Wind Power and Intermittency

BWEA Briefing Sheet

THE BRITISH WIND ENERGY ASSOCIATION

Wind Power and Intermittency: The Facts

Wind generation is often described as intermittent, as the wind doesn't blow continuously. This is a misnomer as it implies an 'all or nothing' delivery of energy.

An individual wind turbine will generate electricity for 70-85% of the time and its electricity output varies between zero and full output in accordance with the wind speed. However, the combined output of the UK's entire wind power portfolio shows less variability, given the differences in wind speeds over the country as a whole. Whilst the amount of wind generation varies, it rarely (if ever) goes completely to zero, nor to full output.

This briefing sheet addresses some of the most common questions associated with the variability of the wind. It concentrates on the issues that apply to modest contributions of variable renewables to a power system - up to 20%, say. This is not a ceiling and many argue higher amounts can be accommodated. The aim is to clarify the short to medium-term issues, drawing upon the considerable body of analysis that has been carried out during the past 25 years.


Askam wind farm © Ecconect

This is followed by a selection of findings from Parliamentary Select Committees and other authoritative bodies who have examined the variability issue.

Managing the electricity system

In order to maintain security of supplies, a second-by-second balance between generation and demand must be achieved. An excess of generation causes the system frequency to rise whilst an excess of demand causes the system frequency to fall. The electricity system is designed and operated in such a way as to cope with large and small fluctuations in supply and demand.

No power station is totally reliable and demand is also uncertain. Therefore, the system operator establishes reserves that provide a capability to achieve balance given the statistics of variations expected over different timescales. The variability of wind generation is but one component of the generation and demand variations that are considered when setting reserve levels.

Frequency Response

The reserves scheduled include frequency response, the automatically controlled generation or demand that can respond to instantaneous imbalances. The system operator buys sufficient frequency response such that system frequency remains near to 50Hz for the continuous demand and generation fluctuations and also remains within statutory limits (50.5Hz and 49.5Hz) following any sudden tripping of the largest generating units or any sudden disconnection or reduction of demand.

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The short term variations of wind generation (second-to-second or minute-to-minute) are small compared to the corresponding variations in demand. In addition, it is very unlikely that a national portfolio of wind generation would give rise to instantaneous power changes as large as those currently managed. When large power stations 'trip', up to 1320 MW of generation is lost - instantaneously. Wind generation is not like that; as more wind plant is built it will be widely spread over the country and so the power swings will be generally quite gentle.

Longer Term Reserves

The system operator also requires longer term reserves. These are used to manage any longer term discrepancies between generation and demand that would otherwise exhaust the available frequency response. Unlike frequency response which is an automatic service, reserves are despatched by the system operator. Reserves are particularly valuable at times when the demand is changing rapidly and large power stations are connecting (or disconnecting) from the system. For example on a typical winter's morning, electricity demand can increase by 12,000 MW over a 2 hour period.

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Operational data from wind plants in Denmark[1] and Germany[2] show that the maximum power swings within an hour never exceed about 20% of the installed wind capacity. So with 5,000 MW of wind on the system, the maximum hourly change (which will occur once or twice a year) will be about 1000 MW. This is of a similar order to existing reserve holdings, and while there may be a need increase reserve holdings somewhat, it is unlikely to give rise to unfeasible requirements.

Studies of wind power changes in Germany, Denmark and Finland[3] also show that for 90% of the time, power swings of dispersed wind generation within one hour are less than 5% of the installed wind capacity. These studies (and others) estimate that additional reserves required on the system are only a few percent of the installed wind capacity[4]. The evidence in this area is pretty robust.

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Utilities first started looking at the issues surrounding variability about 25 years ago[5]. Since then numerous studies have been published, and they all reach very similar conclusions. A comprehensive list of these studies is included in the DTI/Carbon Trust "*Renewable Energy Network Impacts Study*".[6] Parliamentary Select Committees that have looked at the question in some detail have concluded that variability is unlikely to cause any significant problems. The GB system operator, National Grid Transco, is also quite relaxed about accommodating wind, as quoted overleaf.

Standby Capacity

There is, as far as we are aware, no evidence that demonstrates that windless days regularly coincide with peak demands on the UK electricity network. That is what matters, as the risks of power shortfalls are highest on days of peak demand. Several studies have shown that wind power is available on days of peak demand, more often than not[7,8]. System operators do not rely on all the wind being available, any more than they rely on all the conventional plant being available. On average, at times of peak demand, roughly 85% of the conventional plant operates and about 35% of wind capacity. In each case, more will be available on some occasions, less on others. Operating power systems is all about managing risks and what matters is the overall risk.

Summary Statements from Key Bodies

The GB System Operator, National Grid Transco, "*Seven Year Statement*", May 2005

"…based on recent analysis of the incidence and variation of wind speed, the expected intermittency of wind does not appear to pose major problems for stability…

Current levels of frequency response and short term reserve are believed to be sufficient, even if the Government's 2010 goal of 10 per cent of electricity supplies sourced from renewable fuels were all to be met by, say, wind technologies. In any event, should more response and reserve services be required, then ancillary service market arrangements should encourage their cost effective provision. So although there could be an increase in operational costs, significant technical problems arising from accommodating the Government's targets for renewables and CHP by 2010 are not foreseen."

Welsh Affairs Committee (Commons), Session 1993-94, "*Wind Energy*"

"The routine variations in demand within the grid and the need to protect against the failure of conventional power sources together require a flexibility far greater than that demanded by wind energy either at present or in the foreseeable future."


Cruach Mhor Wind Farm © ScottishPower

Trade and Industry Committee (Commons), Session 2001-02, "*Security of Energy Supply*"

"We take comfort from the assurances given by the National Grid Company and others that the intermittency of certain types of renewable power - principally wind, but also wave and solar -would not cause supply or balancing problems for the transmission and distribution systems at the 10% level.

Cabinet Office, Performance and Innovation Unit, 2002, "*The Energy Review*"

"As a rough rule of thumb, while the share of intermittents remains below about 5%, the system costs would be insignificant. With a share between 5% and 10% costs start to rise to about 0 .1p/kWh…. the current estimates suggest a cost of about 0.2p/kWh when intermittents provide 20% electricity."

These are the costs per unit of wind electricity generated; not per unit of all electricity.

Science and Technology Committee (Lords), Session 2003-04, "*Renewable Energy: Practicalities*"

"The amount of standby capacity that is needed reflects the aggregated uncertainty of the power supplies, not the marginal uncertainty of wind power alone. The consequence is that for relatively low penetrations of wind power (up to 10% of total demand) the additional standby capacity required is small".

This report also quoted some figures for the additional costs, updating the estimates in the Cabinet Office report, above. The Committee also quoted some figures for the amount of conventional capacity that wind power can displace: 12,000 MW would displace 3300 MW of conventional capacity and 25,000 MW would displace around 5000 MW.

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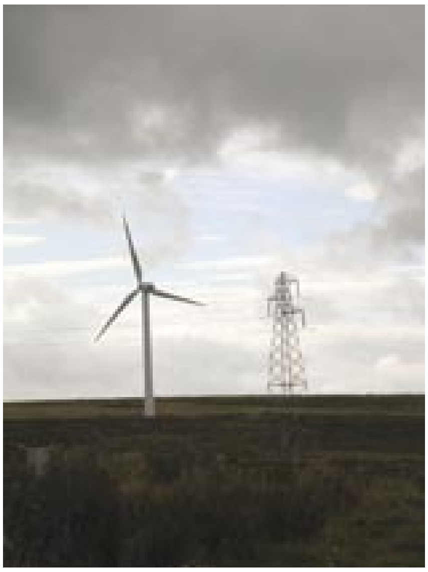

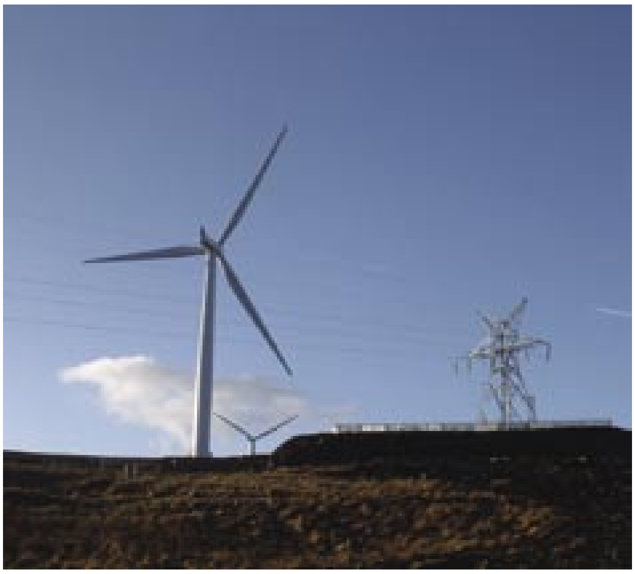

References and further information

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[5] Farmer, E D, Newman, V G and Ashmole, P H (1980), Economic and operational implications of a complex of wind-driven power generators on a power system. IEE Proc A, Vol 127, No 5

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[9] National Grid Company PLC (2005) GB Seven Year Statement, May 2005. Available at www.nationalgrid.com

[10] For the latest UK wind energy statistics go to www.bwea.com/ukwed

[11] For other Briefing Sheets in the series go to www.bwea.com/energy/briefing-sheets.html

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