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Sustainability Committee

Inquiry into Carbon Reduction in Wales: Electricity Generation (including renewable energy)

Response from Mr Ian Gardner

Lies, Damned Lies and Windpower Statistics – Some thoughts

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Abstract

This paper reviews some of the common statistics used by both developers and opponents of windfarms to clarify the basis on which competing claims are made.

In general the claims made by developers tend to overstate CO2 savings. In a specific and current example of the Brenig windfarm the developer has overstated CO2 savings by 53,402 tonnes per annum or by a factor of 60%.

The more accurate measure of CO2 emissions outlined in this paper fully accounts for the relevant Capacity Factor of wind in Wales, Backup Generation, Transmission Loss and Deforestation.

Background

The wind industry regularly makes claims about wind energy as a renewable energy source. Chief amongst these claims are

1. How productive windfarms actually are – the Load or Capacity Factor[1] issue
2. How much conventional energy can actually be replaced by wind power – the Capacity Credit issue
3. The number of households that can be served with energy if a windfarm is developed - the household equivalent issue.
4. Renewable energy CO2 displacement – the fossil fuel power station CO2 emission reduction issue

The current political and environmental argument hinges on the contribution of windpower as a means of reducing C02 emissions and thus reversing climate change. A secondary issue is one of Security of Supply but this is not covered in this note.

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[1] The UK power industry uses the phrase Load Factor to describe the ratio of the energy actually generated over a given period of time to the energy the unit would have generated if it had been running at its maximum capacity over the same period. The wind industry use Capacity Factor to describe the same ratio. This paper uses the terminology Load / Capacity Factor to describe the ratio

There have been many statistics used in the argument, but as we all know, statistics are not always reliable. This note tries to understand what is being said and by whom.

Let us consider the following example of a windfarm with 20 turbines each rated at 2 Megawatts (MW). Some of the key statistical relationships relevant to the pro and anti windfarm argument can be set out:

Windfarm	40	Installed capacity[2] in MW
	40,000,000	Watts max output
Multiply by	0.3	Load / Capacity Factor
Gives	12,000,000	Watts actual output
Or	12,000	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	105,120,000	Kilowatt hours (kWh)
Divided by	4,700	av no of kilowatt hours electricity use per annum
Gives	22,366	households provided with electrical energy
CO_2 Saved	90,403	Metric tonnes

The CO_2 saving is based on the 105,120,000 (kWh) multiplied by 860g CO_2 /kWh converted into metric tonnes (i.e. divide by 1000 to give kg and then by a further 1000 to express in metric tonnes)[3]. This is a fairly typical set of data used by windfarm developers in their Environmental Impact Assessments and in windfarm industry marketing material. It is also disputed territory as those opposed to windfarms believe that the information is at best, misleading.

Question 1

How Productive are Windfarms in Wales?

In most of the Environmental Impact Statement submissions, developers are citing the British Wind Energy Association (BWEA) recommended Load / Capacity Factor value of 0.3. This is a factor which, when multiplied by the installed capacity accounts for the wind resource varying and things like the need to take turbines off line for maintenance over a twelve month period. The Load / Capacity Factor is used as follows: Take the following as an example

The Installed Capacity of the Windfarm is 20 turbines rated at 2 Megawatts each. This gives 20 x 2 Megawatts maximum output – or 40 MW **IF** all of the turbines are operational and the wind speed is high enough to drive the turbines at their maximum output. But we know that reality is not like this. Sometimes the wind blows too hard, sometimes it is not strong enough and sometimes the turbines have to be repaired or maintained.

The BWEA, who represent the Wind Industry recognise the above and say that windfarms are fully productive around 30% of the time as a result of the above factors. So to work out what **ACTUAL** output a windfarm produces, the BWEA say that you multiply the Installed Capacity (40MW in our example) by 0.3 –

[2] Installed Capacity is a term frequently used in this paper. It is the product of the number of turbines multiplied by the power output for each turbine. In the above example there are 20 turbines, each with a maximum output of 2 MW so the Installed Capacity is 20x2=40MW

[3] The figure 860g CO_2 / kWh is the amount of CO_2 generated by a Coal Fired power station. See Question 4 for more information on this.

which gives you 12MW of **ACTUAL** rather than **POTENTIAL** output at any point in time.

The problem with this calculation is that there is some evidence that this estimate is too high in Wales. The Government[4] have **MEASURED** the Load / Capacity Factor for actual windfarms in Wales and they say this is not 30% but is in fact 26%. So if we apply the measured 26% to our example, actual output falls to 10.4 MW

To calculate how much **ENERGY** is produced by the windfarm you need to multiply the **ACTUAL** output (10.4 MW in our example) by the time the windfarm can produce electricity. A windfarm can work 24 hours a day, 365 days a year. So, as there are 8760 hours in a year you need to multiply the actual output at any point in time by the time available. In our example this means that the 10.4 MW is multiplied by 8760 hours giving 91,104,000 kilowatt hours of energy produced over a full year.

This compares with the BWEA based estimate of 105,120,000 kilowatt hours that would be produced if the windfarm was 30% rather than 26% efficient. Quite a big difference.

What are the Load / Capacity Factors in Other Countries?

Internationally the average Load / Capacity Factor was reported as 24%[5] in 2005 and with a projected increase in offshore wind, it is expected that the average will increase as the offshore wind resource is greater than on land.

The Government (see footnote 4) say that in England over the period 1998-2004 the figure was 26%. In Scotland over the same period it was 30% and in Northern Ireland it was 36%

Windfarms in Victoria, Australia, one of the best wind resourced countries in the world have a Load / Capacity Factor of between 30 and 40%[6]

As Load / Capacity Factors vary across territories and regions, it is perhaps most appropriate to stick with measured data for Wales rather than use or rely on the Load or Capacity Factors of other countries as some are greater and some are smaller than the Government's figure for Wales.

Question 2

How much conventional energy can be replaced by windfarms?

This is where the numbers start to get even more complex.

The first thing to understand is that windfarms operate within a Power System which includes renewable and non renewable energy producing plants. Windfarms operate alongside Nuclear, Coal and Gas power plants. The precise mix of these at any point in time is largely dictated by the price of power offered by the generating companies to the National Grid.

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[4] DTI Energy Trends March 2006 http://www.berr.gov.uk/files/file27084.pdf

[5] Greenpeace / GWEC Global Wind Energy Outlook 2006

[6] Assessment of Greenhouse Gas Abatement from Windfarms in Victoria, McLennan Magasanik Associates Pty Ltd 2006

Secondly, as windpower is intermittent, there are times when it produces less output and there are times when the output is greater (on windy days). This causes output to fluctuate. However we consumers want electricity all the time so the National Grid has a tricky problem of matching the power generated by all forms of power plant with the needs of customers. This is called **Balancing the Grid.**

Thirdly, as customers want more electricity at particular times of the day, the idea of **Peak Load** is used to describe how much energy is needed at these busy times. Peak Load is the point at which the greatest demand exists relative to supply. To ensure that we can all have our cup of tea while watching Coronation Street at 7.00 pm as dinner is in the oven and the washing machine is working, the Power System has to be able to meet Peak Load demand whenever it occurs and for however long it lasts.

Some of the pro / anti windfarm arguments have focussed on what happens when the wind doesn't blow enough. There are two arguments here. Firstly, the simplistic and largely illustrative point that when the wind does not blow electricity is not produced and this can't be a very reliable way of meeting our energy needs. The pro windfarm lobby has responded by pointing out that in the UK there have been few days when no wind has blown and that some energy will always be produced as a consequence.

A second and more subtle argument is that wind will never supply enough energy to meet a significant proportion of UK energy needs. Part of this argument is based on the problem of Peak Load. Put simply the argument is that while wind is intermittent and there are peaks in demand, the Power System needs to retain sufficient backup capacity to ensure that Peak Load demand can be met. The pro windfarm lobby use this fact to refute the argument, pointing out that windfarms have conventional backup within the Power System and Peak Loads are capable of being met in this way.

So both pro and anti windfarm arguments acknowledge that windpower is only part of the Power System and that backup energy will be required to address the problem of Peak Loads.

If there is such agreement then how is backup capacity factored into energy saving calculations?

The way in which this occurs is through the introduction of another concept, that of **Capacity Credit**. The capacity credit of wind power is the amount of conventional power that it can replace without the need for additional investment. So for a 100MW windfarm, if the Capacity Credit is 50% this means that it will replace 50MW of conventional generating capacity without the need for any additional backup or other investment.

Now it is easy to get confused here as Capacity Credit and Load / Capacity Factors sound the same, but they are different concepts. One – Load / Capacity Factor is about output, the other Capacity Credit is about replacement of conventional energy sources. The Load / Capacity Factor does not account for backup energy requirements, but Capacity Credit does.

Having said this, there is some research that suggests that for low levels of windfarm penetration, the two measures can approximate for one another[7 8] so where there is data on the Load / Capacity Factor (0.26 in our example); this can be used as an approximation for the Capacity Credit. The logic behind this is that there is no significant impact on **existing** conventional backup plant at low levels of windfarm deployment.

Following this line of thinking, no further adjustment is necessary to the calculations before we estimate CO2 displacement. The above does come with a health warning however. Two things impact on the ability for Load / Capacity Factor to approximate to Capacity Credit. These are the relative proportion of windfarms within the Power System and the degree to which windfarms are dispersed.

Windfarm Penetration as % of Peak Load

Where windfarm penetration is at 1% or less then the Capacity Credit is constant and is equal to the Load / Capacity Factor divided by the reliability of the Power System.[9] So where the reliability of the power system is 100% the Capacity Credit and Load / Capacity Factor are the same.

Where windfarm penetration is greater than 1% but less than 10% - as at present in the UK[10], the Capacity Credit reduces in relation to the Load / Capacity Factor and from 10% wind energy penetration the reduction is particularly marked, falling to 50% of the Load / Capacity Factor at 30% of wind penetration[11]. This is reflected in estimates of the cost of balancing the grid (providing backup generation) with an increased proportion of energy from wind[12].

For the purposes of the current analysis, it is arguable that we should not take a lower figure for Capacity Credit compared with Load / Capacity Factor as the backup requirement at present levels of windfarm penetration is not significant.

Dispersal

Where windfarms are dispersed and not concentrated in particular areas, the impact on Capacity Credit is less. Where windfarms are distributed so that each turbine contributes equally across the Power System, Capacity Credit and penetration are independent. It does not matter how many turbines are connected so long as the marginal impact of each is the same. Where this is not the case and where windfarms are concentrated in particular areas – like the seven SSA's in Wales, Capacity Credit is reduced in proportion to the degree of concentration[13].

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[7] Milligan ,R Modeling Utility-Scale Wind Power Plants Part 2: Capacity Credit National Renewable Energy Laboratory 2002

[8] Research cited in Grubb, M; Butler, L & Sinden, G Diversity and Security in UK Electricity Generation: The Influence of Low Carbon Objectives Cambridge Working Papers in Economics 2005

[9] Van Wijk A Wind Energy and Electricity Production Doctoral Thesis Utrecht University cited by Vorspools, K.R & D'haeseleer , W D An Analytical Formula for the Capacity Credit of Wind Power; Renewable Energy 31(2006) pp 45-54

[10] Based on the fact that we have not achieved the 2010 target for renewable energy which equates to 7.6% penetration for wind energy per Carbon Trust & DTI Renewables Network Impacts Study 2004

[11] Vorspools, K.R & D'haeseleer , W D An Analytical Formula for the Capacity Credit of Wind Power; Renewable Energy 31(2006) pp 45-54

[12] Carbon Trust & DTI Renewables Network Impacts Study 2004 p6

[13] Vorspools et al p50

For the purposes of the example and to put Welsh Energy Policy into perspective, some downward adjustment on Capacity Credit should occur because of the concentration effect of the seven SSA's

So what does this mean for the numbers?

Essentially we have to use a figure – Load / Capacity Factor or Capacity Credit to adjust windfarm potential output to account for the intermittency of wind, maintenance periods and backup requirements from conventional energy.

A review of some research has highlighted a simple way of doing this – to use the Load / Capacity Factor where windfarm penetration is below 10% but to use Capacity Credit at higher levels of windfarm deployment. A complication is that the degree of windfarm concentration does reduce the values for Capacity Credit. If we use Load / Capacity Factor as a proxy for Capacity Credit it would be appropriate to make a small downwards adjustment on the Capacity Factor number because windfarms in Wales are becoming more concentrated.

Question 3

What is the correct number of households that can be served with energy if a windfarm is developed?

Developers often refer to the number of household equivalents or households that can be served with energy as a result of the output from a windfarm. This is how they do the maths.

Take the Brenig Windfarm which is currently awaiting Planning Permission in Denbighshire. At section 1.3.17 of the Environmental Impact Statement, the developer states that:

1.3.17 Using an annual net energy yield of 105 GWh/yr and a figure of annual domestic electricity demand of 4700 kWh per household7 (as advised by the British Wind Energy Association) the number of household equivalents that could be served by the proposed development is approximately 22,000.

This 22,000 figure is derived as follows

Windfarm Brenig	40	Installed capacity in MW
	40,000,000	Watts max output
Multiply by	0.3	Load / Capacity Factor
Gives	12,000,000	Watts actual output
Or	12,000	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	105,120,000	Kilowatt hrs (kWh)
Divided by	4,700	av no of kilowatt hours electricity use per annum
Gives	22,366	households provided with electrical energy

To get the number of household equivalents, all you have to do is find out how much electricity each household uses a year on average and divide this into the windfarm output. This does give over 22,000 households based on the information used by the developer and supplied by the BWEA. This means that each household continuously uses just over 0.53kW of power during the day or consumes around 12.7kWh of energy[14] per day.

The question is though, are these numbers correct and can they be used in this way?

The Load / Capacity Factor has been described at length and the Government say that this should be lower at 26% (0.26) or less if we are using this as a proxy for Capacity Credit and dispersal is not perfect. If we use the lower figure for Load / Capacity Factor we get a different number of households

For the Brenig windfarm example

Windfarm Brenig	40	Installed capacity in MW
	40,000,000	Watts max output
Multiply by	0.26	Load / Capacity Factor
Gives	10,400,000	Watts actual output
Or	10,400	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	91,104,000	Kilowatt hours (kWh)
Divided by	4,600	av no of kilowatt hours electricity use per annum
Gives	19,805	households provided with electrical energy

In the above calculation the Government figure of 26% has been substituted for the Load / Capacity Factor in Wales and a slightly lower consumption of electricity has been used based on data provided by DEFRA[15]. So from 22,366 households in the developers' submission we now have a more accurate 19,805 households or less if we want to adjust the Load / Capacity Factor / Capacity Credit further to allow for concentration of windfarm development. If this is adjusted by just 1% to 25% the result is

Windfarm	40	Installed capacity in MW
	40,000,000	Watts max output
Multiply by	0.25	Load / Capacity Factor
Gives	10,000,000	Watts actual output
Or	10,000	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	87,600,000	Kilowatt hours (kWh)
Divided by	4,600	av no of kilowatt hours electricity use per annum
Gives	19,043	households provided with electrical energy

A reduction of 3323 households or nearly 15%.. So as we said at the beginning….quite significant.

The developers' words in their Environmental Impact Statement are important. This is why they are quoted exactly. They say that

"the number of household equivalents that could be served by the proposed development is approximately 22,000"

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[14] Energy = Power x Time
[15] Energy Trends 2005 - http://www.berr.gov.uk/files/file10737.pdf (NB data refers to 2003 consumption)

What does this mean? Well, it means that if on average each household continually uses around 0.5kW of electricity then the windfarm would supply enough energy to meet their needs. Fairly straightforward you might think? Well not actually…

Remember in the answer to **Question 2** when we said "as windpower is intermittent, there are times when it produces less output and there are times when the output is greater (on windy days). This causes output to fluctuate. However we consumers want electricity all the time so the National Grid has a tricky problem of matching the power generated by all forms of power plant with the needs of customers. This is called **Balancing the Grid."**

We also said that

"as customers want more electricity at particular times of the day, the idea of **Peak Load** is used to describe how much energy is needed at these busy times. Peak Load is the point at which the greatest demand exists relative to supply. To ensure that we can all have our cup of tea while watching Coronation Street at 7.00 pm as dinner is in the oven and the washing machine is working, the Power System has to be able to meet Peak Load demand whenever it occurs and for however long it lasts"

So while it is true that on average the windfarm can (on the basis of the simple average used in the calculations above) supply enough energy to meet around 19,000 households electricity needs, there are some times when it can't meet demand and conventional power stations have to be used.

Modern homes have a main fuse which could permit a Peak Load of 23kW and domestic Peak Loads can reach 10kW. Research[16] has recently shown that for a small sample of domestic properties in the North West of England during 2004/5, average load was 0.83kW rather than 0.53kW and Peak Load ranged from just over 6kW to 9.32kW. To fully meet the electricity needs of households the windfarm would either need to call on backup supply at peak load periods or serve fewer households. At an average Peak Load of 6kW the windfarm could serve 12 times fewer households than claimed if no backup were available and wind strength was constant. If the wind dropped, then without backup generation supply would not equal demand.

<u>So what does this mean for the numbers?</u>

Those opposing windfarms argue that developers have overstated the number of households that can be supplied with electricity because Environmental Impact Statements are selective in how they use data. By not explaining that windfarms still require backup generation from conventional sources, opponents of windfarms believe that developers are misleading the public. Either the EIS should make it clear that the windfarm still needs backup generation to cope with Peak Loads or the number of households served should be adjusted downwards.

However as the issue of backup supply has been considered in the Capacity Credit / Capacity Factor part of the calculation, it is difficult to account for Peak

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[16] The nature of domestic electricity-loads and effects of time averaging on statistics and on-site generation calculations: Wright, A & Firth, S – Applied Energy 84 (2007) 389–403

Load issues again as this would effectively be double counting. So it would be more transparent to require developers to explain the Peak Load problem and backup needs as part of their EIS submission.

On this basis the calculation should not be adjusted but explained more fully by all concerned.

Question 4

What is the correct estimate for Renewable energy displacing fossil fuel power station CO2 emissions?

The first three questions have been necessary to get to a base calculation for CO2 displacement by renewable energy. This is the crux of the argument in favour of wind power. To answer this question we first have to agree what conventional generation is being replaced. This is not as simple as it seems.

Traditionally windfarm developers have used the statistics provided by the BWEA. An emissions factor of 860g CO2/kWh has been regularly used as this is the amount of CO2 displaced by a Coal fired power station. To calculate the CO2 saving of a windfarm, developers have multiplied the annual windfarm energy output in kWh by the above Carbon Emissions Factor and this produces a value for the amount of CO2 that would be "saved" if the windfarm were generating electricity instead of the Coal fired power station.

In the Brenig developers view the numbers are as follows:

Windfarm Brenig	40	Installed capacity in MW
	40,000,000	Watts max output
Multiply by	0.30	Load / Capacity Factor
Gives	12,000,000	Watts actual output
Or	12,000	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	105,120,000	Kilowatt hrs (kWh)

Taking the 105,120,000 kWh and multiplying this by 860g/kWh the amount of CO2 displaced we get 90,403,200,000 grams or 90,403 tonnes of CO2.. A seemingly huge amount of CO2 saved.

Unfortunately this is too high as we have explained before. The Load / Capacity Factor should be lower so the actual amount of CO2 displaced is

Windfarm Brenig	40	Installed capacity in MW
	40,000,000	Watts max output
Multiply by	0.26	Load / Capacity Factor
Gives	10,400,000	Watts actual output
Or	10,400	Kilowatts (kW)
Multiplied by	8,760	No of hours in a year
Gives	91,104,000	Kilowatt hrs (kWh)

Taking the 91,104,000 kWh and multiplying this by 860g/kWh the amount of CO2 displaced we get 78,349,440,000 grams or 78,349 tonnes of CO2..A lower amount.

But it gets worse. In reality the Power System we have been describing contains a mixture of Coal, Gas, Nuclear and Renewable energy producers. Not all the power stations are Coal fired and not all generate CO2 at the same rate. Gas power stations generate around 360g of CO2 per kWh and Nuclear Power stations have an even lower emissions factor.

Defra's *Guidelines for the Measurement and Reporting of Emissions by Direct Participants in the UK Emissions Trading Scheme*[17] gives a grid average emissions figure of 430g CO2 per kWh.

If the grid average is used then the amount of CO2 displaced is halved. In the Brenig example the CO2 displaced becomes 39,175 tonnes – some 44% of what the developer originally claimed in their Environmental Impact Assessment.

The statistics are confusing aren't they? In simple terms though it looks like windfarms "save" 1000 tonnes of CO2 per year per MW of Installed Capacity. Or two thousand tonnes per year per modern (large turbine)

CO2 Savings Expressed in a different way

But what does two thousand tonnes of CO2 equate to in layman's terms and what does 39,175 tonnes compare with if we consider one of the larger proposed windfarms where Planning Permission can be decided locally?

Windfarm developers and opponents often express the CO2 saving in terms of things we can understand more readily than a tonne of CO2. One common example often cited is the number of long distance aeroplane flights that are offset

So how do the maths work on this comparison?

If an aeroplane flies from London to Miami and back again, it travels approximately 14,280 km. To calculate how much CO2 the flight generates, a range of data is required including the type of plane, it's capacity, and the number of passengers that actually fly.

There are several ways in which the CO2 produced can be calculated. These range from simple estimates (commonly used in Carbon Offset calculations[18]), to more complex calculations based on fuel consumption, and ultimately to models involving analyses of elements of the flight from runway taxi phase through takeoff, cruising, descent and ultimately landing. Each method uses different calculations and assumptions.

In the London to Miami example, if the plane did the return journey each day for a year, total CO2 emissions could range from 578,554 tonnes[19] to 221,980 tonnes[20]. So why do the figures differ so greatly?

[17] DEFRA, Guidelines for the Measurement and Reporting of Emissions by Direct Participants in the UK Emissions Trading Scheme (June 2003), Protocol A1, p. 20.

[18] See www.sustainabletravel.com for example

[19] Calculated by Sustainable Travel International (see footnote 16 above)

[20] Calculated using Defra's Passenger Transport Emissions Factors as published in the revised Methodology Paper, June 2007 available at www.defra.gov.uk

Firstly, in the simple Carbon Offset calculations, different methods assume different values for CO_2 per passenger in kg. These are illustrated below

Source	**CO2 Per Passenger on the London to Miami Flight**
Sustainable Travel International	4824
The Carbon Change Trust[21]	4220
Choose Climate[22]	3851
Terrapass[23]	3459
Co2 Balance[24]	3270

If the number of passengers remains constant in the calculation then the higher the value for CO_2 produced per passenger, the greater the CO_2 emissions will be. This can be seen in the following table which shows the CO_2 emissions of a plane flying 14,280 km (London to Miami & return) 365 days a year.

CO2 Emissions

	Base Data	**STI**	**The C Change Trust**	**Monbiot**	**Terapass**	**CO2 Balance**
No of Passengers	370					
No of KM return	14,280					
No of Days Flying	365					
Multiplier						
Multiplier 2						
CO2 emission / passenger in kg		4,284	4,220	3,851	3,459	3,27
CO2 emission for flight						
CO2 emissions in KG		578,554,200	569,911,000	520,077,550	467,137,950	441,613,50
In Tonnes		578,554	569,911	520,078	467,138	441,61
Radiative Forcing Index	1 to 5	2.7	2.73	3	Unknown	

[21] http://www.thec-changetrust.com/fullCalculator.cfm?stage=air
[22] www.chooseclimate.org
[23] http://www.terrapass.com/flight/products.flight.7500.php?flight_carbon=3443&flight_miles=8829
[24] http://www.co2balance.uk.com/co2calculators/air-travel/

The example above takes a calculation cited by the environmentalist George Monbiot[25]. This calculates the warming effect equivalent of the greenhouse gas emissions per seat of a fully occupied jumbo jet on a return trip at 3851kg. It assumes a total of 370 seats. 3851 x 370 = 1,425,000 kg. 1425t x 365 = 520,125 t/year.

If the same base data is used for the calculation (No of passengers, distance and no of days flying) then there is quite a range of answers to the question of how much CO2 is produced. In fact for five of the examples above, the measure is not the amount of CO2 produced, but in fact it is the **Warming Effect Equivalent.**

This is not the same as the CO2 produced. The reason is that CO2 emitted at height is assessed as having a greater impact through something called **Radiative Forcing.** As CO2 and other greenhouse gasses are emitted when aircraft are in flight, they impact on specific parts of the upper atmosphere (the upper troposphere and lower stratosphere) and change its composition. These changes have the effect of magnifying the warming effect of CO2 emitted so an Index is sometimes used to multiply CO2 emissions to calculate the Warming Effect Equivalent. The Intergovernmental Panel on Climate Change estimate this index as being between 1 and 4[26] and a common average of 2.7 has been used for some time as a multiplier for CO2 emitted by aircraft. In the above table the first five measures have some value for the Radiative Forcing Index and as a consequence the CO2 emissions are high.

In contrast, Defra in their revised model exclude Radiative Forcing effects as they state that the science of Radiative Forcing is “currently uncertain”

So the same aircraft could be said to produce between 578,554 and 221,980 tonnes of CO2 depending on the method of calculating emissions and the treatment of Radiative Forcing.

If we use the Defra measure then it could be said that the Brenig windfarm would save the same CO2 in a year, that one Jumbo Jet flying between London and Miami produces if it is in use for sixty four days a year (or in just over two months)[27]

Extending this, on the basis of the 390 MW of Installed Capacity of onshore wind either operational or in development in North Wales as at November 2007[28] then the total renewable energy savings for onshore wind in North Wales is less than two Jumbo Jets continuously flying between London and Miami each year[29].

For Wales as a whole with an onshore wind target of 1120 MW[30] this equates to the CO2 Warming Effect Equivalent of **just over five Jumbo Jets** flying between London and Miami each year!.

Question 5

What about Transmission Loss?

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[25] http://www.monbiot.com/archives/2005/04/26/a-different-kind-of-revolution Note 7
[26] Aviation and the Global Atmosphere , IPCC May 1999
[27] 39,175 tonnes / 221,980 tonnes x 365 days = 64.41 days
[28] Source CHA
[29] 390 MW X 1000 tonnes of CO2 saved per MW = 390,000 tonnes / 221,980 tonnes = 1.75 aeroplanes per year or 1 aeroplane flying over 18 months
[30] Technical Advice Note 8 Table 1 page 5

As electricity is transmitted down power lines from the point of generation to end users, it loses energy through heat.

Defra[31] accounts for the issue of transmission loss by multiplying the emission factor for various primary fuels by a factor of 2.6. The emission factor of 830g CO_2/ kWh for a Coal Fired Power Station allows for this multiplier.

The 430g CO_2 /kWh for the grid average already takes account of inefficiencies so does not need to be multiplied by 2.6[32]. The calculations we have used throughout this note do not need further adjustment as a consequence.

Question 6

What about Carbon Fixing Loss as a result of deforestation?

Scottish Natural Heritage issued a Technical Guidance note in 2000 which details the implications of deforestation and loss of peat.

Loss of carbon fixing as a consequence of deforestation amounts to 3.6 tonnes of Carbon per Hectare per annum[33]

Any removal of peat bog will further prevent Carbon Fixing to the value of 0.25 tonnes of Carbon per year.

In the Brenig example the developers say at para 1.3.23 of their Environmental Impact Statement that 165.1 hectares of woodland will be cleared, resulting in the inability to fix 594 tonnes of Carbon per year, or 2,174 tonnes of CO_2 per year[34]

To account for this loss of Carbon Fixing potential, the CO_2 saving should therefore be reduced from 39,175 tonnes per annum to 37,001 tonnes per annum.

This is the equivalent of a Jumbo Jet flying between London and Miami for two months in a year.

Conclusions

This note has attempted to review some of the common statistics used by both developers and opponents of windfarms to explore the basis on which competing claims are made.

In general the claims made by developers tend to overstate CO_2 savings. In a specific example of the Brenig windfarm the developer has overstated CO_2 savings by 53,402 tonnes per annum or by a factor of 60%.

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[31] Defra Climate Change Agreements: Guidance on converting electricity from dedicated supplies to primary energy, December 2001

[32] Scottish Natural Heritage Technical Guidance Note: Windfarms and Carbon Savings 2000 p4 para 11

[33] See Footnote 30 Para 25 page 7 for Sitka Spruce

[34] Natural Power Planning Application for Development of Windfarm at Brenig, Denbighshire. Environmental Statement Vol 1

The more accurate measure of CO_2 emissions outlined in this note fully accounts for the relevant Load / Capacity Factor of wind in Wales, Backup Generation, Transmission Loss and Deforestation.