numbers of hours with output lower than 10% and higher than 60% have been counted. The upper and lower limits are arbitrarily chosen.

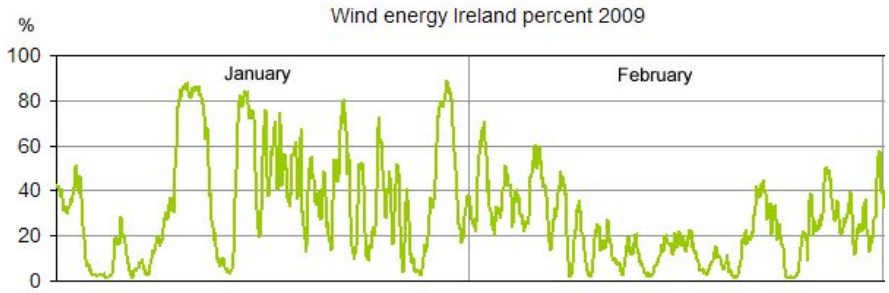
Number of hours	Denmark	Germany	Ireland	DE/DK	DK/IRL
Output < 10%	2447	2392	1733	1999	1019
Output > 60%	901	390	1289	456	528

This observation indicates that a considerable reduction of hours with extreme output can be obtained if Irish and Danish wind power resources could be combined. However, it is necessary to study the time series in order to evaluate the effects from an operational point of view.

The time series

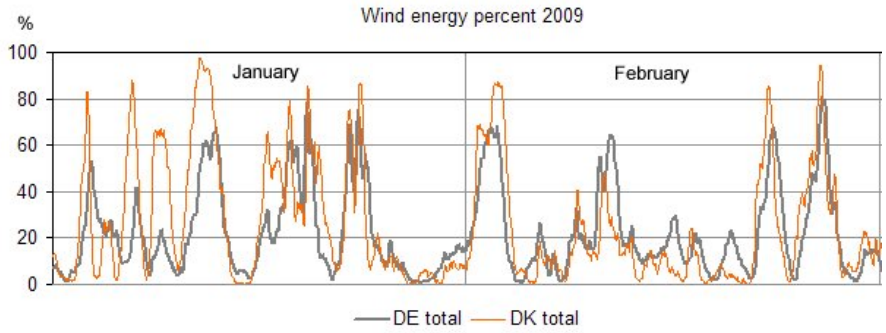
January and February 2009 will be used for presentation of the time series.

The following chart shows the relative wind power output in Ireland in January and February 2009:

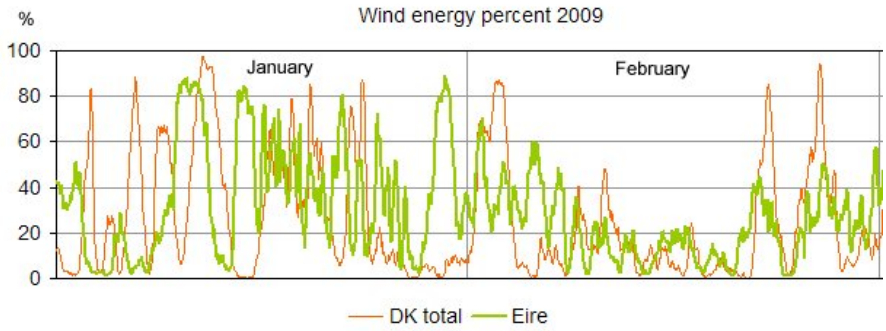


There seem to be some oscillations with higher frequency than what has been seen in Denmark and Germany. The variations could be connected with the number of wind farms and the distances between locations in Ireland rather than with special wind properties.

The comparison between wind power in Denmark and Germany shows a clear synchronism:

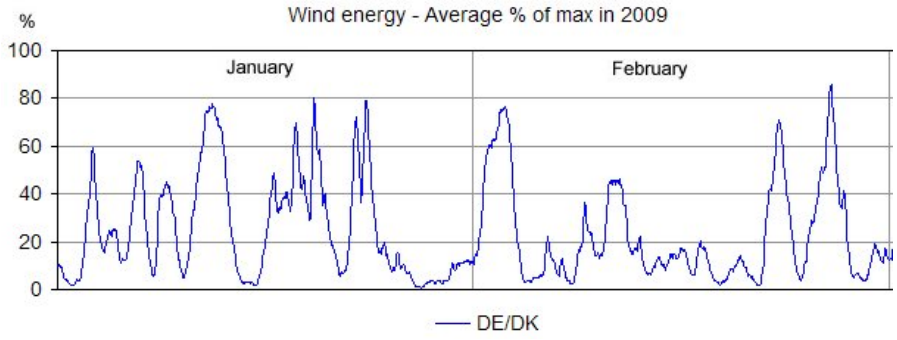


The wind power time series and Denmark and Ireland are more different:



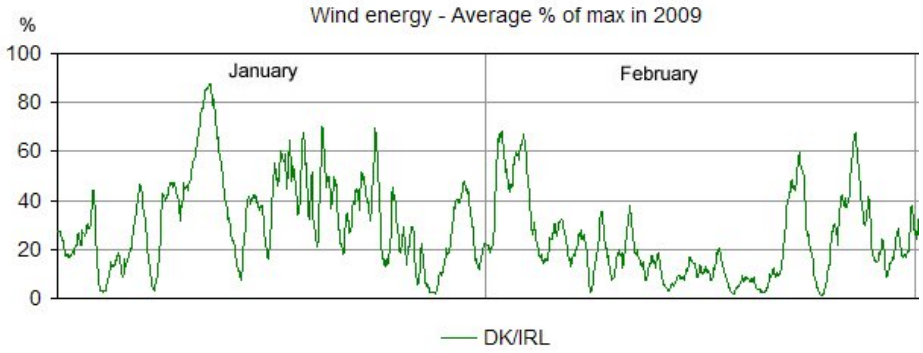
A considerable smoothing could be expected by combining the two time series in this confusing pattern.

Average time series will be used for visual inspection of the smoothing effect. The following chart shows the merged Danish and German time series:



The chart shows the volatile and random nature, even for the average wind power output for Germany and Denmark. The duration of typical wind power waves can be between 2 and 4 days. The peaks are slightly lower than for each country, but there are still periods with very low generation and several days with less than 20 % energy output.

The next chart shows the average wind power output for Ireland and Denmark:



From a statistical point of view some smoothing effects have been detected, but from an operational point of view there are still random variations with peaks and periods with low energy output.

A combination with UK data would probably eliminate the fast variations, which seem to be due to local Irish conditions. The volatility might be further damped, but the peaks and the calms would still be there.

Conclusion

A smoothing effect has been calculated in statistical terms from combining wind power in Denmark and Germany and from combining wind power in Denmark and Ireland.

The most significant smoothing has been observed for the Danish Irish combination. The reasons can be that typical weather fronts are moving from west to east, and that the distance between wind power gravity centres is larger between Denmark and Ireland than between Denmark and Germany.

The question is if the smoothing effects are sufficient for justifying large scale interconnections. Visual inspection of time series for wind power output has demonstrated that the there will be waves with peaks and deep valleys for both the north-south combination and the east-west combination.

Wind power variations are challenging electricity markets and transmission grids. Better market coupling across borders and stronger grids and interconnections are required for paving the way for a large scale international solution.

As alternatives and supplements local measures for utilization of wind energy are considered. With the current ambitious plans for wind power development in several countries the development of all measures should be supported.

Convenient access to market data time series for more countries and particularly for the UK is desirable and necessary for an efficient preparation of a successful future utilization of wind energy.