The effect of wind energy in the electricity system

IESIS — A MULTI-DISCIPLINARY ENGINEERING INSTITUTION

IESIS promotes the principle that, before proceeding with any policy for the electricity system, comprehensive independent assessments should be carried out. This would significantly reduce the risk of unsatisfactory outcomes

This presentation explains the serious difficulties involved in introducing wind generation to the system.

For more information about the IESIS stance on how policy for the electricity system should be formulated see: www.iesisenergy.org

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The effect of wind energy in the electricity system

It is being assumed that:
(a) the increasing amounts of wind energy in the electricity system will be good for security of supply and
(b) wind energy will be cheaper than from other sources.

We show here that these assumptions are not valid.

Preliminary

It is important to note that we avoid making any statement about what the electricity generation mix should be.

We do say that that the technical complexity of the electricity system needs to be recognised and that whatever decisions are made about it should be based on the most reliable and comprehensive information that can be assembled.

Security of supply

Security of supply - is the risk that demand for electricity will exceed generation.

Some people assume that because of the increase in electricity generation capacity in Scotland, security of supply will not be a problem.

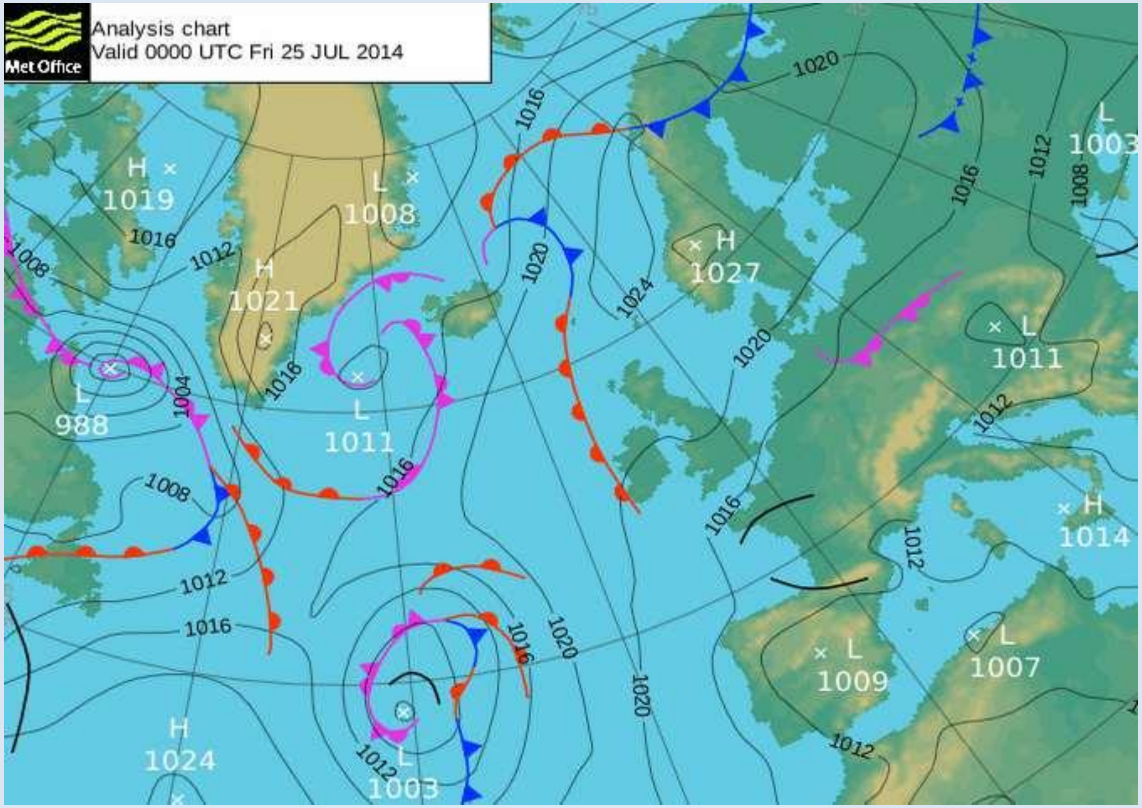
This assumption is false because of the deeply intermittent nature of wind power generation.

We present evidence to support this conclusion.

Low wind across Europe

The chart shows the atmospheric pressure over Europe on 25 July 2014
When the isobars (lines of equal pressure) are close together the wind is strong. For example there were strong winds off the coast of Labrador.
Over the whole of Europe the isobars were widely spaced. This indicates low wind speeds. There was very little 'good wind' in Europe at that time.

Synoptic chart at 0000UTC 25 July 2014

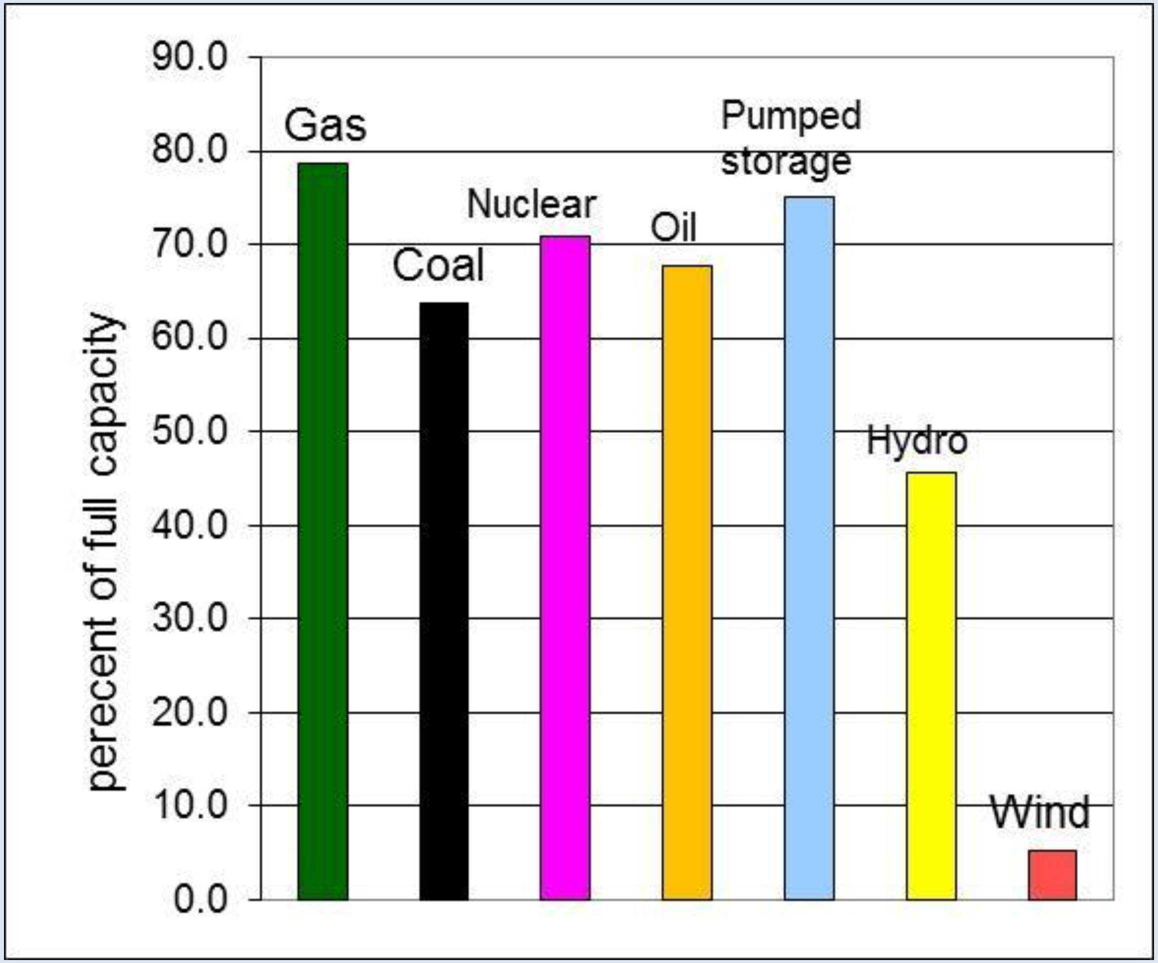


This is not a rare occurrence

It also happens in winter at times of peak demand

Low wind during a winter freeze-up

The diagram shows the generation used to meet peak demand on 7th December 2010. Very low temperatures were experienced that day. The GB demand was met, but only just.

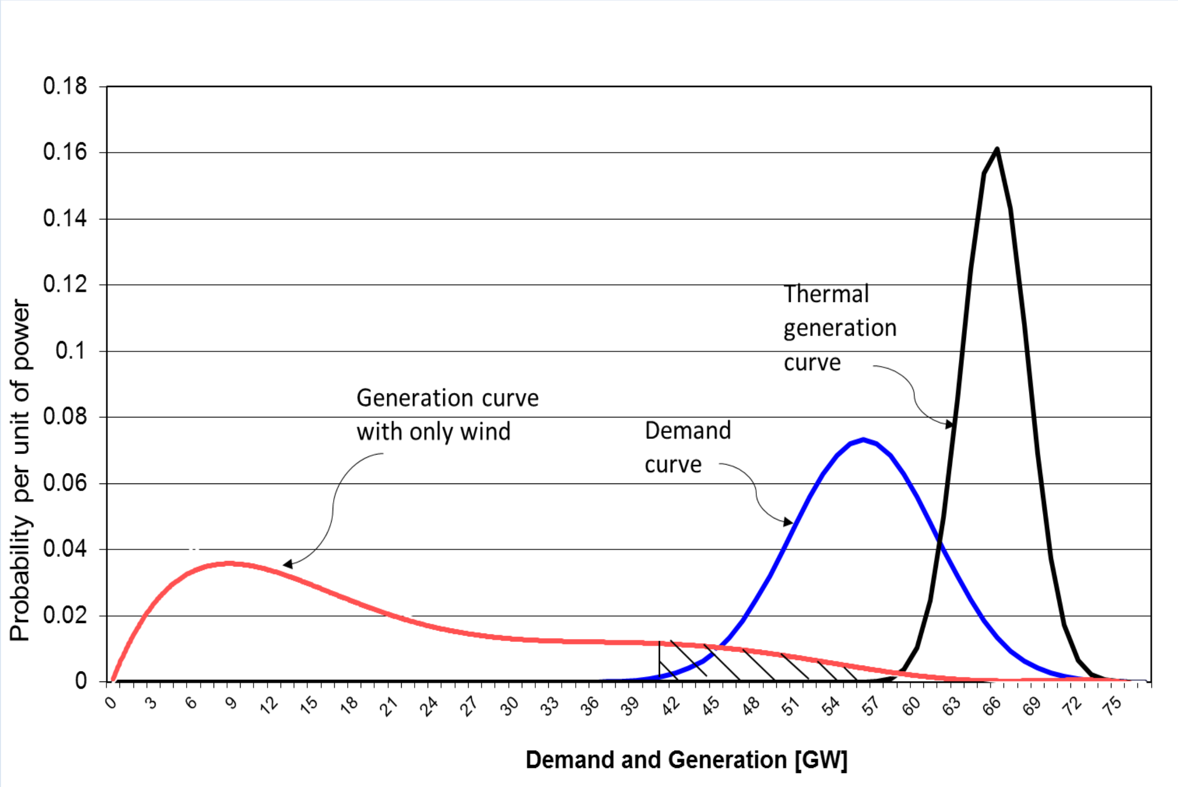


The generation is expressed as a % of the installed capacity for that source. Other sources of power were working hard to meet peak demand.

Wind was only producing 5% of its capacity.

Probability density

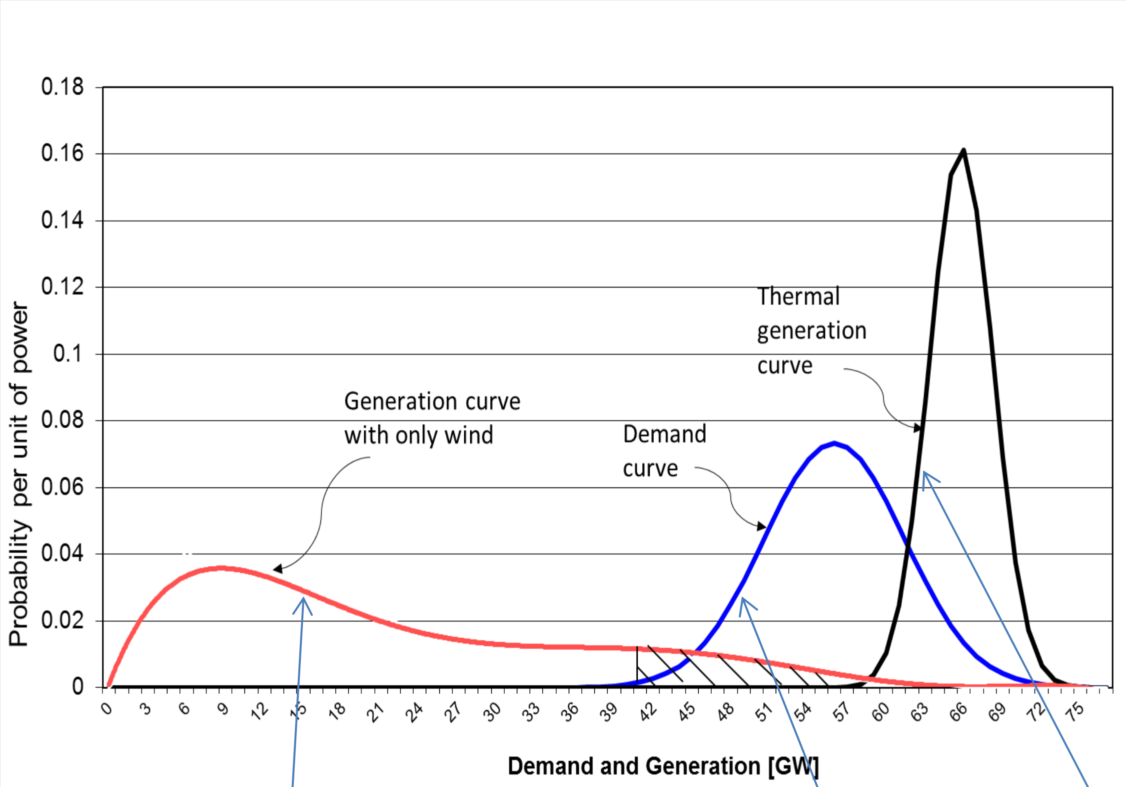
These are just two observations. One cannot draw general conclusions from a small sample. Probability analysis is needed.



The argument which follows is rather technical but (1) the intermittency of wind power cannot be well understood in the absence of technical arguments, (2) it is not necessary to have a full understanding of probability density to follow the argument and (3) the basic theory of probability distribution is not rocket science. It is covered in high school curricula.

This diagram shows the probability densities for wind (red), for demand (blue) and for thermal generation (black). Thermal generators are mainly gas, coal and nuclear.

Probability density



The horizontal axis of the diagram is power capacity for the GB electricity system with a maximum of 77 Gigawatts (GW)

The vertical axis represents the probability density function – the pdf. It is a probability rate - the probability per GW of power.

The red curve is the pdf if the only generation available was 77 GW of wind power

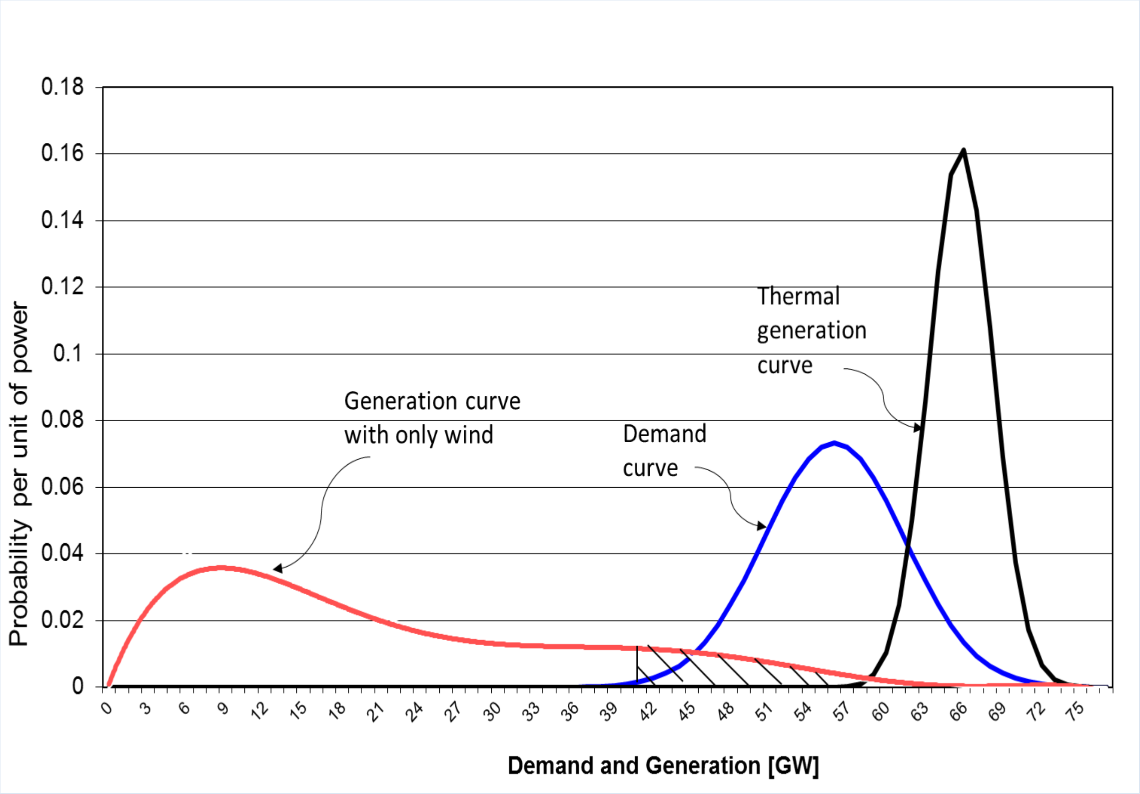
It is based on data from a range of wind farms in the GB system

The black curve is the pdf for thermal generation

The blue curve is the pdf for demand

The demand and the thermal generation curves are 'normal distributions' – the most common type of pdf

Probability density

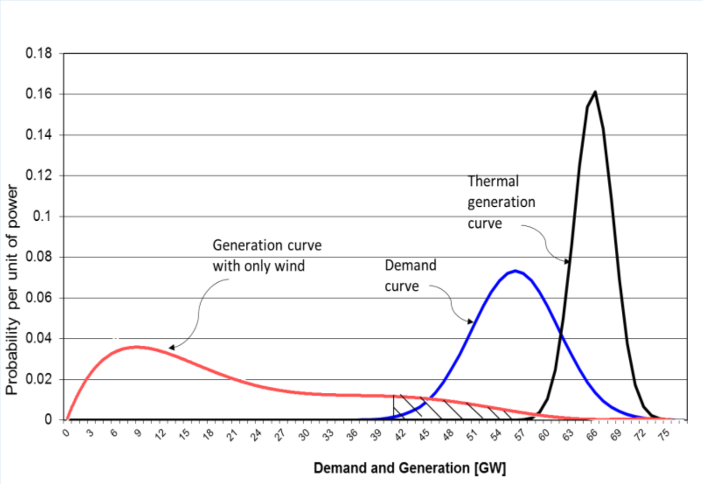


For example if you want to know the probability that the wind generation will be equal to or greater than 40 GW you calculate the area under the pdf from the 40 GW value to the right hand end of the curve – the hatched area shown.

This gives a probability of about 20%

In other words, if there were only onshore wind energy being generated, there would be a one in five chance that the lowest demand would be met. The probability of meeting the highest demands would be much lower.

Probability density

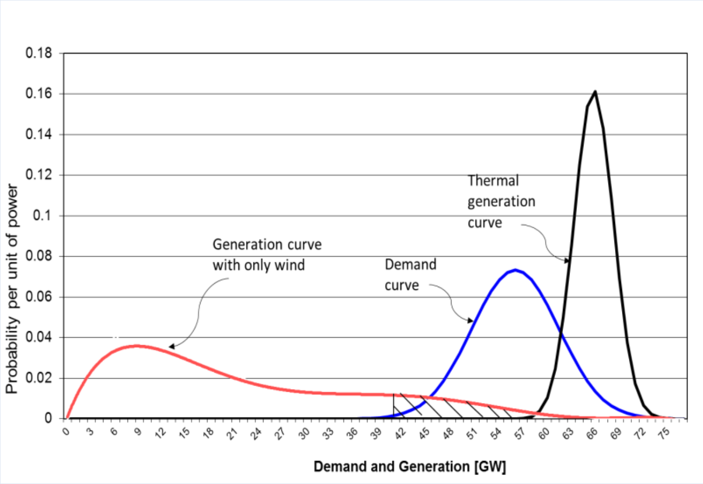


No one suggests that we should only have wind in the system but the diagram indicates the scale of the intermittency problem with wind.

The rule for security of supply is that the generation curve must be mainly to the right of the demand curve. Problems with meeting demand arise where the curves overlap.

Therefore to reduce the risk to security of supply, you want to push the generation curve to the right. If you replace thermal with wind, the distribution for the combination will move to the left. This will increase the overlap and hence increase the risk of demand not being met.

So how much thermal generation can be replaced by wind and still maintain security of supply? The answer is that most of the intermittent generation must be backed up with thermal generation.



Probability density

The pdfs for wind power vary around the country and from year to year. Offshore wind is more favourable but all wind pdfs have the same basic shape - the most likely levels of generation are towards the low end of the range.

Wind power is therefore deeply unreliable. The chance of it being at the level that you want, when you want it is very low. The diagrams of probability density confirms this.

To maintain security of supply, either reliable generation or storage is essential. Even if storage can prove to be technically feasible it would be very expensive. Gas fired generation has the required degree of flexibility and, in the short term at least, must be available for security of supply.

Note that hydro power is very good for helping to meet spikes in demand but we do not have and cannot have enough to significantly replace thermal generation.

Cost of wind energy

Wind energy is the main renewable source that is being used to ‘go green’ and therefore its cost is a critical factor in the price of electricity.

Claims are being made that the cost of wind energy is coming down and will soon be competitive with conventional generation.

This cannot be so.

Cost of wind energy

Levelised cost is a method of estimating the cost of different generation types. It is not the best method but it gives an indication of the relative costs

The table here shows estimates of levelised cost for gas, nuclear, onshore wind and offshore wind. Note that these are estimated costs and not estimated prices.

	Levelised cost £/MWhr		
Generation type	Basic	Integ-ration	Total
Gas (Closed cycle GT)	34		34
Nuclear	92		92
Onshore wind	109	65	174
Offshore wind	171	49	220

The estimate for onshore wind has a *basic* cost of £109/MWhr. This covers capital, repayment of debt and operation and maintenance.
The integration cost for onshore wind is estimated to be £65/MWhr giving a total estimate of £174 for or onshore wind.

The costs in the table are have been extracted (February 2018) from the latest version of the IESIS levelised cost spreadsheet - see: http://www.iesisenergy.org/lcost/index.html

Integration costs

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Where do the integration costs come from?

We have already shown that thermal generation plant needs to be retained to maintain security of supply. Having two sets of generators available when previously one set was needed cannot be anything other than expensive. This is backup generation that has corresponding *Planning reserve cost.*

When thermal generators are used to to cope with intermittent input from renewables they need to operate inefficiently to keep the system stable This also adds to cost. It is extra *System operation cost*

Also renewable generators are often installed in remote places needing extra transmission facilities. This adds extra *Transmission cost.*

Cost of wind energy

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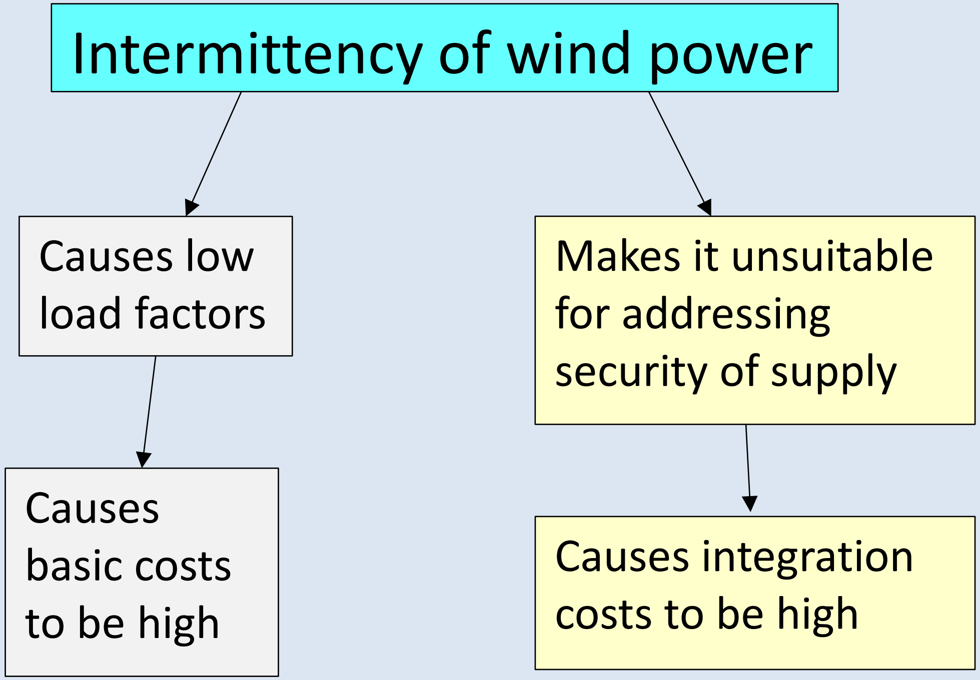
The basic costs are in general agreement with those from other reports. We know of no other estimates of integration costs for wind power for the GB system and therefore cannot make a comparison.

The integration cost estimates presented in the IESIS spreadsheet are based on 28 GW of wind capacity in the GB system.

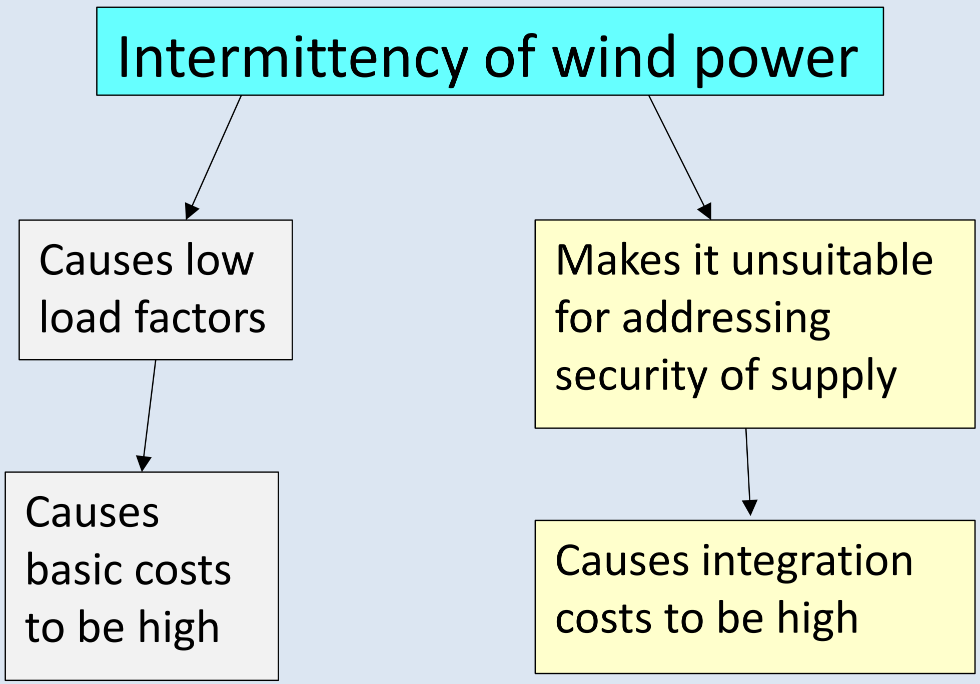
Double whammy of intermittency on cost of wind energy



A main reason why the basic cost of wind energy is high is because wind generators operate with low load factors. The load factor is the ratio of the energy produced by the turbine over a period (normally one year) and the amount of energy it would produce if it ran continuously at its maximum capacity for that period. The load factor is a measure of the productivity of the generator,,

The load factors for onshore wind turbines tend to be less than 30% and for offshore less than 40%. Thermal generators are capable of having load factors in the range 70% to 85%. The low load factor for wind generation is due to intermittency of the input power.

Double whammy of intermittency on cost of wind energy



The intermittency of wind causes the need for backup power and balancing power that are major contributors to the cost of integration.

Cost of wind energy

Important conclusions that we can draw from these observations are:

(a) The cost of wind energy will not come down, it can only go up.

(b) Having cheap electricity from wind energy does not appear to be achievable using existing technology.

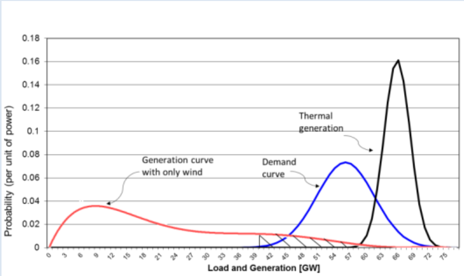
(c) The need to carry out cost estimates for the electricity system using the most reliable methods available is evident.

Reduction in CO_2 emissions

When thermal generators are used to maintain security of operation to cater for wind intermittency, they operate inefficiently. Therefore they use more fuel and emit more emissions than they would otherwise

Therefore as well as extra costs to the system, there are system emissions due to wind power intermittency.

These are not easy to calculate and we are not aware of any report that provides estimates of them for the GB system. Calculations for other countries indicate that they may be important.



What should be done?

	Levelised cost £/MWhr		
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The fundamental problem in planning the electricity system to reduce CO_2 emissions, is that decisions are being made without investigating their unintended consequences.

A professional approach to electricity planning would be:

1. Decide on a standard for security of supply. Seek to ensure that any planned mix of generation would be in accord with the standard.
2. Consider a range of options for the generation mix and develop information about all their expected positive features and all their expected negative features. Compare the options against a set of criteria that would include cost, emissions reduction, health and safety, etc.
3. Then make informed decisions.

Would that be a sensible way forward?