

Wind - Whitehall's pointless profligacy

As regular readers of *New Power's Project Monitor* know, there are many, many developers looking to develop wind power plant both onshore and offshore. But if they are all built will they lead to a big cut in the UK's carbon emissions? *Alex Henney*¹ and *Fred Udo*² think not.

Section 3 of the draft Energy Bill 2012 states "Electricity Market Reform will secure the investment needed to deliver a reliable diverse low carbon technology mix" (para 30), and "It is our intention that CfDs (contracts for difference) are available to low carbon generators from 2014." (para 59).

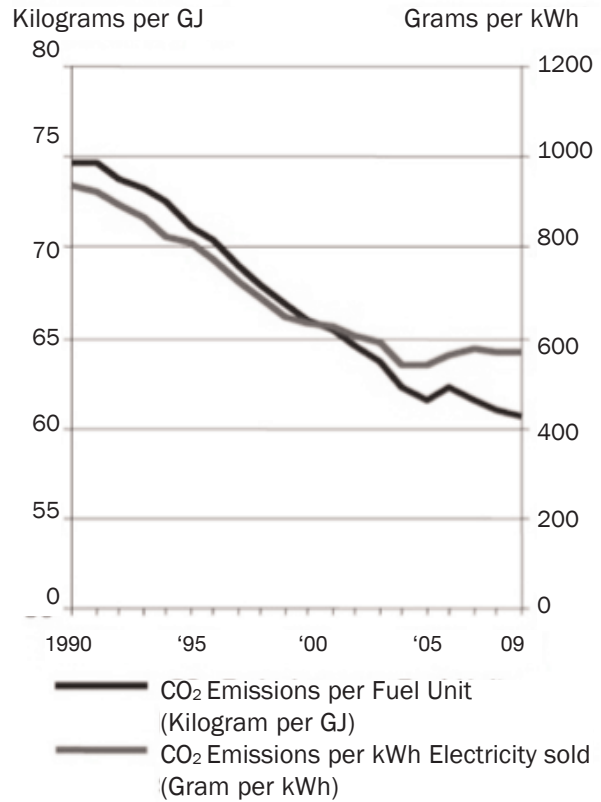
The intent is clear, and the government takes for granted that windmills are such low carbon generators. Empirical evidence suggests however that in a thermal system the deployment of a significant level of wind as proposed by the government may not significantly reduce the level of CO₂ emissions.

We start with a brief analysis of the operation of the system in Denmark, which is held up as an exemplar of producing a high level of wind to reduce CO₂ emissions. We next look at the system in Ireland for which CO₂ emissions are calculated every 15 minutes. We then refer to the study of emissions in Colorado and in Texas. Finally we consider the implications for policy in Britain.

Danish unintended consequences

In 2011 Denmark produced 33.3TWh of which 9.8TWh (29%) was wind from 3100MW of capacity. This capacity has hardly changed since 2004. In 2011 Denmark imported 4.5TWh and exported 3.2TWh; most of the trading is with Scandinavia. The Danish system is effectively regulated by hydro in Norway and Sweden to follow the variability of wind

Chart 1 CO₂ emissions per fuel unit and per kWh of electricity)

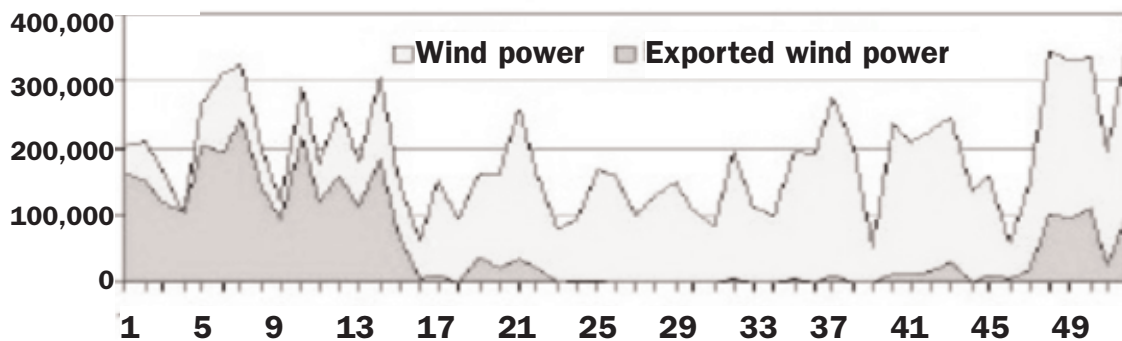


production. Data from Energinet's environmental report shows that although the CO₂ emissions per fuel unit used has continually declined since 1990, the emissions per kWh sold in Denmark have more or less leveled since 2003 (see Chart 1).

Chart 2 Wind exported from Denmark

MWh/week

2011 Denmark



The reduction from 1990 to 2000 was mainly due to the conversion of power stations to CHP units and the introduction of gas in the fuel mix. The CO₂ content in the electricity produced shows a leveling off from 1998 onwards. This is the year large scale wind energy was introduced in the system.

The unintended consequence is that during winter the electricity production is dictated by the demand for heat, so the system cannot accommodate the fluctuating contribution of wind (see chart 2)

The share of exported wind energy is high during the cold seasons when increased demand for heat entails high electricity production from the combined heat and power (CHP) plants. The export of wind energy was 3.0TWh in 2011 or 31% of the wind energy production.

Consequently, Danish customers pay part of their windmill subsidies twice over, once to produce the power and ship it to Norway for lower or even negative prices³, and again to reimport it often at higher prices⁴. (Effectively Danish customers are subsidising Norwegian and Swedish customers). Neither of these factors are what the Danish government intended, when starting the build up of wind power.

Ireland

In 2010 gas produced 66% of Irish electricity; coal 13%; peat 8%; wind 10%; hydro and pumped hydro 2.5%; other 1%. Most of the regulation to respond to variations in wind and output is usually provided by combined cycle gas turbines (CCGTs) and open cycle gas turbines (OCGTs) and three hydro facilities totaling about 180MW. A pumped storage facility of 270 MW was being rebuilt during 2011.

Eirgrid, the system operator, calculates the emissions of CO₂ from the system as a whole using “static” heat rates for thermal plants (i.e. assuming they operate at a constant output). This approach overstates their efficiency and understates their CO₂ emissions because when gas plant ramp-up and -down (i.e. “cycle”) their thermal efficiency reduces - hence their CO₂ emissions/MWh increase⁵.

The estimated average emissions using static heat rates for the period November 2010 to August 2011 was 451g/kWh while the average CO₂ emissions calculated from the carbon input from gas and coal was 528/kWh, which is 17% higher. Part or all of this difference can be attributed to the static approach used in the CO₂ calculation of Eirgrid.

The CO₂ savings for the period November 2010 to August 2011 were analysed and the “efficiency” of wind in reducing CO₂ emissions is defined as⁶:- The ratio of the measured reduction in CO₂ emissions, to the reduction in CO₂ emissions calculated as if every MWh of wind energy produced replaces a MWh of conventional electricity production without change in efficiency of the conventional plants.

The efficiency varies month by month(see chart 3).

Why the difference from month to month? In particular what happened in April 2011? The answer might be the availability of hydro (see chart 4).

In 2011 the pumped storage facility at Turlough Hill was being renovated; in consequence gas plants had to cycle more and thus produced more CO₂. The result was that a 12% wind contribution saved only 4% CO₂ emissions.

Chart 3 The efficiency of wind in reducing CO₂ in Ireland

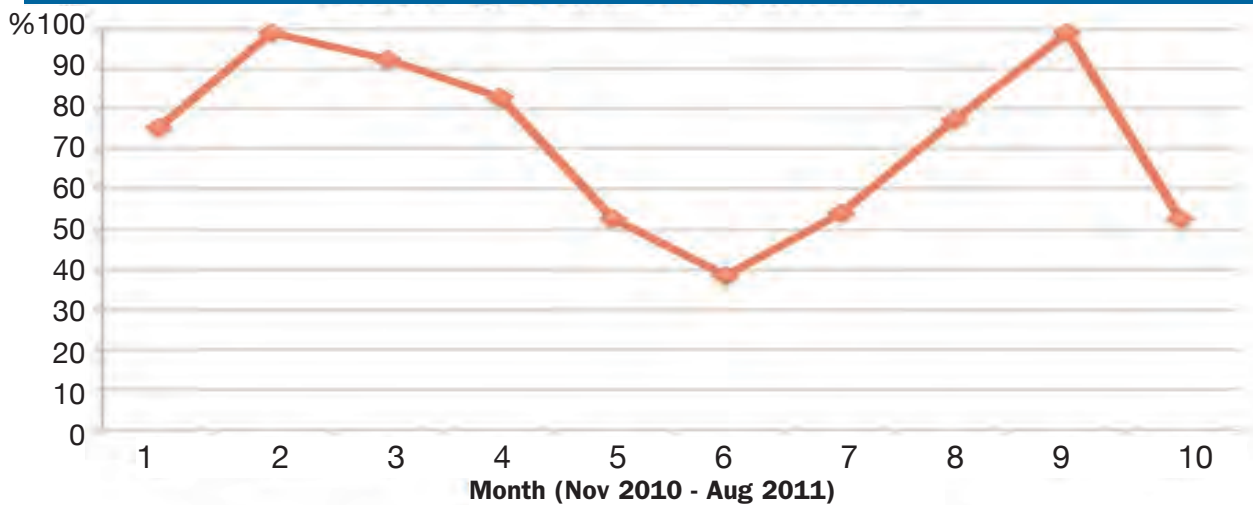
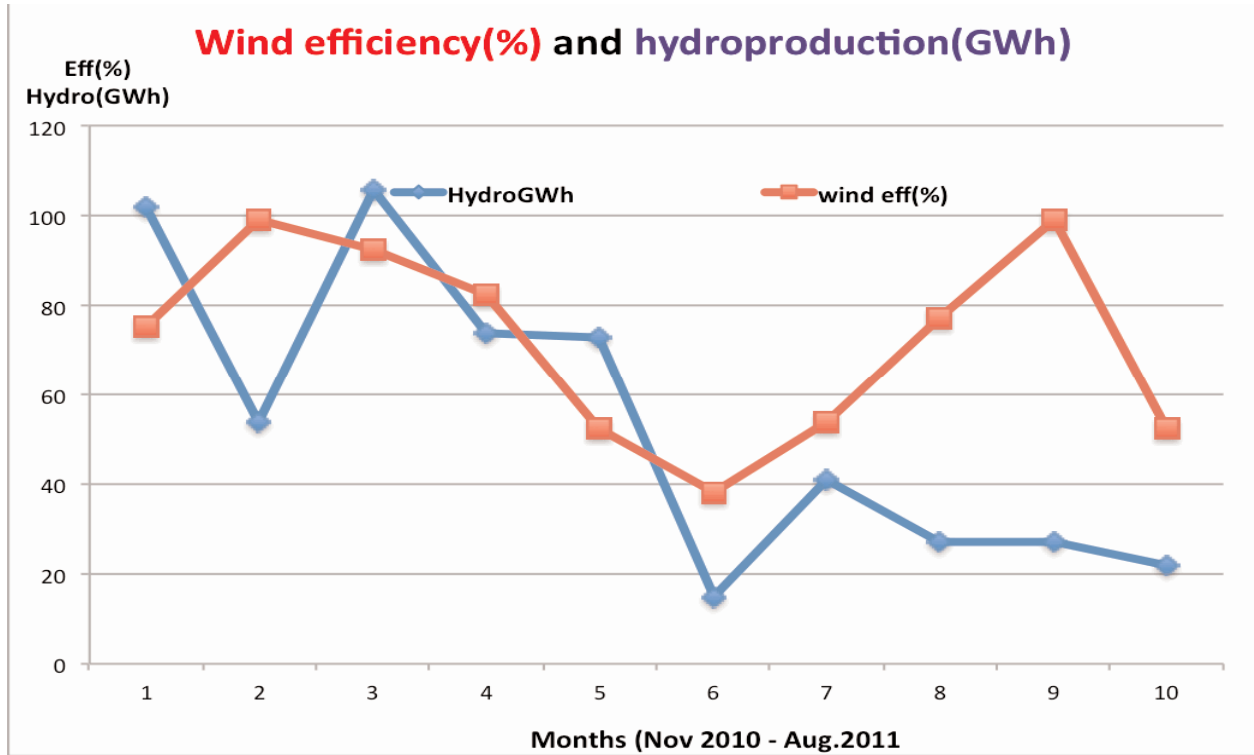


Chart 4 The influence of hydro power on CO₂ saving efficiency



Wind not correlated with demand

As is well known the wind blows when the wind blows and it is not correlated with electricity demand. This is a significant feature of wind, which is implicit in the

Danish situation of shipping wind to Norway and Sweden because the Danish system cannot absorb the wind. This situation occurs in every power grid as generators cannot be shut down at will. In the absence of export possibilities, such wind will have to

Chart 5 Wind and demand not correlated

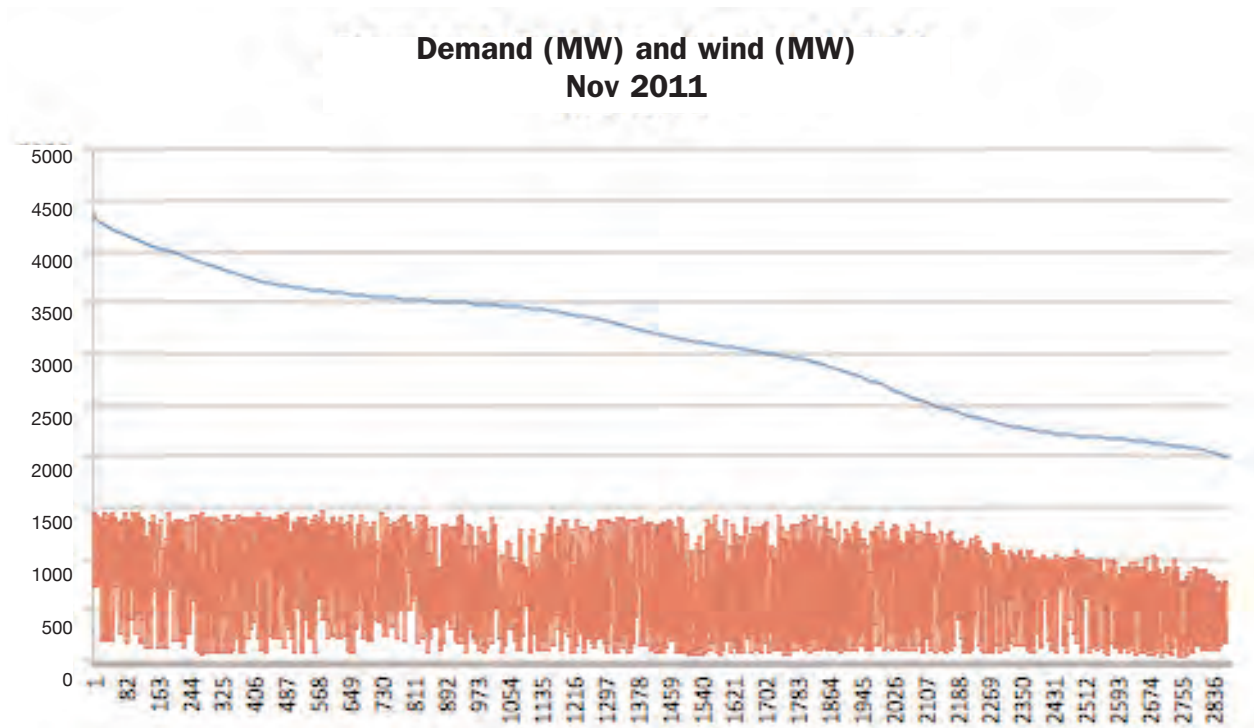
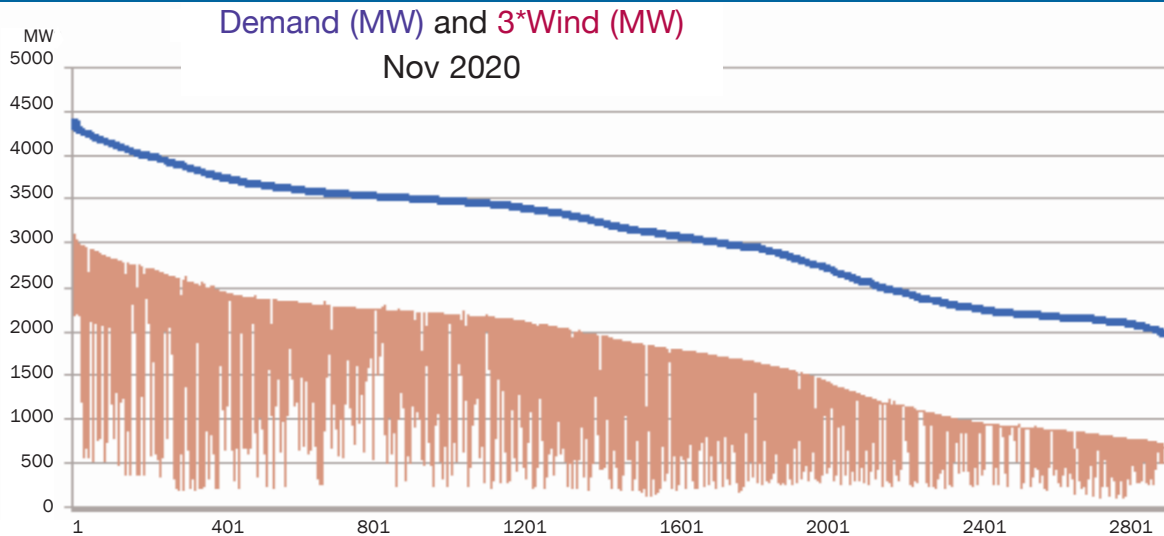


Chart 6 If the government target for wind in 2020 were met, 30% of the wind energy would have to be spilled



wind energy has to be spilled. This is demonstrated with the aid of a load duration curve is constructed from all the daily load curves put together with the points sorted in order of decreasing demand. (For a complete explanation see the appendix of reference 5). Chart 5 shows the load duration curve⁸ for November 2010 with the associated level of wind; once demand reduces below about 2500MW the wind is increasingly curtailed – In this case about 3% is lost.

The Irish government has a target of three times the current level of wind by 2020, which would result in spilling 30% of the wind energy production (chart 6).

The upper limit of the wind contribution follows the demand curve, in such a way, that the must run capacity of 1300 MW can always run. The non-curtailed wind is the same as in figure 5, but three times higher. Its upper limit runs now at 4200 MW. It follows, that curtailment now can occur at all times during the day.

Colorado and ERCOT

Energy Consultant Bentek⁹ undertook a study of the effect of wind on emissions of SO_x, NO_x and CO₂ for two systems:-

- The system of Colorado Public Service Company (PSCO), with in 2008 3.8GW of coal plant, 3.2GW of gas plant, 0.4GW of hydro and pump storage, and 1.1GW of wind.

- The ERCOT system in Texas, which is a virtually stand alone system that manages about 85% of the capacity in Texas. In 2009 it had 17.5GW of coal

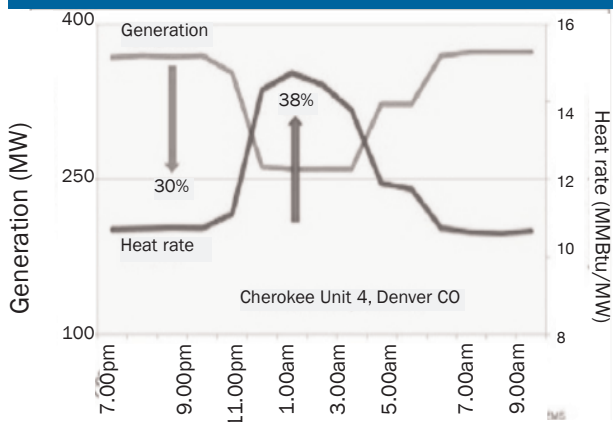
boiler specific emissions and production which are provided to the Continuous Emissions Monitoring System of the Environmental Protection Agency and data provided to the Federal Energy Regulatory Commission. ERCOT also publishes wind, coal, nuclear, natural gas and hydro generation data on a 15-minute basis. The PSCO part of the report first examines in detail the impact of cycling for CO₂ coal plants over a number of days when there are “wind events”. The avoided generation from coal plants was calculated; the monthly and quarterly “stable day” emission rate was calculated; finally the difference between the actual emissions and the emissions that would have been generated if the avoided generation had been produced with the “stable day” emission rates was calculated.

The effect of cycling coal plant is shown by the operation of Cherokee Unit 4 located in Denver. Between 7:00 pm and 9:00 am on March 17 and 18, 2008, see chart 7. Between 9:00 pm and 1:00 am, generation from the Cherokee 4 fell from 370 to 260 MW. It then increased to 373 MW by 4:00 am.

During the period in which generation fell by 30%, heat rate rose by 38%. Heat rates are directly linked to cycling: as the generation from coal plants falls, the heat rate begins to climb. Initially, the heat rate climbs because generation of the plant is choked back and fewer MW are produced by the same amount of coal.

Later in the cycle, the heat rate climbs further because more coal is burned in order to bring the combustion temperature back up to the designed, steady-state rate.

Additionally, for many hours after cycling, the heat rate is slightly higher than it was at the same generation level before cycling the plant.”

Chart 7 Impact of generation decline on heat rate

Source BENTEX Energy CEMS

In addition to the micro study of wind events on particular plants, the study also looked at the coal cycling impacts on PSCO's territory emissions. The conclusion of the study was that:- "...cycling of coal-fired facilities has increased significantly since 2007 as wind energy generation increased to its current levels...the increased incidence of cycling has led to emission of greater volumes of SO₂, NO_x and CO₂.

In 2008, depending on the method of calculation, cycling coal plants caused between 1.1 and 10.5 million pounds of SO₂ to be produced that would not have been produced had the plants not been cycled...Cycling's impact on CO₂ is more ambiguous as the range is between creating a saving of 164,000 tons and a penalty of 151,000 tons.

In 2009, generation from PSCO's coal-fired plants fell off by about 20%, but their emissions did not diminish proportionately. Again, cycling appears to be a central factor...between 94,000 and 147,000 pounds of CO₂ [was produced] more than would have been generated had the plants been run stably."

The conclusion of the study of ERCOT, which was undertaken in a similar manner to their PSCO analysis, is:- "Not only does wind generation not allow ERCOT utilities to save SO₂, NO_x and CO₂ emissions, it is directly responsible for creating more SO₂ and NO_x emissions and CO₂ emission savings are minimal at best."

Britain

The system in Britain is predominantly coal and gas with some nuclear and very little hydro, proportionally less than in Ireland. The wind capacity at April 2012 was 6.6GW. National Grid's Gone Green Scenario, which is consistent with the ambitions of the government, is for about 25GW of wind. The system

currently needs about 4GW of regulating capacity available at all times, of which about 1.8GW is provided by pumped storage and the balance by part-loaded CCGT and coal plants. Most, if not all, of the additional 18GW required under the Gone Green scenario for 2020 is likely to be thermal plant. A comparison with the Irish case result in 20% of the wind energy will be spilled and the fuel saving of the remainder will be merely between a third and a half of the anticipated value.

The latest levelised cost estimates¹⁰ for windmills were prepared in October 2011 for the government by Ove Arup and Partners with assistance from Ernst & Young¹¹. To these costs we have (after crawling through the detailed figures) added the annuitised value of a relevant share of the cost of transmission development proposed in the Electric Network Strategy Group's recent report¹². Thus for a total of 14.4GW of offshore wind we will incur £3.8billion of transmission investment and for 6GW of onshore wind an additional £3.9billion.

Annuitising the investment, we get a charge of about £240million for 14.4GW offshore wind and £240m for 6GW of onshore wind. Suppose the offshore windmills generate with a load factor of 34% and onshore at 25% (which is perhaps a generous estimate given that the actual load factor of windmills in England averaged around 20% across 2010) then we get a charge of about £5/MWh for offshore and £16/MWh for onshore wind. Thus the medium scenarios for wind in 2015 are costs for offshore of £144/MWh (say £145/MWh) for round 2, and £197/MWh (say £200/MWh) for round 3, and £104/MWh (say £105/MWh) for onshore¹³. By way of comparison, the winter 2012 baseload strip is £48/MWh¹⁴ which indicates the cost of offshore wind is about 3-4 times and onshore wind twice current power price.

The implication of these costs and the possible ineffectiveness of windmills in mitigating CO₂ emissions we identified above is that the cost/ton of CO₂ saved is above £200, which is truly extraordinary.

We most strongly recommend that before spending £ tens of billions more on windmills, the Department of Energy and Climate Change (DECC) should commission an objective and *empirical* scientific study of how efficient windmills are at mitigating CO₂ emissions. We italicize "objective and scientific"¹⁵ to differentiate from some of the glib and clearly politicized Impact Assessments prepared by DECC (such as the recent ones on smart metering, see *New Power* 44).

We emphasise empirical to differentiate from DECC's practice of calculating CO₂ emissions ratings simplistically and incorrectly from the steady state

running of thermal plant assuming that a MWh of wind displaces a MWh of thermal running with an equivalent saving of CO₂ emission, which is what it currently does.¹⁶

While this approach gives a satisfactory approximation for the current low level of wind whose fluctuations can be absorbed by the system, it is most definitely not satisfactory for 20-25GWh of wind.

References

1. Director EEE Ltd; once a director of London Electricity Board; the first person to propose in 1987 a competitive restructuring of the electric industry in England & Wales; advisor on electric systems from Finland to Australia; author of "The British Electric Industry 1990-2010: the rise and demise of competition". This is a personal submission backed by no vested interest other than a dislike of the visual impact of enormous on-shore windmills and a strong objection to the government incompetently wasting even more of people's money than it already does.

2. Retired Dutch physicist who worked at CERN Geneva, lately on the Large Hadron Collider.

3. The phenomenon of a large production of wind energy has led Nordpool, the Nordic electricity exchange, to lower the floor price from zero to minus 200 euro/MWh.

4. Wind Energy, The Case of Denmark, Hugh Sharman CEPOS 2009 www.cepos.dk

5. The topic of the significant loss of thermal efficiency of gas and coal plants cycling is dealt with in detail by Willem Post in "Wind Power and CO₂ Emissions" www.coalitionforenergysolutions.org/research_and_reports.

6. Wind energy and CO₂ emissions – 2, F. Udo, 21 October 2011, www.clepair.net/udo_okt-e.html.

7. Curtailment in the Irish Power system, F. Udo 2012 .

8. Wind turbines as a source of electricity. F. Udo, K

de Groot and C. le Pair:

http://www.clepair.net/windstroom_e.html

8. How less became more: wind, power and unintended consequences in the Colorado Energy Market, Bentek Energy LLC, 16 April 2010.

10. Note that although it is conventional to calculate and compare levelised cost estimates for different generation technologies, the comparison favours windmills (and solar panels) because unlike nuclear and dispatchable thermal plants there is no guarantee that windmills will be producing at times of system stress. Estimates put the value of wind electricity at half the value of electricity produced by dispatchable sources.

11. Department of Energy and Climate Change, Review of the generation costs and deployment potential of renewable electricity technologies in the UK, Study Report, Arup, October 2011,

12. ENSG 'Our Electricity Transmission Network: A Vision For 2020', 11D/954, February 2012,

13. The calculations are available from "The collapse of the Coalition electricity policies", available on request from

14. Energy Spectrum, 1 October 2012.

15. While National Grid should be involved in the study, it should not lead it because it has a vested interest in claiming that windmills mitigate CO₂ because it wants as many windmills on the system as possible in order to justify bulking up its grids. An example of the reaction of vested interests is given by the response of Mr. Nick Winser to Mr. Udo's analysis of Ireland was "Thanks. Interesting. I doubt that your point about part loaded fossil negating the carbon benefits of wind is well founded particularly with our huge advances in wind forecasting accuracy." There is a basic flaw in his response, namely although the forecasts may be more accurate that per se will not alter the outturn variability – hence cycling of plant

16. It took three months of to-ing and fro-ing to extract DECC's methodology in an e-mail of 01/08/12 from Benjamin Marriott, Acting Senior Economist, DECC.

DECC's response to "Wind – Whitehall's pointless profligacy"

In Issue 45 of *New Power* Alex Henney wrote an article called 'Wind – Whitehall's pointless profligacy'. In it he argued that even if the all of the vast number of wind farms planned are built they will not lead to a big cut in the UK's carbon emissions. The Department of Energy and Climate Change wrote back to him following the article. What follows is his response to DECC.

A 3 page letter dated 11 October from Mr. Bill Lacy of DECC responded to our article in *New Power*. The majority of this article responds to various points in the letter, quoting the letter in normal script and then putting our comments in italics. *As a general comment our paper is based on assuming a significant level of wind such as envisaged by DECC in its aspirations for 2020. When there is little wind as now the loss of efficiency from "cycling" is not significant. And given the historic unreliability of energy forecasts we do not think it is realistic to look 20 years ahead.* For good measure we note an open goal in the letter.

The mitigation of wind in a thermal system

"We note that you look at a number of international examples where deployment of high levels of wind power has led to the level of emissions reduction being materially lower than anticipated because of power system balancing issues. We will tackle the examples in slightly more detail but before doing so it is worth making some over-arching comments.

Firstly, the question of what the carbon intensity of the power system is under high wind scenarios is not a simple one. In practice the carbon intensity on any given day depends not only on whether the wind is blowing, but also on what power flows are between a country and its neighbours, on the shape of the demand curve on that specific day, whether any big power plants (e.g. large nuclear units) are out for maintenance, and various other factors."

Comment: We can agree on all this – so why does DECC use – and promulgate results from – a simple model, see "The calculation of savings of CO₂ emissions" below.

"Secondly, it is only recently that we have had a significant level of wind generation connected to our system and therefore it is not the case that we have multiple years of historical data to look at, neither is it very meaningful to draw overall conclusions about the GB situation specifically by taking (as some commentators have tried to do) short snapshots of time and extrapolating them forwards into the future."

Comments:

1. We were looking at the fundamental behaviour of gas and coal plant used to balance the variability of significant wind production – namely causing thermal plants to cycle reduces their thermal efficiency and increases their CO₂ emissions per MWh generated. Further – and conclusive – empirical evidence is provided by the paper "Emissions savings from wind power generation: Evidence from Texas, California and the Upper Midwest" which is discussed in our Addendum.
2. Because of the limitation of our data and of DECC's data, we recommend a thorough scientific study of the future prospects of the British system with a significant level of wind. Note that it took several months of to-ing and fro-ing with DECC to discover that its claims for savings of CO₂ emissions from wind are based on a simplistic calculation that 1MWh of wind displaces 1MWh of thermal generation².

This approach overstates the savings – the higher the proportion of wind the more overstated are the CO₂ savings – because it takes no account of the loss of thermal efficiency by thermal plants, hence increasing CO₂ emissions.

"The primary over-arching lesson you draw from your various examples, is that if you use old, relatively inefficient power plants to back up wind generation, the result of running large amounts of them part-loaded could well be that the wind generation abated materially less carbon overall than was originally anticipated."

Comment:

This is an unsubstantiated comment. The gas power stations in Ireland are of various vintages up to 2010 when the latest 435MW plant at Aghada was commissioned. A solid response would require a detailed analysis of which plant were cycling when; whether they were open or combined cycle; and what their thermal efficiency was. The simple point we are making is that the efficiency of all thermal plant – new/old, gas/coal – reduces when it cycles. American electrical engineer Willem Post has set out the effect in detail³.

“In practice, today, it is no doubt true that in the GB market some of the power stations used today to back up wind generation are old and relatively ‘dirty’ power plants nearing the end of their life. Power plant owners have always used older plant in this manner and would probably be doing so to a large extent anyway whether wind generation were connected or not. A number of these older power plants will close over the next few years as the various elements of emissions legislation result in their owners deciding to close them rather than invest more in mitigation of emissions.”

Comment:

These points are irrelevant since we are looking at 2020.

“In the long run a key intention of DECC’s EMR programme is to create the market conditions where the capacity to back up wind is provided by a mixture of newer, more efficient power plants (which could well be modern, more efficient flexible CCGTs), interconnection, demand response and storage. It is our vision that the power system post-2020 could look very different to what we see today, and therefore looking at carbon intensity now, in what is effectively a period of transition, is only going to tell us limited things about the future.”

Comments:

1. *When will more interconnection come? From personal experience with North Connect between Norway and Scotland they take a good decade. Furthermore interconnectors suffer from hardware faults, as shown by the experience of the Sweden-Denmark interconnector in 2009 which had an average availability of 73% (both ways).*
2. *We have talked about demand response for decades. It was one of the stated objectives of NETA which was not fulfilled⁴. What will be different in future?⁵*
3. *What type of storage and when?*
4. *Visions do not keep the lights on!*

“Having said all the above, you have provided some interesting and thought provoking case studies of issues happening now elsewhere in the world, so the cases you put forward merit some specific comment.”

“Denmark

The Danish system is substantially different in two important respects. Firstly, it has a much higher degree of interconnection with neighbouring states than the GB power system has, relatively speaking. This means that wind energy can be ‘spilled’ into neighbouring states at times of high wind, as you clearly demonstrate. In addition, Denmark has a

large installed base of district heating systems which provide both heat and electricity, and have to run regardless to provide heat. Your argument is that this plant has to run anyway regardless of the wind regime, and therefore the overall carbon intensity is not greatly affected by the wind generation.”

Comment:

No, the point we are making (which is made explicitly and more clearly in the published version) was to illustrate the law of unintended consequences. Namely, the purpose of the Danish government in subsidising a lot of wind turbines was not to sell power cheaply to Norway. DECC’s comment was naïve and neglects the fact that not only do the emissions savings entail a transfer of wealth from Danish consumers to others, the cost of those savings are particularly high because a third of Danish wind comes from offshore wind farms⁶.

“In the UK we have very little district heating installed today and most of our space heating is provided from mains gas. So, whilst your example tells us something important about the issues we might encounter in developing district heating in the future, we are not in a directly comparable situation. In addition, your calculation looked at the carbon intensity of Denmark alone. Given the extent to which Danish wind power is exported, it might well be the case that Danish wind power is abating emissions in neighbouring countries, to the general benefit of Europe as a whole. When examining countries heavily embedded within the European grid it is important to look at the issue holistically, however, this is not analogous to GB today, although it is a relevant example as we explore questions about the appropriate future level of interconnection between GB and continental Europe.”

Comments:

1. *The graph shows, that the carbon intensity of the total Danish electricity production is adversely affected by the presence of wind power. This is independent of exports. DECC is completely wrong here*
2. *There was no intent to compare Britain and Denmark, nor to envisage extensive CHP because (despite much talk) the government has consistently failed to meet targets for CHP⁷*

“Ireland

The Irish system is a better comparator to GB as it is an island with wind being backed up predominantly by gas fired generation. Unfortunately we feel your otherwise very informative analysis falls into one of the traps described above, i.e. looking at a specific time period and trying to extrapolate from it. By looking at a period of time when pumped storage

(which is a low carbon technology for balancing wind) was out of service you demonstrates a significant divergence between anticipated and actual emissions. It may be that the average intensity is significantly better than this, which is the danger inherent in taking short time periods in this way and using them to make a general point.”

Comment:

This entirely misses our point. We looked at the time when the pumped storage was out of commission in order to see how the system performed when the wind was balanced by thermal plant, which is how the British system is balanced, and will increasingly be balanced if the governments wind ambitions are achieved.

“Your example, is, however, an eloquent and useful example of the need to incentivise low carbon balancing technology at high levels of wind penetration, which is something DECC has done considerable work on recently.”

Comment:

What is the work and when will it come to fruition?

“Another point various independent commentators have made is that the Irish market arrangements are more likely to incentivise investment in lower efficiency open-cycle gas turbine power stations, and GB market arrangements create a different set of incentives.”

Comment:

Which commentators and with what evidence?

“In the section on Ireland you also makes the statement that wind forces are highly correlated. Whilst it is true that a big weather system might mean that it is either windy or not over several countries simultaneously, the increasing operational evidence is that on an hour-by-hour basis the level of correlation is not nearly so great, with wide regional variations in weather patterns meaning that a system operator has scope within normal dispatch timeframes to take more advantage of the level of correlation than might on the face of it appear to be the case.”

Comments:

1. The correlation length of wind systems in NW Europe is about 80 miles/hour, so the smoothing disappears over longer time spans. There is a directional effect as well.
2. While we welcome DECC's evidence, we note the paper “Will British weather provide reliable electricity?” by J. Oswald and others⁹ which shows clearly the considerable variability of the British

wind, which is the pertinent issue. We also note the paper “Geographical Distribution and Wind Power Smoothing” by Paul-Fredrik Bach who was Planning Director at the TSO in West Denmark until retiring in 2005⁹. The paper analyses data on the correlation between wind in Denmark, Germany and Ireland. It concludes:-

“The combination of wind power in Denmark, Germany and Ireland produces a statistical effect, with the most significant smoothing observed the Danish-Irish combination. This is to be expected since typical weather fronts move from west to east, and there is a Greater distance between the Danish and Irish wind fleets than between those of Denmark and Germany. However, the effect is not strong, and even assuming market interconnections which are perfect in a physical and regulatory sense there would still be extreme peaks and troughs in wind output for both the north-south and the east-west combination.”

“Colorado and ERCOT

In both these examples, unabated coal plant is being used to back off wind. This is a helpful case study of why it is important for DECC to pursue the development of CCS if we do want coal to play a long term role in our energy mix, and also a helpful example of why the design of EMR needs to incentivise the building and operation of the right kinds of balancing generation. This is the subject of ongoing work within DECC, also of ongoing dialogue with relevant industry players.”

Comments:

1. Let us believe CCS when we see it tested and viable. The 2003 Energy White Paper stated (para 70) “We will set up an urgent detailed implementation plan with developers, generators, and the oil companies to establish what needs to be done to get a demonstration project off the ground.” After an aborted competition DECC has just agreed to fund a 5MW pilot plant. A second competition is in progress. Large scale implementation is not yet within the time horizon of 10 years.
2. Our paper was focused on 2020 and the technologies that are on the table. The electric industry has been bedeviled by dreams of technologies of the future and in the past we have spent fortunes on fast reactors and fusion to no effect, and we have spent non-trivial sums on “the battery problem” to at best modest effect. In practical terms (which is what keeps the lights on) there have been only two new technologies that have achieved mass production through competitive costs in the last quarter of a century, CCGTs and on-shore wind turbines. And both of those are evolutions of technologies several decades old. The only technological cost breakthrough for mass generation

that is in clear sight is PV. But while it offers significant prospects in (e.g.) Andalusia, it has obvious limitations in the British climate.

“We can agree with you on the need for objective and scientific study of the issues. DECC is engaging with the range of relevant industry players who have the data to inform this discussion, and will use this to inform our market design decisions as we finalise the operational details of EMR.”

General comment:

Our concept of an “objective and scientific study” does not envisage either DECC or industry having a lead role because neither have a record of either rigour or objectivity. Our concept of an objective and scientific assessment would be one run by a very intelligent person (possibly a judge) supported by a small group of suitable independent techies and a competent economist. It is implicit in our use of the words objective and scientific that it would be independent and the people involved would not be seeking favours from the government.

The open goal on retailing

Although not germane to windmills, the following paragraph in the letter is too good to miss.

“Furthermore, regarding your comments on retail competition, I believe it is important to note that the UK has a competitive market, with the lowest gas prices and the fourth lowest electricity prices in the EU15. Price regulation is needed where competitive markets cannot deliver the best outcome for consumers, often in natural monopoly situations.

This is not the present position in UK retail energy markets. Some EU member states still use price controls to regulate the market, particularly where there is a monopoly supplier. And to introduce price caps could introduce investment risks across the economy. We strongly encourage UK consumers to shop around for the best deal – this will help control costs and helps ensure competition keeps UK prices as low as possible.

Lastly, artificially reducing retail prices to levels below the competitive levels would be unsustainable, discourage investment in the new infrastructure we require and put at risk energy security of supply and our climate change objectives.”

No comment needed in the light of recent observations by the Prime Minister and consultation by Ofgem!

We offer a bottle of wine for the snappiest description of what the foregoing tells us about

DECC.

References

1 Mr. Lacy is in the Correspondence Unit. These letters are put together by the person in the Correspondence Unit referring to people in the relevant policy sections.

2 In response to various queries to DECC asking about CO₂ emissions savings from wind, DECC has directed various people to “The Carbon Footprint of Generation” by the Parliamentary Office of Science and Technology. Checking with the author revealed that the figures cited for emissions/kWh of thermal plants were based on steady output of the various units. A letter from Mr. Jonathan Brearley, Director of Energy Strategy and Futures, was vague on the methodology adopted. A subsequent email from an official explained that the basis of DECC’s claims was unpublished modeling in 2009 by Redpoint. When contacted, Redpoint first pointed out that their study was not aimed at looking at CO₂ savings; and second their modeling assumed a simple displacement of 1kWh of thermal output by 1kWh of wind. Eventually an e-mail dated 01/08/12 from Mr. Benjamin Marriott, Acting Senior Economist, revealed that “The direct answer is that the efficiencies of thermal plant were held constant in the modeling.”

3 Willem Post, Wind power and CO₂ emissions. <http://theenergycollective.com/willem-post/57905/wind-power-and-co2-emissions>

4 See pp65/66 of one of the author’s book “The British Electric Industry 1990-2010: the rise and demise of competition”, Alex Henney, 2011.

5 Some people think that smart metering will achieve some demand response, but there is little or no empirical evidence to support this view.

6 In 2011 on-shore production was 6.23TWh and off-shore production was 3.40TWh.

7 See pp56/57 and 290/291 of Henney’s book.

8 James Oswald, Mike Raine, Hezlin Ashraf-Ball, Energy Policy, 36, 2008.

9 Included in The Variability of Wind Power, Collected Papers 2009-1010, Paul-Fredrik Bach, published by the Renewable Energy Foundation, www.ref.org.uk.

Addendum and Annex to “Wind – Whitehall’s pointless profligacy by Alex Henney

In our article published in *New Power* in October we quoted from a study of emissions in Colorado by Bentek Energy “How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market”. We have just received an academic development of that study titled “Emissions savings from wind power generation: Evidence from Texas, California and the Upper Midwest”¹ which is a Working Paper published by the Colorado School of Mines.

Unfortunately our article omitted the Annex “The going forward cost of wind” which sets out the figures DECC cites, and adds to them the additional costs of system integration and of transmission that is allegedly required to accommodate the additional wind the government hopes to see. Generally the wind lobby and DECC prefer to ignore these costs.

Key points

The study considers wind generation and emissions from power plants in the territories of the Electric Reliability Council of Texas (ERCOT) for the period 2007-2009, the California Independent System Operator (CAISO) for 2009, and the Midwest Independent System Operator (MISO) for 2008-2009. These three systems contain about 60% of total wind generation in the US. The generation mixes of the systems differ considerably. ERCOT is predominantly a mix of gas (43%), coal (37%) and nuclear (12-15%) with very little hydro; gas and coal run at the margin. In 2010 CAISO in state generation consisted of 53% gas, 16% nuclear, 15% hydro, 2% coal and 14% renewables; gas is generally at the margin. MISO is predominantly coal (80%) and nuclear.

The average emission rates from thermal generation in the three systems were as follows (CO₂ tons/MWh):-

ERCOT	0.80
CAISO	0.46
MISO	1.04

The average CO₂ emission rate in the United states for coal-based generation is 1.1 tons/MWh of CO₂, and for natural gas-based generation is 0.57 tons/MWh of CO₂.

Wind comprises the following proportions of production:-

	(%)
ERCOT	4.7
CAISO	2.0
MISO	3.2

These proportions are comparable to Britain, and far less than Ireland (12-13%) and the government’s ambitions for Britain.

The report notes that cycling of thermal plants to offset the variability of wind will cause them to increase their output of CO₂/MWh. It refers to “Back-of-the-envelope calculations by Lang (2009) incorporating emissions from natural gas backup generation suggest that CO₂ emissions savings may be very small (less than 0.1 tons/MWh).”² And it also cites that “Liik et al. (2003)³ raise the concern that rapid ramping of fossil fuel plants (known as cycling) to accommodate wind is emissions-intensive, implying that marginal emission rates are the appropriate measure of emissions savings. Their operations research simulation model suggests that emissions savings may be completely eroded in some scenarios due to cycling-related emissions. A recent study [which is the one we cited] by Bentek Energy LLC (2010) raises similar concerns about emissions associated with cycling.”

The study is based on 50,000 hourly observations of emissions of NO_x, SO_x, and CO₂, and of wind generation. Hourly emissions data is sourced from the Environmental Protection Agency’s (EPA) Continuous Emission Monitoring Systems (CEMS) program, which requires coal and gas power units with over 25 MW of capacity to submit hourly data on SO₂, NO_x and CO₂ emissions.

These emission reports are required by the EPA to monitor compliance with emission regulations, and strict quality assurance standards are in place to guarantee the accuracy of emission measurements. Wind data is sourced from the system operators’ websites. The data was analysed using sophisticated statistical techniques.

Empirical analysis

The empirical analysis concludes “that emissions savings across territories are less than the hypothetical savings based on average emission rate

analysis.” The savings for CO₂ (tons/MWh) are:-

ERCOT	0.52
CAISO	0.29
MISO	0.92

“These results suggest that emissions savings are strongly driven by differences in existing generation mix - coal-intensive territories experience larger reductions in emissions due to wind generation.”

We observe that even at the low levels of wind penetration similar to Britain there is a significant loss of “CO₂ emissions mitigation efficiency” (viz actual emissions savings divided by the amount that would be saved if 1MW of thermal generation were saved by 1MW of wind⁴), with a provisional⁵ loss that appears to be about 30% in coal based MISO, 50% in gas based CAISO and 50% in gas/coal based ERCOT. Regardless of the precise level of the loss of mitigation efficiency, the findings of the study implies that the CO₂ savings claimed by DECC for wind output which are based on assuming a “one for one saving” are significantly overstated.

The report significantly comments “increasing wind penetration will likely require an increase in ramping of thermal generation, as the magnitude of shifts in wind speed is amplified into larger swings in aggregate wind generation. This increased cycling of thermal generation (in magnitude and potentially frequency) may erode the emissions savings per MWh of wind power as thermal generation is utilized less efficiently to accommodate wind.” This observation prima facie calls into question the justification presented in DECC’s Impact Assessment in the Electricity Market Reform (IA DECC 0104) which probably uses the simplistic one for one savings rate. The costs and savings figures for the future are driven through DECC’s Dynamic Dispatch Model to achieve a decarbonisation level of 100gCO₂/kWh in 2030.

Given the findings of the study (and of our earlier study of Ireland) this target will not be achieved by the capacities thrown out by the model, hence the modeled carbon savings will not be achieved. Alternatively perhaps twice as many windmills will be required to achieve the decarbonisation target, thus significantly increasing the costs.

As per our original article “we most strongly recommend that before spending £ tens of billions more on windmills, the Department of Energy and Climate Change (DECC) should commission an objective and empirical scientific study of how efficient windmills are at mitigating CO₂ emissions. We italicize “objective and scientific” to differentiate

from some of the glib and clearly politicized Impact Assessments prepared by DECC (such as the recent ones on smart metering, see *New Power* 44).”

The going forward cost of wind

The conventional manner in which the cost of generation is presented is as a “levelised” cost using low, central, and high estimates and basing the costs on the capital cost of the facility; its availability; its fixed and variable O&M; its fuel cost; and (if significant) its decommissioning cost. DECC is using cost estimates prepared by Ove Arup and Partners with assistance from Ernst & Young as the basis for its review of banding.⁶ Arup’s estimates for the levelised costs of (large) onshore and offshore wind farms of >5MW for 2015 are as follows:-

The basic “production” costs are, however, only part of the story when there is a significant level of wind. For a start National Grid estimates the extra system cost required to handle the variability of wind for 2020 at £286m for a wind output of about 70TWh p.a. say an average of £4/MWh⁷. Next the Electricity Network Strategy Group has just reported “The total estimated cost of the potential reinforcements contained in this report, based on National Grid’s Gone Green 2011 scenario is around £8.8bn”⁸. The ENSG report assesses the reasons for, need for, and cost of transmission reinforcement in – areas of the country as follows:-

Scotland, which is divided into:-

- SHETL where “The volume of generation...is expected to increase over the coming years due to the growing capacity of renewable generation” and it refers to various wind developments. The Gone Green 2011 (GG2011)scenario refers to 2.2GW offshore; 4.5GW onshore.

£/MWh		
Onshore	low	72
	medium	88
	high	105

£/MWh		
Offshore	low	123
	medium	139
	high	158

£/MWh		
Offshore round 3	low	168
	medium	192
	high	225

• SPT – “The volume of generation...is similarly expected to increase...due to the growing capacity of onshore wind farms...together with the Crown Estate Round 3 offshore wind farm in the Firth of Forth.” GG2011 refers to 1GW offshore and 4GW onshore

The estimated cost of reinforcements in Scotland for the GG2011 scenario is £2.5bn.

Scotland-England interface: “A number of potential reinforcements have been identified which have the ability to increase the boundary capacity to meet the increasing transfers from Scotland to England” due to increased generation of 9GW of Scottish Wind (namely the above 11.7GW, minus 2.5GW of existing onshore capacity).

The reinforcement includes both the Western HVDC link (around £1bn) for which “The main driver...is the large volume of renewable generation that is expected to connect Scotland to Northern England over the next ten years.” It also includes the East Coast HVDC Link 1 between the North East of Scotland and the North East of England (£1.2bn) for which the “main driver...is the large volume of renewable generation (mainly onshore wind and some offshore wind and tidal) that is expected to connect in the North of Scotland...”. The reinforcement also includes increasing the three Scotland/England onshore boundaries to give a total cost of £3.5bn.

The total “Scottish” cost is £6bn of which (say) a £5.7bn share is due to wind of which there is 3.2GW new offshore wind and 6GW new onshore. Pro-rating according to capacity gives £2.3bn for 3.2GW offshore and £4.4bn for 6GW onshore wind.

North Wales: a net increase of 2.8GW of generation is forecast under the GG2011 scenario because of a nuclear plant at Wylfa of 1.2GW (current nuclear capacity is 1.0GW) and 2.6GW of offshore wind at a cost of £1.1bn, then on a pro-rata basis £0.75bn is for offshore wind.

Mid Wales: “The area has been identified as one that has significant potential for onshore wind generation” and is marked for 0.8GW at a cost of £0.2bn.

South West: GG2011 forecasts “a significant amount of new nuclear (1.6GW) and wind generation” (offshore 1.1GW) at a cost of £0.5bn. Pro-rating credits £0.2bn to 1.1GW of offshore wind.

East Coast and East Anglia: GG2011 foresees a cost of £0.75bn driven by 6GW of offshore wind.

London, Thames Estuary and South Coast:

GG2011 foresees 1.5GW of offshore wind incurring a cost of £2-400m (say £0.3bn).

Thus for a total of 14.4GW of offshore wind we are incurring £3.8bn of transmission investment and for 6GW of onshore wind a total of £3.9bn. If we annuitise the investment at 6.25% over 40 years we get a charge of about £240m for 14.4GW offshore wind and £240m for 6GW of onshore wind. Suppose the offshore windmills generate with a load factor of 34% and onshore at 25% then we get a charge of about £5/MWh for offshore and £16/MWh for onshore wind.

Thus the medium scenarios for wind in 2015 are costs for offshore of £144/MWh (say £145/MWh) and £197/MWh (say £200/MWh) for round 3, and £104/MWh (say £105/MWh) for onshore.

Endnotes

1 Daniel T. Kaffine, Brannin J. McBee, Jozef Lieskovsky, <http://econbus.mines.edu/working-papers/wp201203.pdf>

2 Lang, P. (2009). Cost and quantity of greenhouse gas emissions avoided by wind generation. Working Paper.

3 Liik, O., R. Oidram, and M. Keel (2003). Estimation of real emissions reduction caused by wind generators. In International Energy Workshop, June 24-26, IIASA.

4 Viz actual saving * 100 where the denominator is ideally the volume weighted marginal thermal emission one for one saving rate, but this is not available in the paper. Since marginal (thermal) plants have a higher emission rate than average let us assume the marginal plants have an emission rate of 1.25 times the average rate, which gives figures of 1.00 for ERCOT, 0.57 for CAISO, and 1.30 for MISO.

5 If the figures can be improved, they will be.

6 Department of Energy and Climate Change, Review of the generation costs and deployment potential of renewable electricity technologies in the UK, Study Report, Arup, October 2011, <http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/3237-cons-ro-banding-arup-report.pdf>.

7 Operating the Electricity Transmission Networks in 2020 – Update June 2011, National Grid

8 ENSG ‘Our Electricity Transmission Network: A Vision For 2020’, 11D/954, February 2012, <http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/future-elec-network/4263-ensgFull.pdf>.