An Economic View of Wind Power in Scotland

by
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Introduction

It is the purpose of this short document to look dispassionately at the economics of wind power in general and, by doing so, the lessons that can be learnt for Scotland.

The information here, is to become part of a larger study into the feasibility of various types of storage of energy for transport, domestic and commercial use. I have published this brief document, to clarify some of the issues involved in the use of wind as a source of electrical energy to be fed into the grid in Scotland.

I have deliberately not included any data from bodies, either side of the debate over wind power, that make absurd or unsubstantiated claims, or claims that just have not been verified by use of accessible and public data. One such claim stands out in particular and that is the claim by governments and the Department for Trade and Industry (DTI) that wind generation is 30% effective. In other words, that a collection of wind farms with a total capacity of 100MW will generate, on average, 30MW of power.

Again and again, when total generation is taken over a twelve month period and using figures that are accessible to all and can be verified, land-based wind farms average output is about 22-25%. The figure for the whole of Denmark in 2005 and 2006 was 22% and was also true for large wind farm schemes around Britain. Off-shore wind power schemes have better results, usually around 27%. Older installations and also wind farms based in wind-poor regions such as Germany, achieve far lower outputs.

The 30% figure is almost certainly true for a theoretical wind tower, perfectly positioned, with no other towers to interfere with flow across its blades and requiring no maintenance or other reasons for ‘down-time’ and is probably where this figure came from originally. In the real world, 22-25% keeps rearing its head as the realistic figure. A recent study done on behalf of the John Muir Trust (who, it must be pointed out, are strongly opposed to wind farms) into the performance of 47 wind farms, mostly in Scotland, came up with almost identical figures.

I have only looked at the effects of wind farms on tourism and housing on an anecdotal level and by setting questions of tourist based industries in two areas of Germany (Eifel and Schwartzwald) that have been effected by wind farms and their associated infrastructure, such as high-tension electricity lines. I am aware of the study called ‘The Economic Impacts of wind Farms on Scottish Tourism’ and for those seeking further information on this subject, the full document (as opposed to the rather brief executive summery) contains a great deal of useful information and is available on-line.

The forward projections of this study however, only looked only at the results of a survey of tourists and did not seek to generate models, based on what has happened elsewhere. It has been my experience in business, that surveys are excellent at certain things, such as benchmarking, but are extremely poor at predicting future trends. If you ask people in the High Street if they would use a local butcher, usually results in an 75% ‘Yes!’ response. Experience has shown us that just as many, about 75%, are likely to abandon the local butcher, when a large supermarket moves in!

So, although it is outside the remit of this short study, I do mention the effects of wind power on tourism, but only to point out that the effect varies enormously, depending on the type of tourism one is discussing. If wind power is to be a major feature of the Scottish landscape, then further investigation is required, modelling future trends on the effects of the introduction of wind power elsewhere.

Terms and definitions

GW	-	Gigawatt
MW	-	Megawatt (1,000 MW in a GW)
GWh	-	Gigawatt-hours
MWh	-	Megawatt-hours (1,000 MWh in a GWh)
kWh	-	Kilowatt-hours, i.e. one thousand Watts, used over one hour

Nominal power usually refers to the capacity of the generator or alternator. This is often referred to in the US as the name-plate capacity.

Effective power refers to the actual power being generated.

Average effective power refers (in this document) to the actual power generated over a period as a percentage of nominal power, or as an absolute value, expressed in Watts or Watt-hours. Unless otherwise stated, all figures for the UK are based on figures and measurements supplied by Ofgem. This is also referred to as the load factor or the average load factor and is defined as the average power as a percentage of the theoretical maximum, over a period of time.

Basic facts about Scotland's power requirements, as supplied by Ofgem

Peak usage for Scotland 6GW
Legal peak supply requirement is 7.2GW (i.e. peak plus 20%)

The average Scottish household uses 3.3MWh p.a.
A land-based 1MW wind tower generates 1.925 GWh p.a. (average effective power).
Therefore the average 1MW tower can supply the effective equivalent of the needs of c.a. 580 households - and not 700, which seems to be the figure so often wheeled out in the media.

The Office of National Statistics states that there are 2.3m households in Scotland and predicts that there will be 2.5m by 2020.

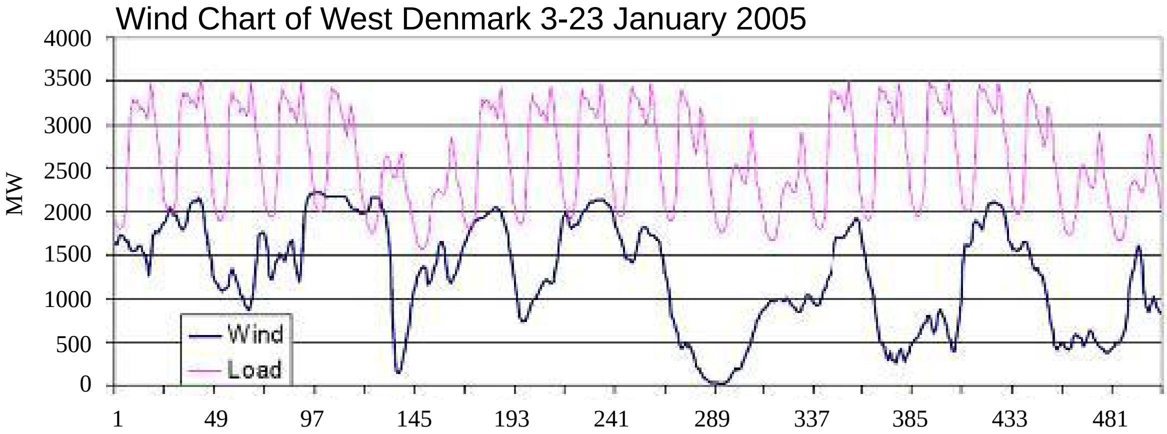
Because the number of people in each household is falling slowly, yet electricity usage is rising slowly at the same time, Ofgem states that use per household has remained constant for the past ten years and expects usage to remain constant for the next ten years at an average of 3.3MWh per household, p.a.

Ohm's Law - Voltage equals Current times Resistance (V = I x R)

Power Law - Watts (power) equals Volts times Current (P = V x I)

Joule's Law - Heat lost in a wire equals the square of the Current times Resistance times Time. ($Q = I^2 \times R \times t$) By combining Joule's Law with the other two, we can deduce that for a given conductor (wire) and distance, the amount of power that a wire can carry, when compared with another at a different voltage, is the square of the difference (for a given heat loss). This means that a 400kV line can carry nine times as much power as the same line at 132kV (400 divided by 132 = 3, the square of three is nine). 400kV lines are usually twinned in the UK, so the real figure is at least double that, or 18 times as much power.

Intermittance



Total installed wind capaity for all Denmark of 3,127 MW
Average output for period of 1,110 MW

Graph by the European Wind Energy Association 2005.

The above graph was produced by the European Wind Energy Association as an example of the efficiency and reliability of wind and uses figures from January, the windiest month of the year for West Denmark. For the whole of 2005, the average effective power (load factor) was 22%.

The graph gives a poor idea of the intermittence of wind as it does not show the sharp hour-to-hour variations. A better idea of intermittence and the problems that result, can be gained from the National Grid chart on page 12.

On eight occasions, wind was able to provide all, or nearly all power to the region, though on one occasion, almost no wind power whatsoever was produced for a 12 hour period. The shortfall in energy is provided by a mix of local conventional power generation and hydro and conventional power imported from Sweden and Germany.

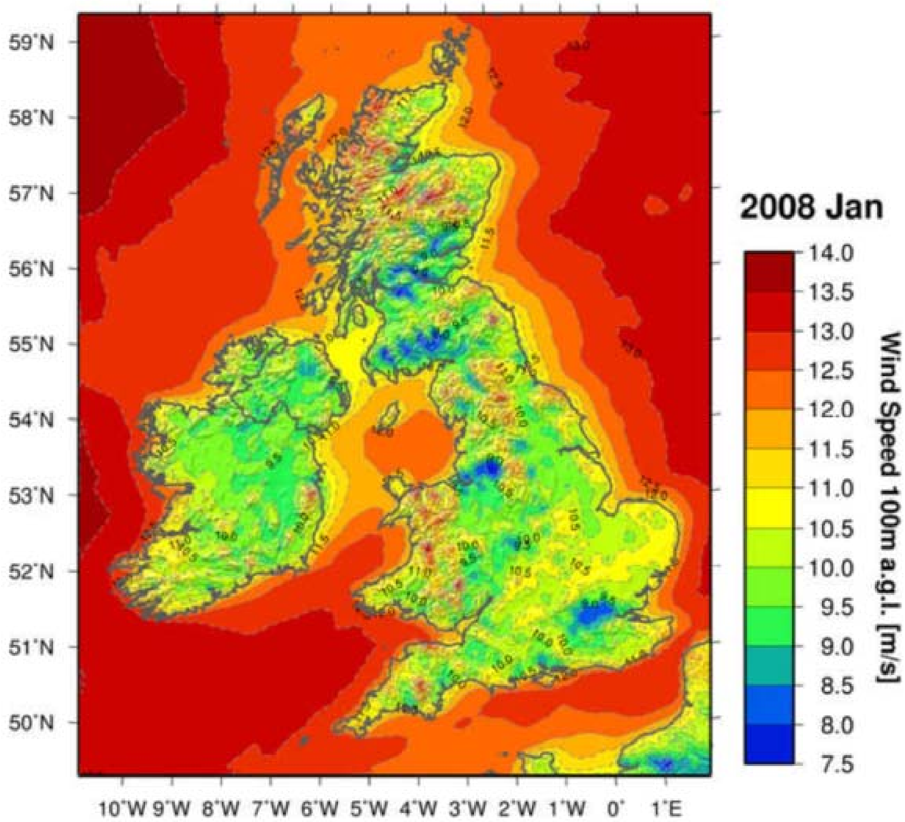
Annual total wind power production accounts for about 19-20% of electricity consumed in Denmark. The proportion of this that is actually consumed in Denmark has been disputed, with claims of up to 40% of wind power being exported, countered by claims that only 1% was exported. The export price should be the intermediate between the prices of the two areas.

Unfortunately, when the wind blows in Denmark, it is blowing in Germany as well and the price for surplus electricity falls. The average price into Germany is now just above 0€ and on several occasions, the German power companies charge Denmark for taking its power.

In 2009, the Institute for Energy Research commissioned the Danish think-tank CEPOS* (Centre for Political Studies) to report on electricity exports from Denmark and the economic impact of the Danish wind industry. This report stated that Danes pay the highest residential electricity rates in the European Union, in part to subsidize wind power and that the cost of saving a ton of carbon dioxide between 2001 and 2008 has averaged US$ 124. The report estimated that 90% of jobs were transferred from other technology industries to the wind industry as a result of government grants to the wind power industry and that just 10% of wind industry jobs were newly created jobs, and states that as a result, Danish GDP was US$ 270 million lower than it would have been without wind industry subsidies.

*CEPOS is a known advocate of school choice, a more open immigration, lower taxes and less regulation, and a known opponent of increased public surveillance and those anti-terrorism laws that curtail civil liberties. It produces both academic research and policy analyses on a wide range of issues, including education, immigration, legal reform, taxation, regulation and the public sector. It was described by the Danish business magazine BNY in 2007 as being “in charge of the public debate.”

Wind Map of Great Britain



Wind speed distribution at 100 m height for January 2008

Map by -
anemos Gesellschaft für Umweltmeteorologie mbH
Bunsenstraße 8
21365 Adendorf
Germany

To state the obvious, Scotland is windy! One of the problems is that the windiest places are also the places of greatest scenic value. Fears have been raised about the effects of the building of wind towers on tourism and to find out what those effects might be, I spent some time talking to owners and managers of tourist businesses in Germany that have had wind farms located near them.

The reactions varied, depending on the type of tourist that the business was catering to.

Activity-based tourism, such as recreational aviation, hang-gliding, BMX bicycle racing, visiting sites of historical interest and taking boat rides on the Mosel river suffered no ill-effects whatsoever. Hunting in particular, remained a healthy source of local income.

The story for what I shall call scenic tourism was completely different. Camp sites, B&Bs and small hotels that did not cater for tourists coming from other parts of Germany for the local boar and deer hunts, reported severe reductions in trade, to the point where those within 15km of the wind farms reported an almost total ‘switching off’ of trade.

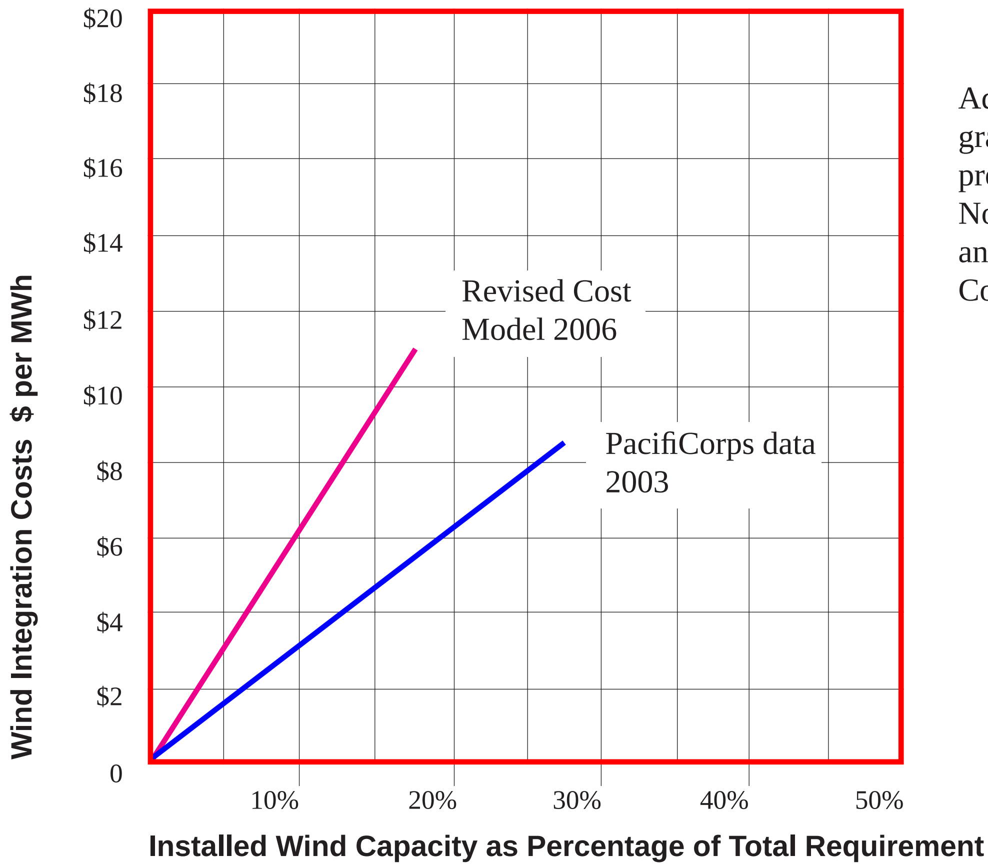
Separating out the two types of tourist is however difficult, as a B&B may be hiring out a bed for a boar hunter from Bremen, or a couple on bicycles, wanting to look at the scenery.

House prices also seemed to have suffered from the proximity of wind farms and houses would appear to have fallen in price severely, when near to a wind farm. Although this fall may be due to a present weakness in the German housing market, it is most acute around wind farms, with prices not rising in line with housing elsewhere for over ten years. Again, the evidence for this is purely anecdotal, but some owners report houses as being unsalable and therefore worthless, if they suffer from noise or flicker from a nearby wind tower.

Both the effects on tourism and the effects on house prices are outside the remit of this study, but certainly merit further investigation, based on effects experienced elsewhere in Europe.

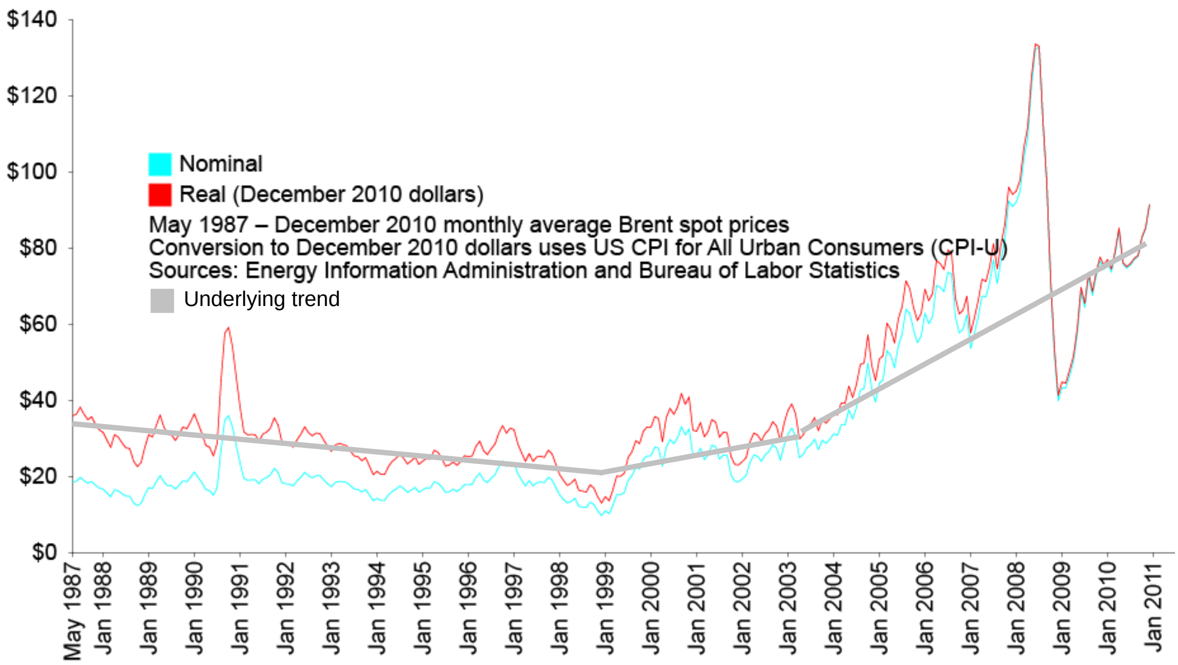
Wind Integration Costs

North West Power and Conservation Council (US) 2006

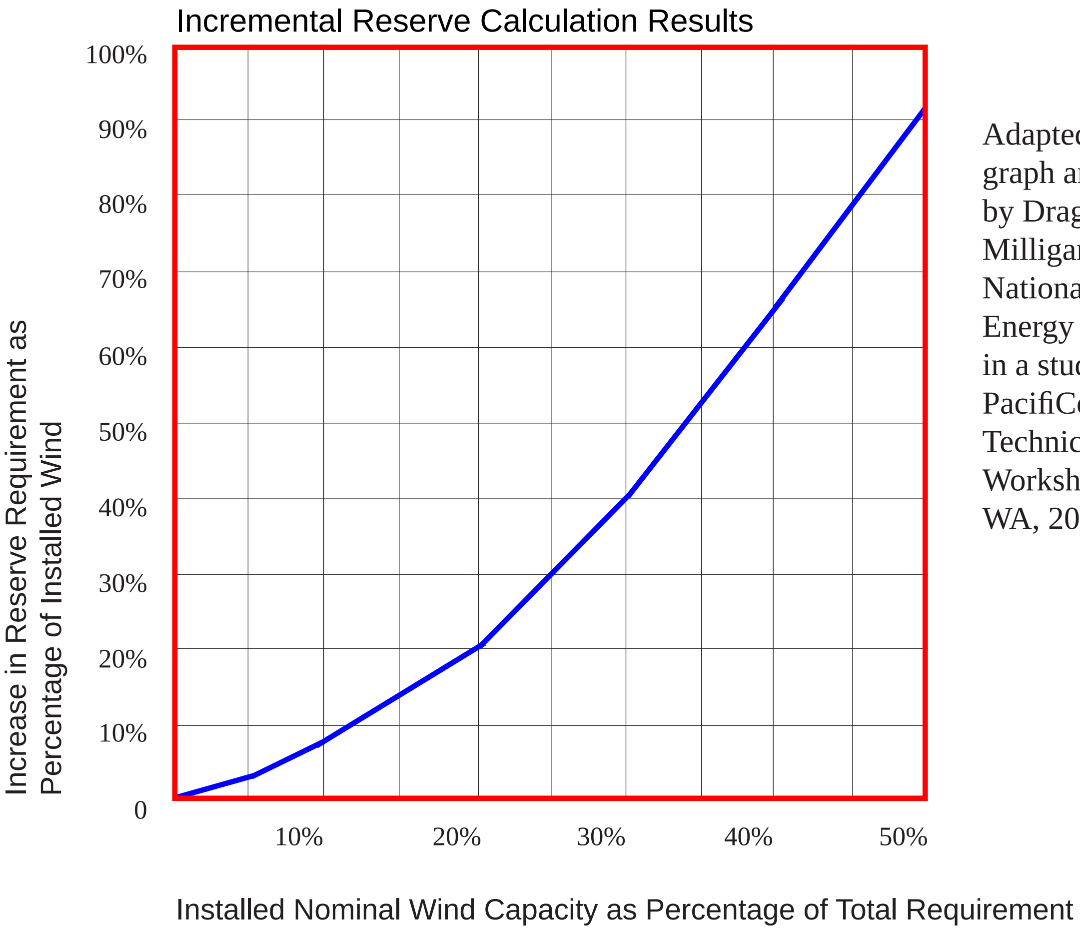


Adapted from graph and figures presented by North West Power and Conservation Council 2006

The rise in the cost of conventional fuels, combined with underestimating the effects of the intermittency of wind power, has resulted in a doubling of the cost of reserve capacity for wind over three years. In mid 2003, oil cost just $24, by mid 2006, it peaked at $80, to fall back to $59 by early 2007. Since 2003, the underlying trend is for conventional fuels to increase in price to the equivelent of $6 a barrel per year. In 2008, West Texas Intermediate was priced at $148 a barrel and Brent (below) was priced at $146.



Reserve requirements



Adapted from graph and figures by Dragoon and Milligan of the National Renewable Energy Laboratory in a study of PacifiCorps (UWIG Technical Wind Workshop Seattle, WA, 2003)

At low installation levels, the need for additional reserve is also low. If 500MW nominal value of installed wind power represents 5% of the total installed capacity in a 10GW system, just 30MW of additional reserve (i.e. 3% of installed wind) has to be installed, over and above the usual required reserve (according to the US National Renewable Energy Laboratory).

If 2GW of wind power is installed, as a part of a 10GW system, a total of 400MW (20% of wind) has to be added to the conventional capacity of the system.

According to the figures from the US National Renewable Energy Laboratory, this increase in the need for additional reserves continues, until at about 55% installed nominal wind capacity, the reserve requirement is equal to the wind capacity. Stated in figures, a 5.5GW wind capacity would require a reserve equal to that capacity and make the total conventional power available more or less equal to the size of the whole system, at 10GW.

The National Renewable Energy Laboratory presented this graph to show that at very low penetrations of below 5% nominal capacity, wind does not incur the kind of additional back-up that some had claimed and these could easily be covered by other suppliers. This back-up can also be in the form of interconnects with the rest of North America, as well as drawing power from other providers that do not use wind.

The PacifiCorps system is similar in capacity to Scotland, but covers an area (Mid-West and Western States) with a population of over 100m and in competition with many other providers, with whom they also buy and sell power, both long term and on the infra-day spot market.

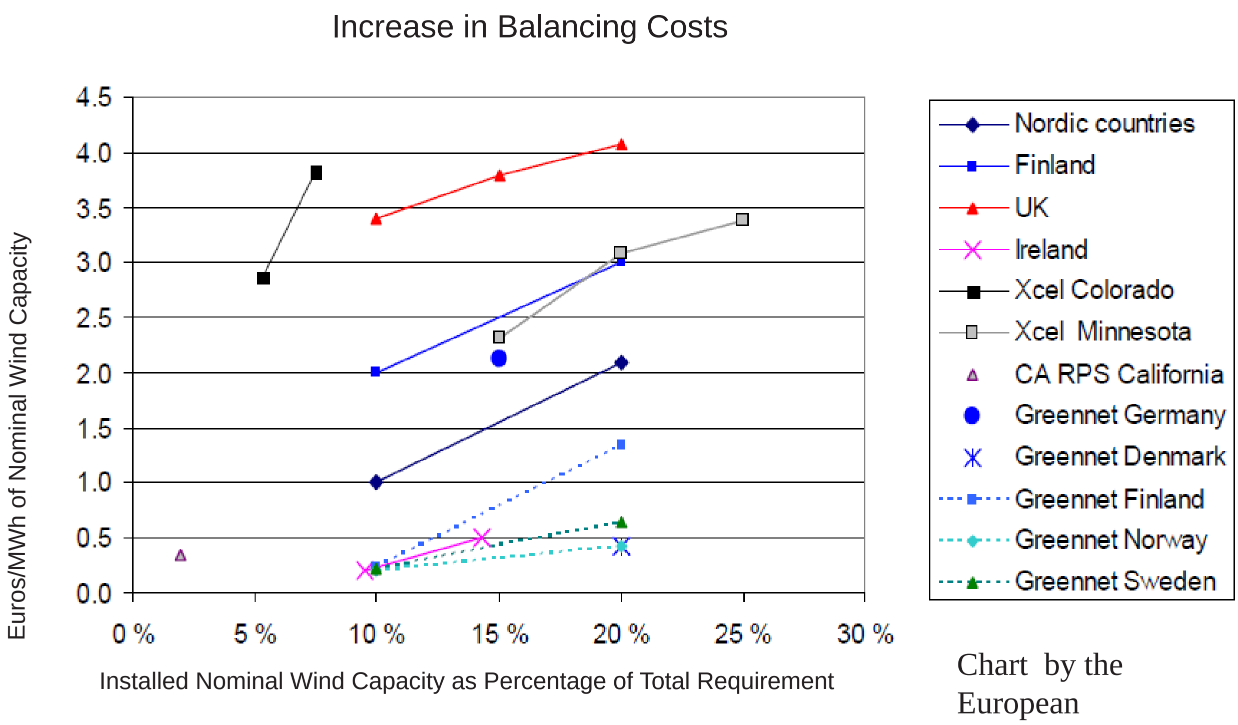


Chart by the European Wind Energy Association 2005.

Although these figures are about seven years out of date and costs will have escalated since then, they demonstrate how severely balancing costs increase with an increase in use of wind power. At 20% nominal installation (c.a. 4% effective generation) according to figures provided to the European Wind Energy Association by Ofgem, balancing cost c.a. 4€ per MWh, or c.a. 20€ per MWh of effective generation.

It is to be noted, that total requirement (average load factor) is very approximately two-thirds of peak requirement.

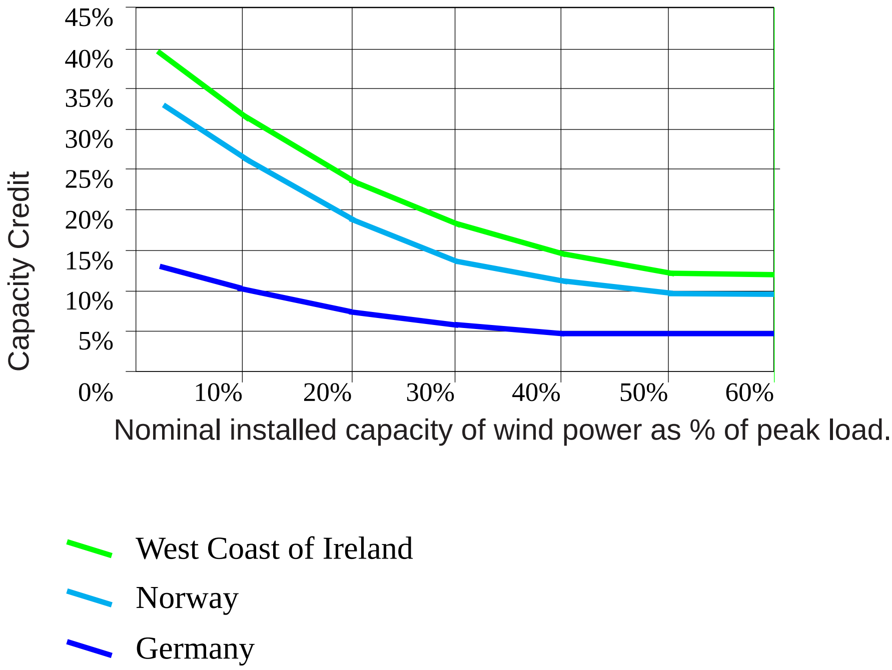
The extreme differences in the figures suggest that those providing the figures did not apply full economic-numerical rigor to their calculations. The cost of balancing the intermittence of wind power is very unlikely to be seven times as great for the UK, as for Ireland.

The chart does however, confirm that balancing costs increase markedly with increased share of wind power generation. Taking the average of the above lines as plotted, the increase from 10% to 20% nominal share, entails an increase in costs of between 60% and 70%. This broadly tallies with the requirement for additional reserve, as outlined in the PacifiCorps presentation on page 5.

The UK data as reported by Ofgem does broadly reflect the revised cost model for wind integration supplied by PacifiCorps, when the lower electricity prices for the US are taken into account.

Capacity Credit

Theoretical Capacity Credit of Wind Power
(assuming installation of the pan-European 'Super-Grid')



Figures provided by the European Wind Energy Association 2005.

The capacity credit of wind power expresses how much conventional power can be replaced by wind power. The capacity credit of a wind farm is the amount by which other generating capacity (such as coal, for example) can be removed from the grid without compromising reliability of supply. This is expressed as a percentage of the nominal, or 'plate' rating. Because of the instances of localised zero wind generation, capacity credit is zero for a single area, but increases with geographic spread.

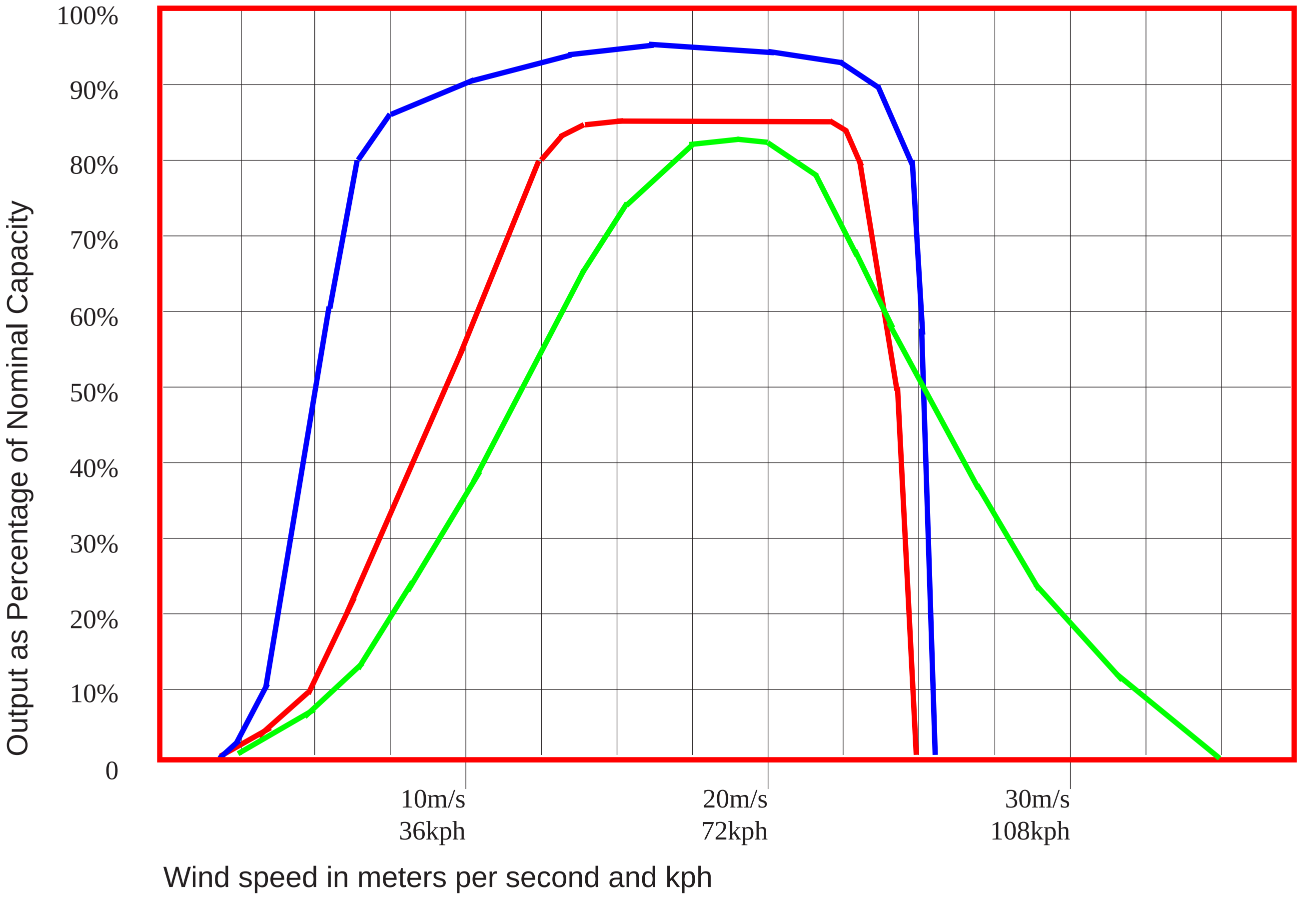
The above graph shows a very optimistic view of the ability of wind to replace conventional power supplies, as there have been many instances of zero and near zero wind in Ireland and also many instances of gales exceeding the 25mps maximum wind speed, forcing most wind farms to shut down. The three curves, however, can be taken as an indication of the ability for wind to replace other sources of power, if the West Coast of Ireland could balance its power supplies with, for example, Norway, Scotland, Spain and Bavaria.

Despite industry lobbying, no plans exist in the medium or even distant future for such a HVDC grid.

If we compare the West Coast of Ireland with Scotland and remember that Scotland has a peak demand of 6,000 MW, 200 large 3MW wind towers (10% of peak load) could replace the building of one 200 MW conventional power plant. That assumes an interconnection with mainland Europe at a total cost for the whole 'Super-Grid' of €18bn (2010 figures from 'Friends of the Super-Grid' lobbying group).

As wind generation fell to near zero, right across the UK in December 2010, a capacity credit representing a genuine ability to replace base load for an area as small as Scotland, without access to a pan-European interconnector would also have to be zero.

Typical Output of Three Types of Wind Power Generators



Adapted from field tests by Vladimiro Miranda, Instituto de Engenharia de Sistemas e Computadores do Porto – Faculty of Engineering of the University of Porto-Portugal, 2006

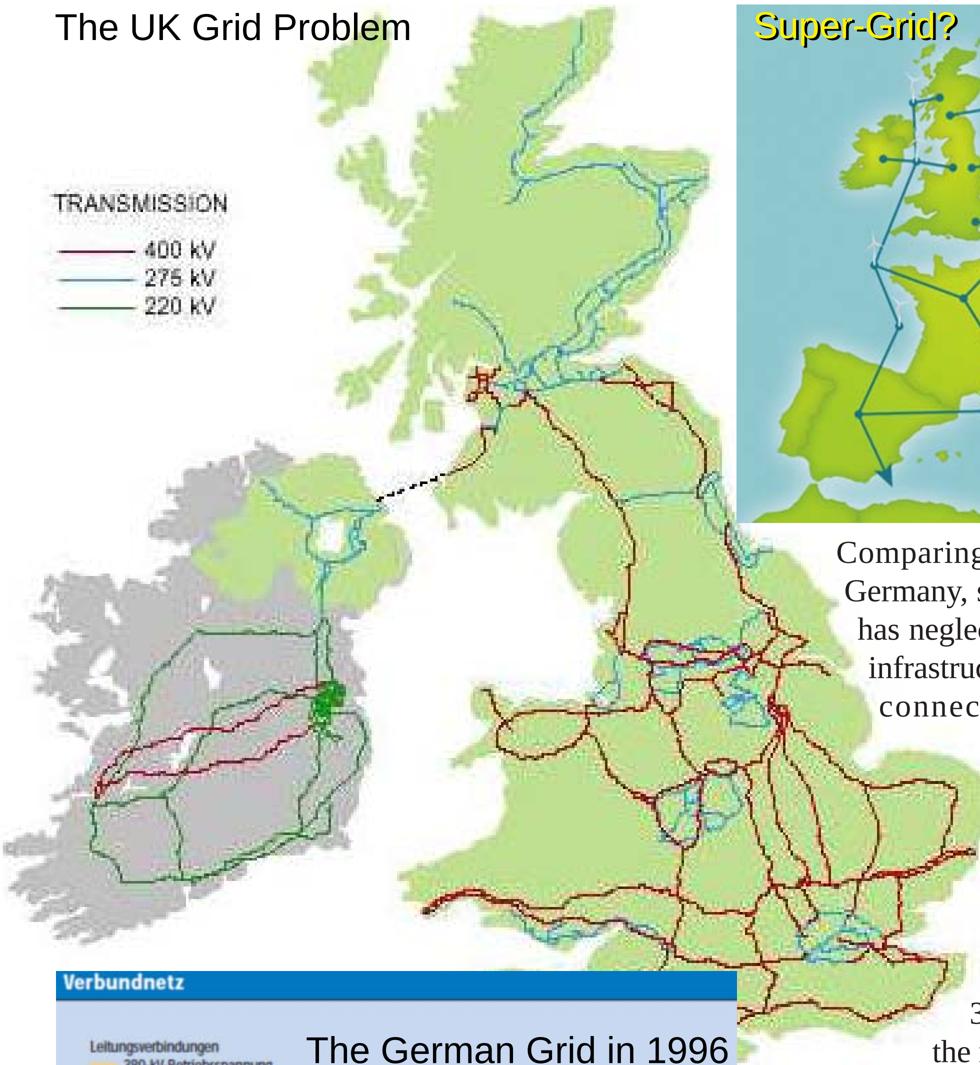
Older design of fixed speed wind power generator, dating from about 2000 and typically just 500kW nominal output.

Modern variable-speed 1.5MW wind power generator.

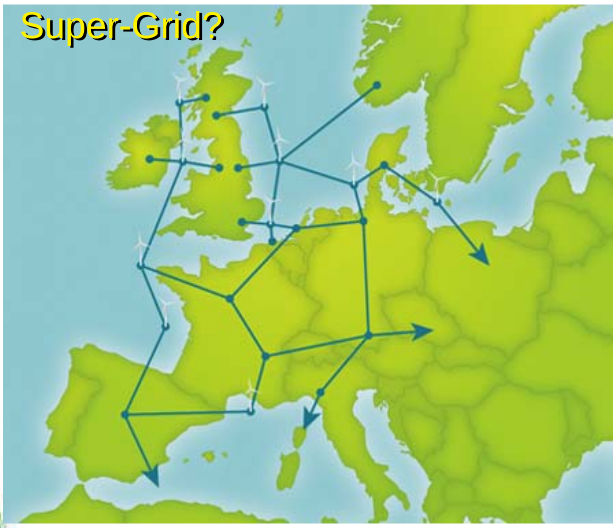
Small scale domestic system using passive pitch control (Mohammed G. Khalfallaha, Aboelyazied M. Koliubb Mechanical Power Department, Faculty of Engineering, Cairo University)

There are about 50 larger manufacturers of wind generators world-wide and hundreds of makers of small systems for farms and isolated communities. No two wind power generators are the same. Not only do manufacturers differ, one from another, but two apparently identical systems situated close by one another can vary as a result of turbulence and being in one another's wind shadow. Age and repairs also cause differences in performance, and the above chart was taken from a series of scatter diagrams of spot measurements taken for different systems over time, to provide an indication of typical performance.

The UK Grid Problem



Super-Grid?



Comparing the UK grid with that of Germany, shows to what extent the UK has neglected its electricity generation infrastructure. Just two 400kV lines connect Scotland with England and only one international 2GW interconnector links England with France. Germany has 17 such international interconnectors and every major town has one and usually at least two 380kV lines, connecting it to the rest of the country.

The German Grid in 1996

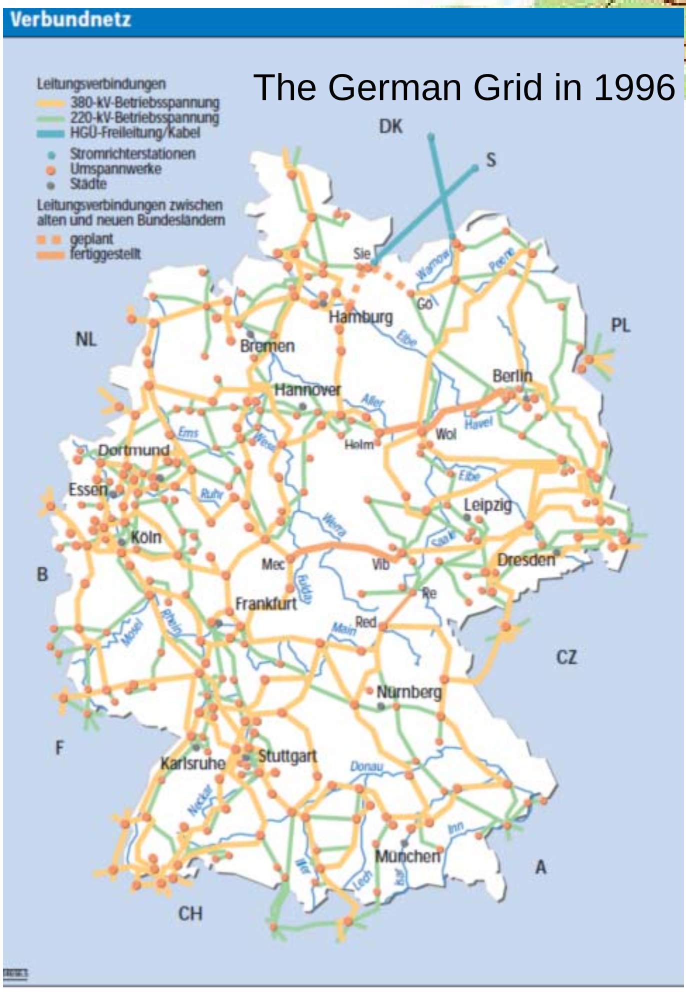


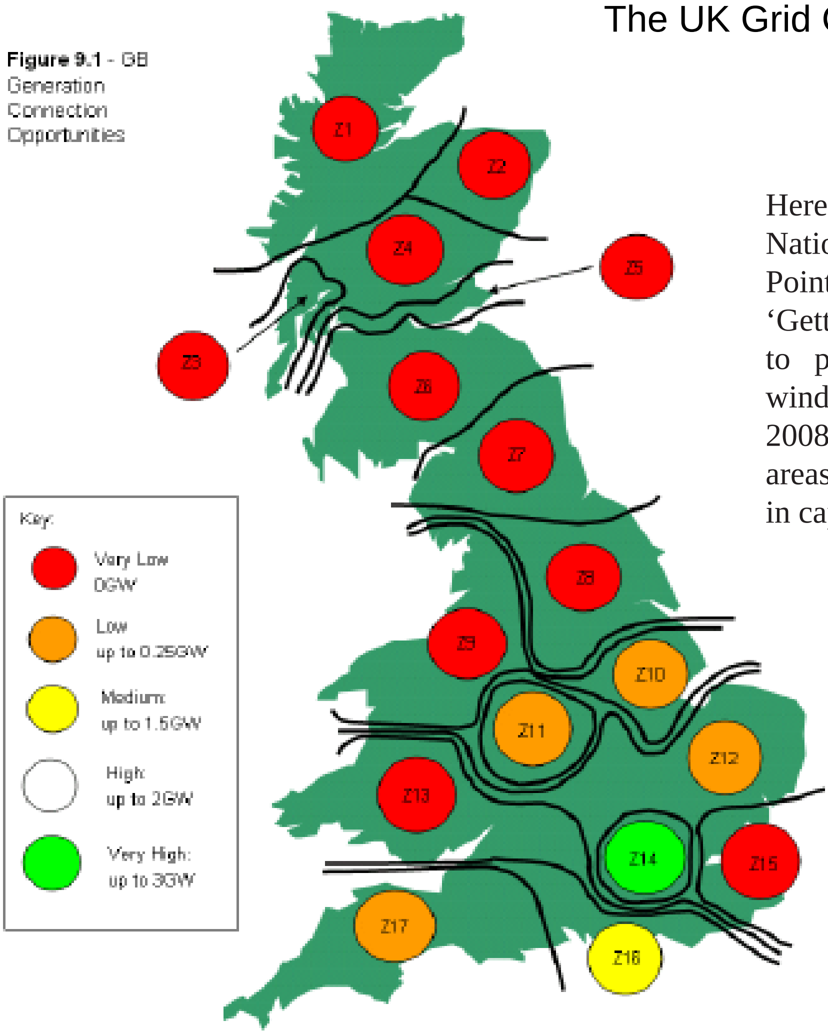
Bild 5. Deutsches Verbundnetz, Stand: 1. Januar 1996   Quelle DVG, mod

As a result, the UK grid looses 10% of its power, 7.5% in the grid and a further 2.5% in distribution, the highest losses in Western Europe.

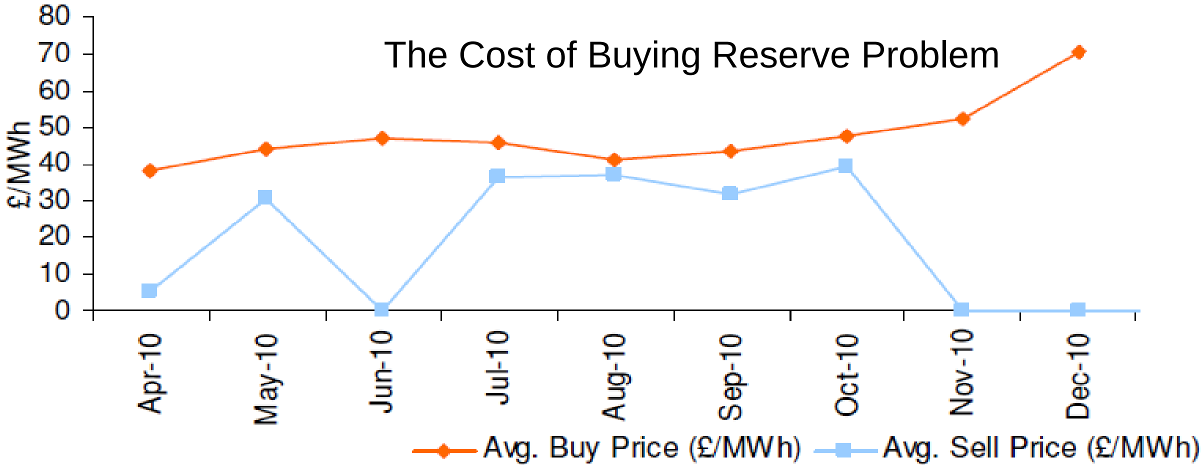
Because of the power loss associated with this North to South flow, the effectiveness and efficiency of new generation capacity is significantly affected by its location. For example new generating capacity on the South coast has about 12% greater effectiveness due to reduced transmission system power losses compared to new generating capacity in North England, and about 20% greater effectiveness than Scotland.

One possible solution is the creation of a pan-European ‘Super-Grid’ (see above) using a new type of high voltage direct current (HVDC) technology. The down-side is, it costs money. According to ‘Friends of the Super-Grid’ total implementation would cost 18bn € in 2010 prices - though it is safe to assume that this estimate is somewhat optimistic.

The UK Grid Connection Problem



Here is a slide from a National Grid 'Power Point' presentation, called 'Getting Connected' given to potential investors in wind farms in December 2008. The red blobs are areas with no surplus feed-in capacity for wind farms.



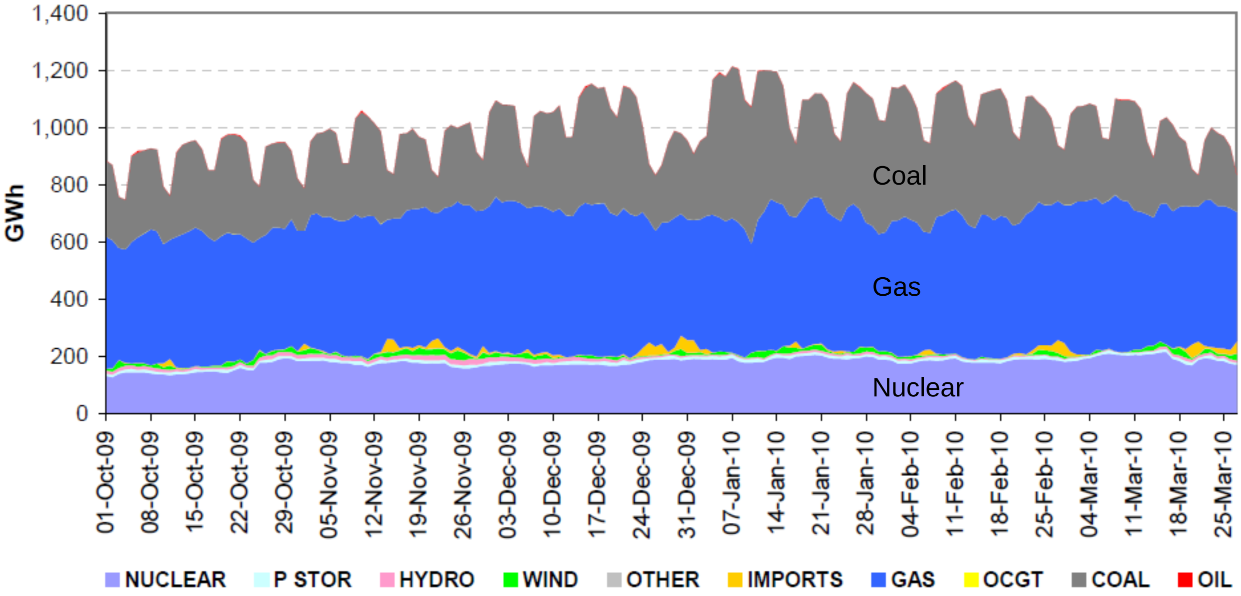
A record cold Winter combined with low wind in November and periods of almost no-wind in December lead to a near doubling of the average price of buying in reserve power.

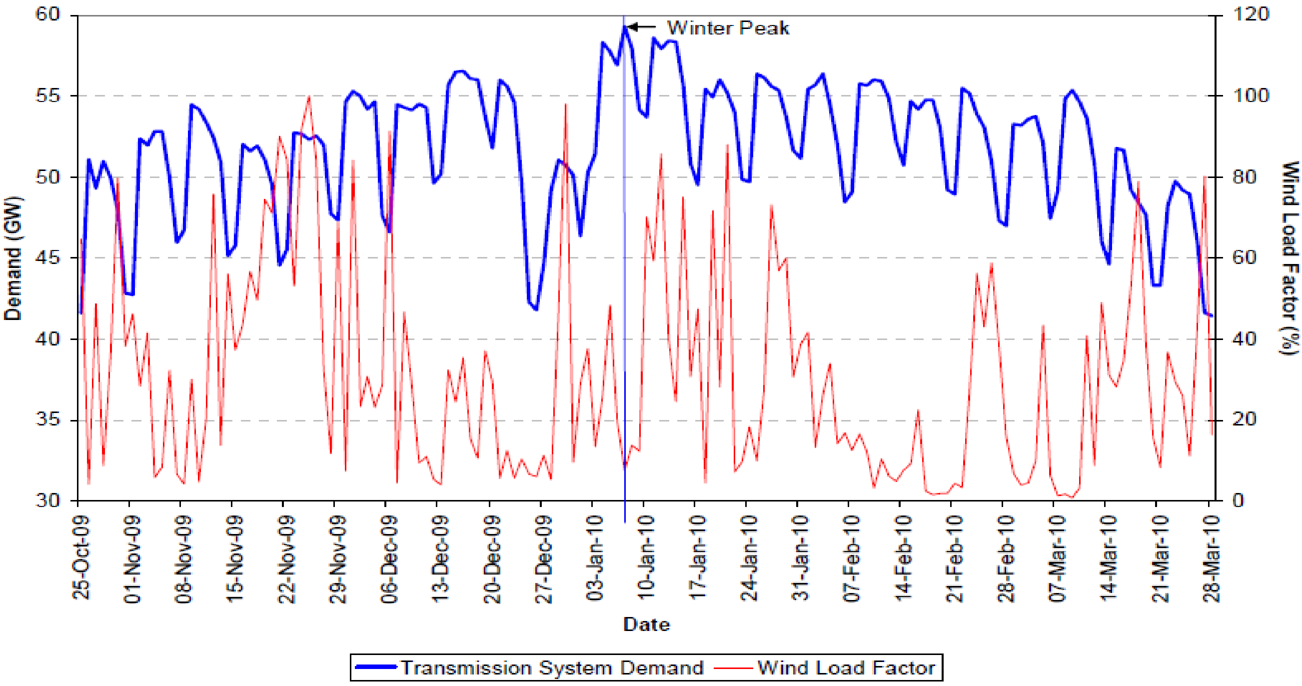
One of the tools required to avoid unexpected costs, is accurate weather forecasting, but this has proven more difficult than expected. Following a series of inaccurate forecasts, the Met Office ceased publication of their long term winter weather forecast for electricity generation industry. However their website continues to provide long term analyses and for the period of December 2009 through to February 2010, the data presented gave -

- a 60 – 80% probability of above normal temperatures
- a 20 – 40% probability of near normal temperatures
- a 0 – 20% probability of below normal temperatures

Where it all comes from -

Charts by The National Grid

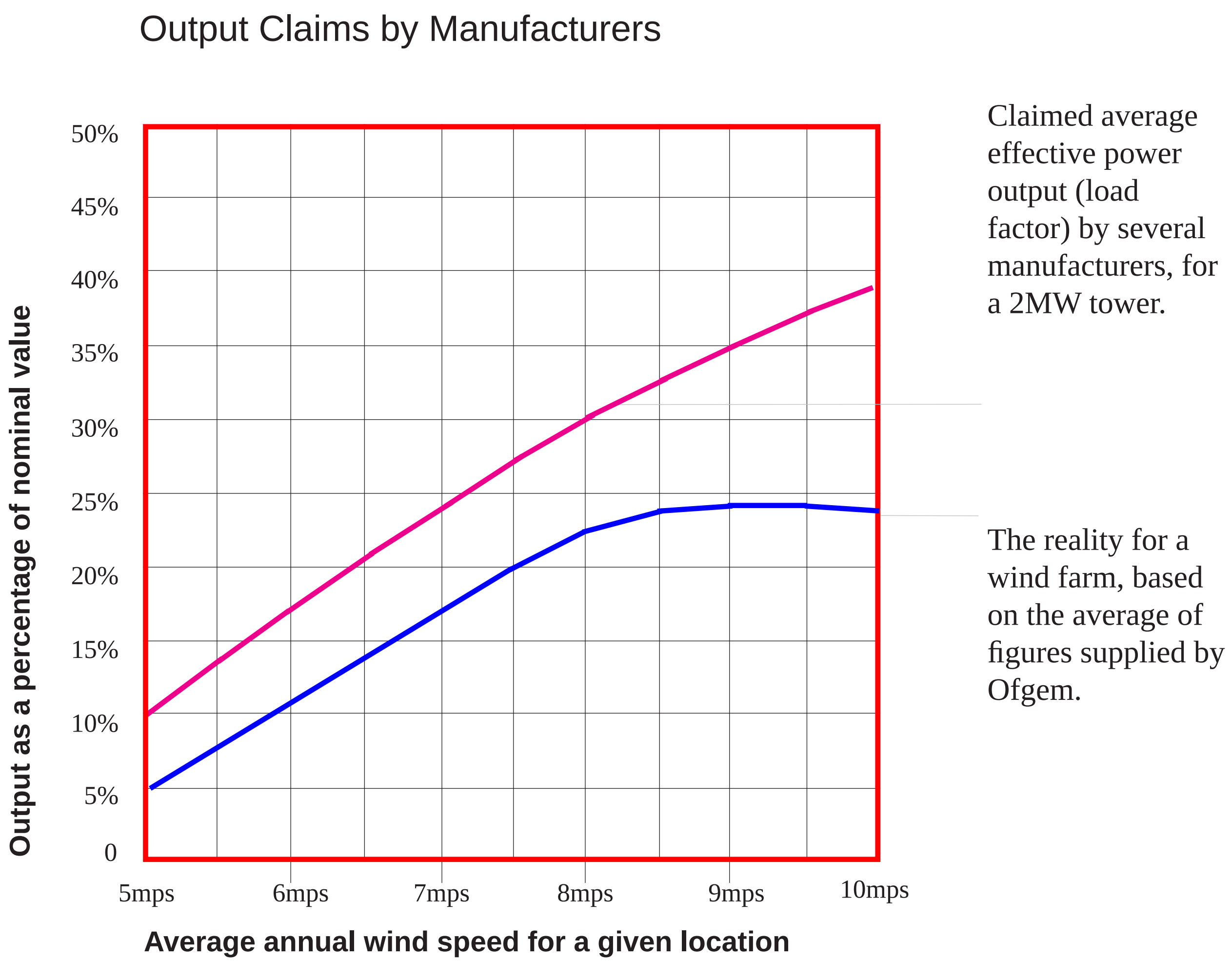




This data is based on the wind farms that are currently visible to National Grid through operational metering. These wind farms have a total capacity of approximately 1586 MW. The output varied between 3 MW and 1586 MW with an average of 435 MW. This gives a high average effective power output of 27% over the period.

From a security of energy supply perspective, the key issue is the uncertainty and variability of output and the average load factor is of limited use. What can be observed from the data below is two periods of low wind output over several days in early November 2009 and early January 2010. Both of these periods were relatively cold for the time of year and coincided with relatively high electricity demands.

In December 2010, extended periods of no-wind coincided with one of the coldest Winters on record.

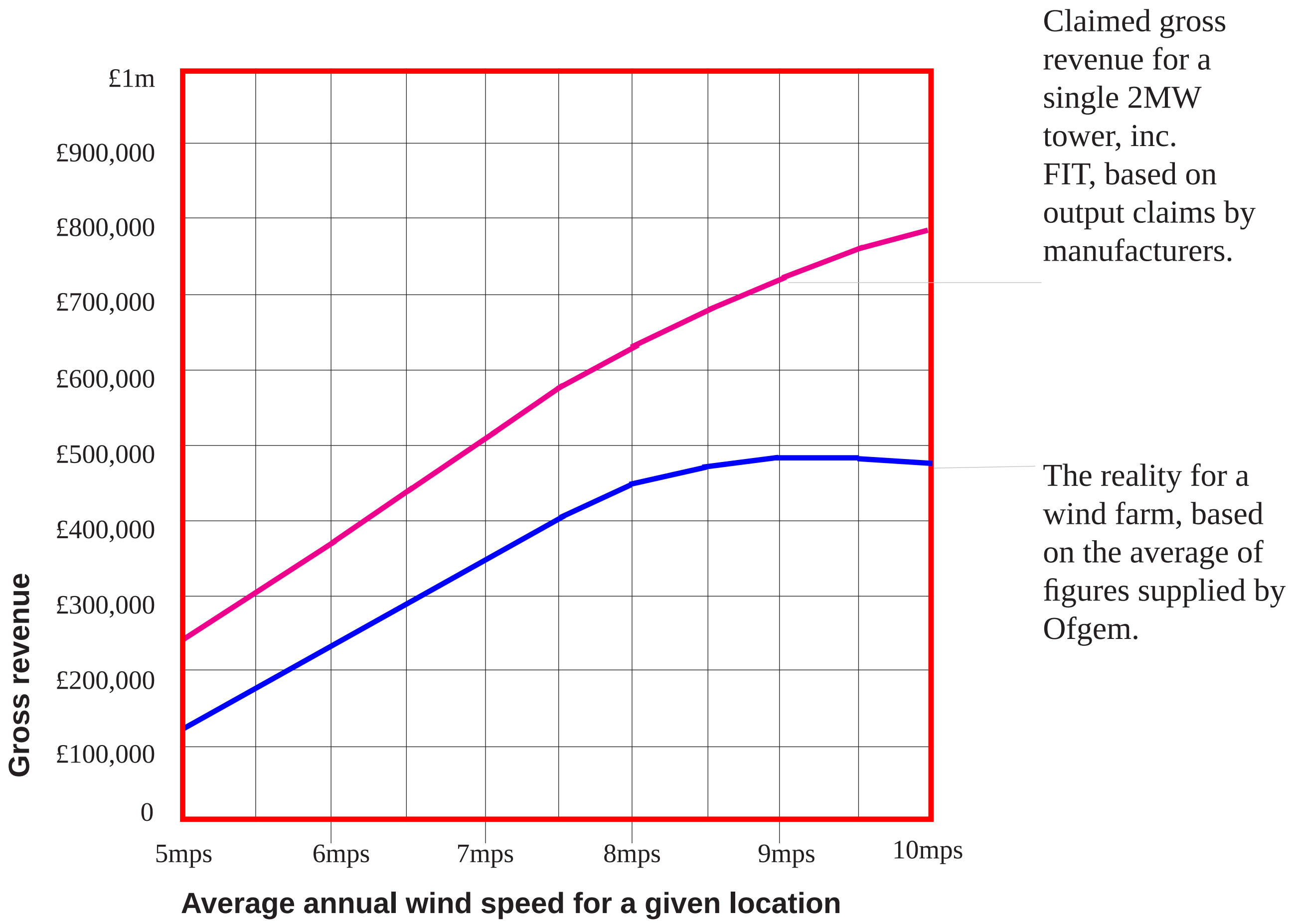


As stated in the introduction, over and over again, one is confronted by an average output over the entire year for most wind farms in relatively windy locations, such as the West coast of Denmark, or in Scotland, of about 22-25%.

To claim far higher figures, one would have to have a very steady flow of wind over a fairly short period and ignore the down-time required for maintenance and repairs. One would also have to ignore the effects that wind towers have on one another, as the wind available to each tower becomes less, when it is down-wind of another tower. So, although in theory, a single wind tower can achieve 30% or more average effective power output, the reality remains about 22-25% for land-based wind farms and about 27% for wind farms out at sea.

Obviously, the stronger the wind, the more maintenance and repair will be required.

Revenue Claims by Manufacturers



If the potential investor in a wind farm, goes by the pure figures supplied by the wind generation industry, an ability to generate power with wind and take full advantage of the present feed-in tariffs, is almost akin to an ability to generate money.

Feed-in Tariff UK

Capacity	FIT	Total Revenue
100 kW - 500 kW	18.8 p/kWh	22.27 p/kWh
500 kW - 1.5 MW	9.4 p/kWh	12.87 p/kWh
1.5 MW - 5 MW	4.5 p/kWh	7.97 p/kWh

The cost of erecting a 2MW wind tower is placed by most manufacturers at about £2m and with an average location wind speed of 10mps, claimed revenue is about £800,000 - a return on investment of 40% p.a. The real figure for build is about £2.5m, including connection to the grid and planning permission. Operation, maintenance and replacement costs would probably be about £50,000 p.a., so gross revenues of about £420,000 for each tower can be expected, a gross return on investment of about 17%. Although this is not quite the license to print money that some may hope for, it is still a respectable figure.

The danger for the potential investor, is that the rules of the game remain unchanged for the expected 20-year life span of such a project and that all future governments are prepared to honour subsidy promises made with the feed-in tariff and do not change the costs of linking to the grid, or impose greater regulation and thereby increase operating costs and reduce profits.

Conclusions

The only mature renewable energy generation that is available today in any scale is hydro and wind. Hydro-electric generation is capable of being a reliable base load; wind cannot do this without some means of long-term, bulk storage. The Danish-German trade in wind power, has shown us that commercially, renewable energy is of great value when the wind is not blowing and can command prices even in excess of some of the UK feed-in tariffs. However, wind power can even carry a negative value when there is an abundance of wind.

Without a completely new high voltage 400kV 'backbone' for the whole of the UK and with HVDC links to mainland Europe, Scotland cannot export energy in large amounts. Unfortunately, only minor improvements are planned for the UK grid system. Either the so-called HVDC Super-Grid has to be built, or a new method of storing wind and other renewable energy is developed. With economic and political support for wind power falling in the rest of Europe and continued subsidies already being withdrawn, the chances of a Super-Grid being built are diminishing.

The obvious candidate for storage would be hydrogen, but the technology remains in its infancy. In particular, cheap, mass-produced hydrogen fuel cells are probably several years away. The technology to generate hydrogen, using wind or other renewable energy sources is maturing rapidly, but without ready demand and an existing infrastructure, there is little advantage to be had, for investors to part with their money just now.

Using present technology and infrastructure, the Danish and German experience has been extremely discouraging for wind power. Germany is a low-wind country and effective output has been about half of what was originally expected. Denmark had hoped to export power to Germany, only to find that, at times of high-wind, German power companies are under an obligation to take German wind power first and the hoped-for profits for Danish wind power never materialised.

One of the surprises for me in looking at the economics of wind energy, has been the poor condition of the UK grid. The 400kV system was introduced in a fanfare of publicity, back in the 60s - and it still has not been completed over 50 years later! Plans to bring the UK grid up to European standard and link up with the rest of Europe with several 2GW HVDC lines, were first announced in 1973 - I am beginning to wonder what the hold up is!

Britain is a long, thin country and it would be normal to assume that it is of great importance to be able to get electricity from one end of the country, to the other, using a high-voltage grid incurring the lowest possible line-losses. The ability to do this, is regarded elsewhere as vital for the security of supply and the economics of generation, without undue line loss.

More importantly, improvements to the existing grid would go a long way to reducing the excessive transmission and distribution losses.

Wind power is extremely intermittent and cannot be relied upon. This has lead to escalating back-up costs and an increase in the need for 'spinning-reserve' (the generation of some power, without it being used, but so that it can be almost instantly switched into the grid). Limited success has been achieved by using pump-storage to smoothen the peaks and troughs. Scotland has two schemes 400MW and 300MW. Wales has a 300MW scheme and the largest Dinorwic is at about 1800MW but has limited upper storage.

US power companies supplying states such as Arizona and New Mexico, have been able to achieve some success in combatting the intermittence of wind, by introducing reactive loads. This is the ability for the power company to switch off certain appliances, such as air conditioning plants and large freezer cabinets, that are not very time-sensitive, by remote control. Despite a 2007 UK government report into this technology, this option does not exist to any meaningful extent for Scotland and is only available to customers able to instantly switch off a minimum of 3MW. The growing use of heat exchangers could be used as an opportunity to introduce this technology at a domestic level.

The UK grid is only connected to the rest of Europe by one 2GW HVDC line to France and a 0.5MW line to Northern Ireland. The French interconnector is used mostly to import electricity generated by nuclear power into the South East of England. In the run-up to Christmas of 2010, the cost of importing this power reached ten times the usual average tariff, as Britain experienced an almost no-wind period and a very low-wind period for about one month. Similar low- and no-wind conditions were experienced right across the whole of Northern Europe.

It is an unfortunate fact that, when Scotland has high winds, the rest of Europe is similarly blessed and therefore an HVDC 'Super-Grid' could not be expected to generate meaningful profits. A similar situation as exists between Denmark and Germany, with excess wind power being unwanted, would be extremely likely, as all North European countries buy their power in order of merit, with home-produced energy coming first.

One of the plans for a Super-Grid, would be to integrate the grid with a series of about ten giant wind farms out at sea, the total cost being somewhere in the region of 50€ billion. Such a scheme could dwarf any land-based wind generation and, because wind at sea is more constant and stronger, would depress the prices for electricity from the more intermittent, land-based wind farms. Other plans are for tidal and wave power, but so far, only tiny test projects exist.

This is, however, all conjecture and investors and decision makers have to look at how things are now and what is genuinely technically and economically possible today - and not at how things may become in ten, twenty, or fifty years time.

One of the most important improvements that is genuinely technically and economically possible today, is the improvement in housing and in state-owned housing in particular. It is wasteful for the state and private enterprise to go to all the trouble of funding and building wind towers and having, in the long run, to have to build new base-load generators as well and all at great expense - only to have that power wasted, heating thousands and thousands of drafty, substandard homes without proper insulation, using inefficient electric heaters.

There is a pressing need for clarity and transparency in the debate over wind power. The data presented by the various bodies, is not only in conflict from one entity to another, but very often, a company or lobby group issues data that is in direct conflict with other data they have issued, or just flies in the face of experience and common sense.

There is also a pressing need for investors and decision makers to acquaint themselves with the technology involved and the mathematics of generating and transporting electricity. In speaking to many such people, one soon realises that they have relied upon the advice given by others, who have a deep, vested interest in wind power. Systematically, effective power generation is exaggerated to absurd levels, investment costs are glossed over with vague 'rules-of-thumb' such as £1m per megawatt, or 5% of revenue for operation and maintenance, ignoring the need for extremely expensive improvements in infrastructure for the windiest and therefore most inaccessible places and the very high costs of replacing whole gear and generator assemblies, when they fail.

Some of the claims made by manufacturers and system providers are laughably inaccurate and not only fly in the face of the laws of economics, but even manage to defy the laws of physics. One system house even claims that a return on investment of 40% is possible. As I show on page 14, 17% would be the real figure, when using commonly available data. If an investor were to factor in other costs and risks that, in all honesty, must also be taken into account, a far lower figure would be the real outcome. If return on investment were to be 10%, (and this would require subsidies to remain at their present level and makes no allowance for inflation) then erecting a wind farm seems a very time consuming and troublesome way to earn money and investing in a good company with a healthy P/E ratio would seem to be a far more attractive prospect.

The true revenues that an investor may expect from wind power in the UK and with the UK subsidies will probably be more in line with those from motor manufacture. The difference is that motor manufacture does not rely on fixed subsidies and is therefore not in danger of having those subsidies withdrawn.

Investment in wind power in the UK depends totally on subsidies and ignores the cost of back-up. Without the feed-in tariffs and other benefits, investment in wind power for feeding electricity into the grid, could only result in huge losses. It also does not have to take the cost of distribution and balancing into account. As the PacifiCorps company has shown (pp 5 & 6) even with the ability to draw electricity as back-up and reserve from any part of North America, at high levels of investment in wind, costs for integrating wind into the grid escalate considerably. At about 55% wind capacity, measured at nominal output (c.a. 13% actual output) they state that the maximum output for wind has to be covered by conventional power supplies by 100%. PacifiCorps covers short-falls, in part, by buying in power from other suppliers.

The US and Canada are building a 765kV ‘Super-Grid’ of their own and this will allow for even more exchange of electricity across North America. Scotland does not have access to such a grid and no such grid is likely to be built in the next ten years and probably will never be built. Without such an infrastructure, for Scotland to export wind generated electricity in any meaningful amounts, beyond the North of England, must remain physically impossible.

Key Points

The wind power industry relies entirely on heavy subsidies and is free of any financial obligations for back-up, additional grid interconnections, or environmental damage. Decision makers need to take a fresh and independent view of the economic and environmental costs of reserve and back-up. Wind is a very expensive way to produce very little energy and the more one produces, the more expensive it becomes.

Scotland cannot export wind power outside of the UK and Ireland and is unlikely to be able to do so in the foreseeable future. The UK grid is largely old and out-dated and only allows for limited export of existing power generation from Scotland to the North of England. Increases in sales of electricity to England and Ireland would have to be matched by improvements in the grid, as present lines are being used to their full capacity.

A dispassionate and more realistic view of the expected revenues, disregarding the wilder claims made by manufacturers and others and bearing in mind inflation and risk of greater regulation and premature withdrawal of subsidies, needs to be taken. There is a real danger that investors, blinded by the sillier claims made by manufacturers, become over-enthusiastic about the kinds of profits that can be made and this could lead to a wind bubble.

Additional wind power has to be matched by additional back-up and reserve, to ensure security of supply, as it has almost no ability to replace base load by conventional power in an area as small as the UK.

Far greater effort needs to be made, in saving energy and managing energy consumption. In particular, some of the funds used to develop new ways to generate electricity, could be redirected to insulate homes and reduce the use of electricity for heating.

About the author -

Andrew Graeme studied electrical engineering at North Lindsey Technical College and went on to study economics at the London School of Economics. He runs a business in Scotland and has further business interests in Germany.