The Case against Wind 'Farms'

Country Guardian's document "The Case Against Windfarms" was last updated in May 2000 but a great deal has happened in the intervening five years. This update printed can be downloaded from http://www.countryguardian.net/ (about 370 kB). It is freely offered for reproduction or other use providing it is acknowledged. The views expressed are those of the author, who is a professional environmental scientist, formerly Reader in Ecology in the University of Wales.

"*Dr Etherington writes with no affiliation to any campaigning organisation and is not a member of one. Neither does he receive payment from any part of the energy industry. He provides consultancy advice in the battle against unnecessary wind power on a* pro bono *basis" (Ninnau,* The North American Welsh Newspaper, July 1, 2004).

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1. Introduction: Why wind ‘farms’ and why now?

Those who advocate wind ‘farms’ base their arguments on three propositions:

i. They produce electricity without harmful emissions - carbon dioxide ($C0_2$), sulphur dioxide (SO_2) and nitrogen oxides (NO_x) - gases associated with either global warming, acid rain or nutrient-enrichment (eutrophication);
ii) They do not deplete finite supplies of fossil fuels;
iii) They produce electricity without the problems associated with nuclear power - such as waste storage, risk of accident, and possibility of military use.

For these arguments to be valid it is clear that wind ‘farms’, if developed in sufficient numbers, must significantly reduce CO_2 and other emissions, measurably slow the depletion of other fuels which will eventually be exhausted and produce a reliable and sufficient amount of electricity to replace nuclear power stations,

The burning of fossil fuels is a major source of CO_2 emissions. Since the Industrial Revolution atmospheric CO_2 has increased by about a third (from less then 280 parts per million by volume to 373 ppmv in 2002). The rate of emission has risen dramatically over the last twenty five years and increasing CO_2 concentration has been linked by many scientists to global warming.

'Global warming' is simplistically explained by the differing transparency of carbon dioxide to incoming solar radiation and outgoing long wave infra red radiation (radiant heat). Extra CO_2 in the atmosphere acts like a blanket preventing the escape of the heat energy which arrived on earth as solar radiation. There is scientific argument about the degree to which CO_2 will cause 'global warming' and what, if anything, to do about it. Indeed the House of Lords (2005) report on economics of climate change suggests that the so-called 'consensus' on the science is a politically created myth. A discussion of the arguments is presented in Appendix 1.

However, few would argue against reducing CO_2 emission. Release of CO_2 by human activity is, after all, an open ended experiment with our one and only atmosphere! Furthermore it is apparent that 'one day' we shall run out of fossil fuel though there is serious dissent about the time period involved.

Nuclear fission power was hailed 50 years ago as the solution to all our energy problems. Since then, for many years it has provided a quarter of British electricity - and even now a fifth. During its developmental period it was expensive but now it is running competitively with other generating technologies and without subsidy (since 1995-6). Across the Channel, France obtains almost 80% of her electricity from fission.

Why then do we need an alternative? Essentially because fears have grown that radioactive materials pose an unacceptable accident risk, because the problem of storage and reprocessing of fission by-products has not been fully resolved and because military use may be made of such materials (see Section 16. How can the need for electricity be met?).

Why have wind turbines arrived so suddenly? This is more a matter of perception than fact. The first windmills date from at least the 10th century in Persia and it is hardly surprising that once electro-magnetic induction was understood, someone would think of driving a generator with a windmill. By the mid-1930s a 1.5 MW machine had been built in the US, driven by a modern aerofoil rotor - quite similar in size and function to a 21st century machine, though without its sophisticated controls.

All that was needed was the perception of need and the ability to link to the AC grid, with its problem of frequency control. This happened in the 1980s driven by the wide acceptance of belief in CO_2 -driven climatic warming. The 'switch' was thrown when various subsidies on ‘green’ electricity became available world-wide. Nothing attracts entrepreneurs more than a free handout!

The first grid-connected wind turbine (more correctly aerogenerator) in the UK was installed at the former CEGB test facility on Carmarthen Bay, southern Wales, c. 25 years ago. We have gone a long way since then.

What 'they' say

"Clean, renewable forms of energy, such as wind power, are essential if we are to tackle climate change. They are also vital in ending the threat of nuclear power, which would leave a legacy of nuclear waste that will remain a threat to our health and the environment for hundreds of thousands of years." Yes2Wind website

Untrue. The variable nature of wind power prevents it from displacing nuclear generation which provides continuous peak output and is best suited to ‘base-load’ supply. Wind power is irrelevant to any discussion of nuclear as it cannot provide such uninterrupted generation.

2. Government policy, costs and 'subsidy'

"The aim of government policy for renewable energy is that it should make an increasing contribution to UK energy supplies in the years to 2010 and, more importantly, beyond. To this end, the Government took powers through the Utilities Act 2000 to impose an obligation on licensed suppliers in Great Britain to source specified amounts of electricity from renewable sources." (DTI 1999 N&R Energy).

The 'Energy White Paper (2003) announced that: -

"*We have introduced a Renewables Obligation for England and Wales in April 2002. This will incentivise [sic] generators to supply progressively higher levels of renewable energy over time. The cost is met through higher prices to consumers. By 2010, it is estimated that this support and Climate Change Levy exemption will be worth around £1 billion a year to the UK renewables industry."*

Note – before reading this section it may help to familiarise yourself with the units and terminology of electricity (see **References and notes**: ‘Units and terminology’ and ‘Prices’).

Government’s action has ensured that renewable power generation is now ‘subsidised’ by the mechanisms of the Renewables Obligation (RO), the Climate Change Levy exemption (CCLe) and the marketing of RO Certificates (ROCs).

The Renewables Obligation as its name suggests places an obligation on electricity suppliers to purchase a percentage of qualifying renewably generated electricity but it also forces a consumer-sourced 'subsidy' to be paid to the renewable generator. During the year 2004-5 the obligation stood at 4.9% of qualifying electricity, rising to 10% by 2010.

The mechanism of payment results in an increase in electricity price to all consumers, whether or not they subscribe to a 'green tariff'. Few consumers are aware of this fact and neither government nor wind power developers apprise them of it. The complexity of this system is deliberately obscure in an attempt to conceal the fact that the RO is effectively a hidden tax on all electricity consumers and a huge hidden 'subsidy' to providers of renewable energy - larger indeed than any subsidy in history.

This obscurity and lack of democracy has been acknowledged by the House of Commons Committee of Public Accounts report on the DTI (CPA 2005) which says: -

"Requiring users to source supplies from uneconomic providers has the same affect as taxing users to subsidise the providers, but is not as transparent or amenable to parliamentary control... [and the DTI] has not consulted consumers, or their representative groups, about their willingness to contribute to the cost of renewable energy"

The net effect of the RO and CCLe mechanism is to pay three premiums on top of the wholesale price of wind generated electricity (and other renewable generation). In summary: -

1. The Renewables Obligation Certificate ‘buyout’ price which is currently £32.33.

The ROC was set at £30/MWh in 2002 and increases each year, Retail Price Indexed. The current period 05/06 known as Compliance Period 4, has a price of £32.33).

2. A trading increment from marketing Renewables Obligation Certificates currently worth about £10/MWh.

This tradable value grew steadily after 2002 when the RO system replaced the former Non-fossil Fuel Obligation. The price of ROCs reached about £47/MWh in 2004 but very recently the increment has dropped back to c. £10/MWh with total ROC value c. £40-£45/MWh.

3. The Climate Change Levy exemption, worth £4.30/MWh.

In addition to the consumer-sourced RO, another small advantage is given to the renewable generator. Non-renewable generating fuels pay a tax of £4.30/MWh, but renewables are exempt and so the electricity is effectively given an extra £4.30/MWh.

The ROC buy-out price, its market increment and the CCLe thus total a premium of £32.33 + c. £10 + £4.30 = c. £ 46 - £47 per MWh, which is added to the wholesale value of the electricity generated from renewable sources - in our context wind power.

Electricity has increased enormously in price since the RO was introduced and is now around £40 - £45/MWh for wholesale base-load generation (DTI 2005) but the trading system of NETA involves short term bidding by National Grid Transco and the price fluctuates wildly, controlled by supply and demand. Thus we have an approximate total, at the moment, of about £90+/MWh paid for wind power compared with c. £40-£45/MWh for conventional generation.

The net outcome of the 'subsidy' system is that wind electricity receives about twice the price of wholesale base-load thermal generation per MWh. An 'effective subsidy' which doubles unit-value is gigantic, historically unprecedented and I believe unsustainable. Coal currently receives less than one twenty-fifth of this subsidy per MWh whilst gas and nuclear get none (personal communication DTI).

The RO and CCLe provide the huge financial incentive which has brought multinational power companies flocking to our shores and has been responsible for the distortion of our planning system which the Committee of Public Accounts virtually branded as undemocratic (CPA 2005).

A single 2 MW wind turbine operating at 30% load factor would, on the basis of the above figures, receive an annual subsidy of over £235,000

It is a salutary thought that it is only this cleverly sourced covert 'subsidy' which allows wind turbines to be built at all. Paul Golby, the chief executive of Eon UK (formerly Powergen), said: "Without the renewable obligation certificates nobody would be building wind farms." (*Daily Telegraph* 26/03/2005).

Capital subsidies

In addition to the huge 'for-life' subsidy on electricity income, substantial capital subsidy is available for some wind power projects.

A recent question in the Commons revealed that the public pocket supported a total capital subsidy to offshore wind farms of £34.7 million pounds in 2004-2005 (*Hansard* 23 Jan 2006 : Column 1770W http://www.publications.parliament.uk/pa/cm200506/cmhansrd/cm060123/text/60123w19.htm). It is sometimes difficult to establish the scale of subsidy, for example the two offshore turbines at Blyth cost £4 million and received unspecified financial support from the European Commission Thermie Programme.

The Moel Maelogan onshore windfarm in the Conwy Valley, North Wales, was awarded a £0.36m Objective 1 ERDF grant against a total project cost of £2.5m in 2002. The normal maximum European Regional Development Fund (ERDF) grant rate is 35%. However, in some circumstances... the grant rate can be potentially up to 50% (pers. comm. 2005 Welsh European Funding Office, which also pointed out that Objective 1 money is now exhausted).

Capital subsidy has also been made available for small scale renewable projects through the Clear Skies scheme, funded by the DTI. This gave householders and communities a chance to install renewable energy systems by providing grants and advice. Domestic grants were from £400 to £5000 whilst 'not-for-profit' community organisations could receive up to £100,000 (£50,000 from April 2005). Funding for this project is now exhausted and it will be replaced by DTI's 'Low Carbon Buildings Programme' scheme in c. April 2006 (http://www.clear-skies.org/).

As if this was not enough public money being funnelled into the pockets of wind developers, the Lottery fund has also been raided to provide yet more. The Burbo

Bank 90 MW offshore station due to be completed in 2010 has been awarded a 'Big Lottery' grant of £10.4 million – not yet paid-out as of March 2005 – with a completion date of 2010 (http://www.biglotteryfund.org.uk/).

Impact of subsidy

So much money is being channelled covertly into onshore windpower development that development companies can offer irresistible sums in rental to landowners or as 'sweeteners' to local communities. Struggling farmers on poor hill land are offered rental sums far exceeding any possible agricultural income from the land. *"If it wasn't for the windmills I'd have thrown in the towel a long time ago"* (farmer, Guto Jones, landowner at Blaen Bowi, Carmarthenshire – reported in the *Tivyside Advertiser* (2002).

A current proposal (2006) by Dutch firm, Nuon, typifies the use of larger scale community 'sweetening' even before a planning submission is made. The publicity material for the 26 MW Nant Bach (Mwdal Eithin) wind 'farm' in Conwy, N. Wales, states that the project "*will make available £60,000 a year as a community funding*" A most tempting offer even though the sum is but 2% of the likely subsidy payment to Nuon! It is interesting to note that the Welsh renewable energy planning document TAN 8 comments on such community benefits *that "It must be clear that the provision of benefits is on a purely voluntary basis with no connection to the planning application process"* (Annex B. 2.4),

3. The scale of development required by government 'targets' and overall saving of carbon dioxide emission

Targets

In January 2000 government announced its aim for renewables to supply 10% of UK electricity in 2010, "subject to the costs being acceptable to the consumer" (Energy White Paper 2003).

The target figure is 39 TWh/y which is 10% of predicted generation based on current forecasts of total energy production of 371–390 TWh/y for 2010 (http://www.dti.gov.uk/renewables/renew_2.1.1.htm).

About 75% will have to be wind power so this will need 29.3 TWh/y or an average running wind power generation of 3,339 MW.

Assuming a load factor or 25% this would require at least 13,356 MW installed capacity of wind power (a 30% load factor would require 11,130 MW) See section 7. Technical aspects... for the explanation of load factor.

An installed capacity of wind power of 13,356 MW would equate to 8,904 turbines of 1.5 MW, each c.100 m (327 ft) in height or 6678 turbines of 2.0 MW each, c. 120 m (394 ft).

It is also fairly certain, on the basis of existing planning applications, that a large number of much smaller turbines will also be proposed (for example Green Amps' current attack on the Cotswolds with 60 or more 0.3 MW refurbished Carter turbines).

What 'they' say

"There are now some 1,120 turbines in 90 locations. Generating 10 per cent of UK electricity from renewables by 2010 could mean an increase by around another one and half times the current number." DTI Myths

“Pigs might fly!”

Saving of CO_2 emission - country wide target

Government's own figure for saving of the UK's CO_2 emission by renewable power generation , mainly wind, is just 9.2 million tonnes per year by 2010 (DEFRA 2004 and DTI Myths).

This is less than the emission from a medium sized coal fired power station and more to the point is less than four ten-thousandths (0.0004) of global total CO_2 emission (OECD 2005) and stands no chance of altering atmospheric CO_2 concentration, still less deflecting climate change as suggested in DTI Myths.

4. The problem of intermittency and need for backup

What 'they' say

“What happens when the wind stops blowing?

When the wind stops blowing, electricity continues to be provided by other forms of generation, such as gas etc. Our electricity system is mostly made up of large power stations, and the system has to be able to cope if one of these large plants goes out of action. It is possible to have up to 10% of the country's needs met by intermittent energy sources such as wind energy, without having to make any significant changes to the way the system operates.” (BWEA FAQs)

A likely story.

In 2003 the BBC 2 programme *If..... The Lights Go Out'* (10 March) included a contribution from Dr Dieter Helm, Energy Economist and Fellow in Economics, New College, Oxford. Dr Helm has been on the DTI Energy Advisory Panel since 1993.

He commented on wind power: -

“What we know, is the wind blows sufficient for these windmills to be producing about 35%, perhaps 40% of the time. So the paradox of building windmills is that you have to build a lot of ordinary power stations to back them up and those are going to be almost certainly gas in the short to medium term and that’s what’s required. If you ask the question who’s making sure that there’s enough gas stations out there to back up the windmills the answer is nobody.”

This was one of the first official acknowledgments of a point which Country Guardian and many campaigners had made for years. Because of the unpredictable intermittency of wind, and the very long time required to bring 'cold' generating capacity into production, it is necessary to keep a substantial reserve of spinning backup. This is usually arranged by keeping turbo-alternators at less than peak output so that an instant increase of generation is possible. This causes a significant amount of extra CO_2 emission from such plant.

E.ON Netz (2004) admitted that every megawatt of installed wind power required 0.8 MW of backup from ‘*shadow power stations*’, thus, even when not generating, wind turbines are still causing some CO_2 emission. The following year E.ON Netz (2005) went further: -

"... Dependence on the prevailing wind conditions means that wind power has a limited load factor even when technically available. It is not possible to guarantee its use for the continual cover of electricity consumption. Consequently, traditional power stations with capacities equal to 90% of the installed wind power capacity must be permanently online in order to guarantee power supply at all times."

In the words of ESB, the Irish National Grid (2004): -

"As wind contribution increases, the effectiveness of adding additional wind to reduce emissions diminishes [and] the cost will be very substantial because of the back up need".

Using wind power to reduce CO_2 emission seems akin to emptying the Atlantic with a teaspoon! The wind power industry and the DTI seem very disconcerted by the widespread revelation of just how serious this problem will be.

A very recent report, commissioned by the DTI, edited by Graham Sinden (Oxford Environmental Change Institute, 2005) purported to demolish this argument by claiming that the wind always blows somewhere in the UK and led Energy Minister, Malcolm Wicks to say "*This new research is a nail in the coffin of some of the exaggerated myths peddled by opponents of wind power."* (*Independent* November 14 2005).

One could retort "So what? - 200 turbines generating feebly on Stornoway and the rest of the country's wind fleet becalmed". However it is worse. Sinden simply compared the incidence of 'no generation' versus 'some generation' but this is not the point. Had Sinden's group compared incidence of generation above a sensible threshold (say 20%) with incidence of maximum generation it would have been apparent that in anticyclonic weather there are many occasions per year when the whole UK wind fleet would be contributing very little.

This was indeed realised by the House of Lords Science and Technology Committee in Feb 2004 when Baroness Platt of Writtle questioned Mr Sinden on his research. He replied: -

"There will be times when you have quite low speeds and consequently you have low electricity output from it. The analysis that I ran was of wind speeds being so low that electricity would not be generated, that was the criteria for it. As I said, the single worse case in the last 21 years was 11 hours over summer when that did happen. If you raise the bar higher and say "We want 20 per cent output or 30 per cent output" then it may look a little bit different but we have not carried out that analysis." (House of Lords Science and Technology - Minutes of Evidence Session 2003-04)

This weakness in the argument is such an Achilles heel that it has led the DTI and wind industry to clutch at the straws of electricity storage and/or hydrogen generation by electrolysis. These are expensive technologies to prop up a wind power industry whose electricity is already over twice the price of 'conventional' generation!

A recent report from UKERC (2006) seems to be directed at downplaying the problem of intermittency but it fails to convince. One of its conclusions is that: -

"Wind generation does mean that the output of fossil fuel-plant needs to be adjusted more frequently, to cope with fluctuations in output. Some power stations will be operated below their maximum output to facilitate this, and extra system balancing reserves will be needed. Efficiency may be reduced as a result."

UKERC suggests that this will happen only with substantial wind penetration but the document also reports "that a study of the *"... transmission network-constrained Swedish system concludes that energy spill levels would reach 16.7% at an 11% penetration level"* "

Energy spill" is a euphemism for shutting down turbines as a consequence of over-generation.

The UK is, like Sweden, constrained by a transmission problem. We have only one interconnector to Europe, the 2.0 GW cross-Channel link so our system is effectively islanded. We cannot export or import significant over- or under-production of electricity and are thus faced with the problem reported to the Royal Society of Edinburgh (2005): -

"As a retired grid control engineer my instincts react against all thought of unpredictable renewable power on the scale proposed, sloshing around the system... Wind resource does not provide any governor response to assist the automatic correction of system frequency deviations. Its exploitation on any scale would deter the introduction of new replacement capacity by soaking up available demand, the basis of payment within a market driven structure. At minimum levels of system demand with fixed base load operation of nuclear plant, in turbulent conditions, the control of system frequency would become a nightmare."

Thus wind-power must call upon conventional reserve generation to smooth its short term vagaries and it is dishonest of the wind power industry and DTI (2005) to claim *"The reserves needed to guard against loss of a large power station will readily cope with the small perturbations due to the wind"*. This may be true at the moment, with wind power providing less than one percent of average generation from an installed capacity of just 1500 MW but if the contribution of wind power should rise to (say) 10% of average generation i.e. 4,500 MW we would need a wind installed capacity of up to 18,000 MW to provide it (load factor 25%).

Thus within a period of just a few hours, wind output could swing by a substantial fraction of 18,000 MW, balanced against the Grid's peak load 'insurance' of c. 20% (which represents about 11,000 MW – see notes on 'Reserve capacity'). It can't be done. We shall in due course need a bigger insurance policy and as Dr Helm said, for the DTI (above) *"the paradox of building windmills is that you have to build a lot of ordinary power stations to back them up..."*

It is my view that the BWEA and the DTI are misleading us over this matter. There is certainly no consensus that intermittent wind power can be fed into our electricity network in large quantities without action being taken soon to ensure stability. Such action will add cost to an already very expensive technology which needs a 100% 'subsidy' to survive and will substantially erode any saving of CO_2 emission.

5. Calculating CO_2 emissions and saving

Saving of CO_2 emission by individual onshore wind turbines

One megawatt of wind power installed capacity generates 0.3 MW assuming a generous load factor of 30%.

The annual electricity yield of this would be 0.3 x 365 x 24 = 2,628 MWh/y

According to BWEA, if this electricity displaces 'dirty coal' generation it will save 0.86 tonne CO_2 /MWh (http://www.bwea.com/edu/calcs.html) so the 1.0 MW of installed capacity would save: -

2628 x 0.86 = **2,260 tonne CO_2 / year.**

Both DTI and the Sustainable Development Commission utilise a much lower factor for CO_2 emission per MWh – also upheld by a recent Advertising Standards Authority (ASA) adjudication.

The more truthful value for saving of CO_2 emission is based on the current generating mixture of fuel used to produce electricity (gas firing is much less CO_2-dirty than coal and nuclear power emits no CO_2) (Etherington 2003).

DTI

In a letter to an MP representing Humberhead Against Turbines (2005), Mike O'Brien (Energy Minister at time) agreed that: *"it would be appropriate to use an average generating mix when calculating CO_2 savings from a wind turbine. This is consistent with DTI Wind Energy fact sheet 14."* Mike O'Brien's letter and notes were presented in evidence at the Whinash Inquiry (2005) and are thus in the public domain.

The current "average generating mix" gives about 0.43 tonne CO_2 /MWh, just half of the saving claimed by BWEA (DEFRA Fuel Conversion Factors http://www.defra.gov.uk/environment/business/envrp/gas/05.htm).

ASA

An adjudication of 21 December 2005 against Renewable Energy Systems (RES) *concluded "although an emissions factor of 860g CO_2/kWh might have been a reasonable figure for RES to use to calculate the reduction of CO_2 emissions at the present time, it was not a reasonable figure to use for calculating the reduction over a period of as long as 25 years without some qualification to indicate the uncertainties about future fuel generating mix."*

Sustainable Development Commission (SDC)

The SDC's report *Windpower in the UK* (see November 2005 corrected edition) also suggest that future projections of saving must be based on a lower figure than BWEA's 0.86 tonne CO_2 /MWh

"There are large differences between the CO2 emissions associated with coal (243 t C/GWh) compared to natural gas (97 t C/GWh), with none associated to nuclear power." [these two factors convert to 0.89 t CO_2 /MWh and 0.36 t CO_2 /MWh]

SDC continues: - for the purpose of this report, it has been assumed that wind output will displace the average emissions resulting from gas-fired plant… it is the figure that the DTI use and is used here so that the carbon benefits of wind power are not overestimated."

"The figure that the DTI uses" is currently 0.43 t CO_2 /MWh (see above)

Thus, calculated on current generating-mix, 1.0 MW of installed windpower capacity displaces no more than: -

2,628 x 0.43 = **1,130 tonne CO_2 /MWh**

Because of the rather 'reserved' wording of the ASA adjudication it is wise only to use the 0.43 tonne CO_2 /MWh to estimate saving over the whole life of the 'farm' (20 to 25 years).

Payback time for energy and CO_2

Generally speaking the wind power industry has correctly observed that a wind turbine pays back the energy consumption of its construction and the accompanying CO_2 emission within a few months (DWTMO 1997).

The cash cost of a wind turbine is a very different matter and arguably without enormous subsidy a wind turbine cannot pay back its financial cost in a reasonable time-frame. This is because a large proportion of the cost derives from value additive operations such as the complex engineering of the drive train and generator and the specialist fabrication of blades which are expensive but do not consume much energy – which is largely absorbed in the smelting of iron and its conversion to steel and to a lesser extent, manufacture of other metals..

In the case of wind 'farms' on deep peat, especially if site operations such as road construction cause drying of previously waterlogged peat, there may be substantial CO_2 emission from its oxidation. This has been specifically observed by the Environmental Management Committee at Cefn Croes which wrote: - "... oxidation of exposed peat was leading to a huge loss of carbon to the atmosphere, and mitigating the impacts of the Wind Farm from a Global Warming perspective." Despite this, even if serious peat oxidation occurs, the displacement of fossil fuel electricity by wind turbines will outweigh the construction energy and carbon emission within a year or two.

Extra CO_2 from backup

It is remarkably difficult to calculate the amount of CO_2 which is liberated from power stations which backing-up renewable electricity generation. This amount must be subtracted from the theoretical saving of CO_2 emission.

Wind power is supported by thermal generation which is operating below peak generation and can be ramped up to cover losses of generation when the wind. This causes fuel inefficiency and emission of extra CO_2 per unit of electricity generated by the backup.

At the present the backup is taken from the existing reserve capacity used as insurance against plant and transmission failure. The wind power industry, unfairly, has argued that because the backup is pre-existing, there are no CO_2 costs.

Be that as it may, it is not a situation which will persist. Once the demands of wind power for cover for its full installed capacity are sufficient to call upon a large proportion of existing reserve it will be necessary to build dedicated backup and it is this requirement that prompted the Irish National Grid, ESB (2004) to conclude, as previously quoted, that: -

"As wind contribution increases, the effectiveness of adding additional wind to reduce emissions diminishes...The cost will be very substantial because of the back up need."

At least some power engineers have attempted to calculate CO_2 costs in these circumstances (Bass & Wilmott 2004). They claim, for a worst-case scenario, that their analysis "*suggests that the current 'Dash for Wind' could actually make the situation worse*."

6. Homes supplied by a wind 'farm'

***What 'they' say**: -*

"4700 is the average UK household electricity consumption in kW hours." (British Wind Energy Association 2005)

Most wind 'farm' planning applications or advertising fliers cite the number of homes supplied and the electricity industry has always done this - it is not a new tack on the part of wind developers. However the method of calculation is not well understood and for an unpredictably intermittent source such as wind, causes much controversy

For it to be correct, given these terms of reference, it must be based on the actual electricity supply from the wind 'farm' – i.e. (installed capacity x load factor)

The "domestic" consumption is based on a DTI estimate in the *Annual Abstract of Statistics* which subdivides UK total consumption into three parts: -

For 2003 (A.A.S. 141 Table 22.8): -

Industrial 115 TWh

Domestic 116 TWh

Other 108 TWh

The number of UK homes in 2003 was 24.5 million (HMSO, 2005 *Social Trends*).

Thus the annual average domestic consumption is (116 TWh)/(24.5 million) which is 4,735 kWh per home and dividing by (24 x 365 h) is equivalent to 0.54 kW continuous consumption per home.

This is the source of the BWEA figure 4,700 kWh per home http://%20www.bwea.com/edu/calcs.html and it rounds-down to a memorable 0.5 kW continuous consumption per home allowing easy mental arithmetic.

How does this work for wind and other intermittent sources? If a home subscribes to a 'green' tariff with a wind power company, the company guarantees to supply the electricity grid with the same amount of wind electricity as the customer's annual consumption. On average this will be 4770 kWh supplied to the customer from the grid.

There is no implication that it is the 'same' electricity in the sense that it would be if the wind turbine were cabled to the home.

If a wind developer or campaigning group claims that a wind 'farm' supplies the entire need of an area, this may or may not be correct in terms of total amount of electricity. It is only correct if the whole consumption of a town or county has been accounted for - in other words almost three times the 'domestic consumption'.

The claim may also be made that the supply is “up to” X,000 homes – a maximum value. In this case the calculation will have been based on installed capacity and will be three to four times the average number of homes supplied.

Some campaigners get very excited about this 'homes' matter and point out (quite truthfully) that wind power cannot 'support' ANY homes as it has to feed indirectly via the network to iron out intermittence. Hayden (2004) consequently describes claims such as “*this windmill farm will provide enough power for 25,000 homes*” as “*misleading garbage*.”

However there is an advantage to fighting them on their own ground: -

A 1.0 MW wind turbine at 30% load factor will support 600 homes

A 1,000 MW 'proper' power station at 80% load factor will support 1,600,000 homes

No real contest is there? - given that it would require 2667 1.0 MW wind turbines to make as much electricity and that they would occupy over 500 km^2, not to mention the constant fluctuation of supply, with all its disadvantages.

7. Technical aspects of wind turbines

A typical wind turbine

Industry standard is now a 2.0 MW installed capacity machine, or often larger.

An example is the Danish manufactured Vestas V 80

Rotor Diameter: 80 m
Swept area: 5,027 m2
Speed revolution: 16.7 rpm
Operational interval: 9 - 19 rpm
Tower Hub height (optional approx.): 60 - 100 m
Total height (blade vertical) 100 - 140 m (depending on tower) i.e. 305 to 427 feet
Generator: Asynchronous
Nominal output: 2.0 MW at 50 Hz 690 V
Weight
100 m Tower: 220 t
Nacelle: 61 t
Rotor: 34 t
Total: 315 t

Installed capacity and load factor (capacity factor)

The nominal maximum output is referred to as the "installed capacity". If the machine generated at maximum rate, continuously for a year, it would yield, per installed MW: - 1.0 MW x (365 x 24) hours = 8760 MWh. The actual yield is much less, mainly because there is insufficient wind to maintain full generation.

Onshore in the UK it is conventional to expect the achieved generation to be about quarter to one third of the maximum. The multiplication factor is called the "load factor" (synonym "capacity factor") - usually expressed as a percentage.

In 2003, Lord Sainsbury told the House of Lords that load factor was about 30% onshore and 35% offshore (*Hansard* 18 November 2003: Column 1851)

During the past two years of DTI records the average UK figures have been much less than this onshore: 24.1% in 2003 and 26.6% in 2004 (DUKES 2005).

Calculation of load factor –

Example for a 1.0 MW turbine: -

(Achieved generation/(Maximum possible generation)/ x 100 = Load factor

Maximum possible is 1.0 MW x 8760 h/y = 8760 MWh

Achieved generation is (say) 2190 MWh

Load factor thus = 2190 MWh / 8760 MWh = 0.25 i.e. 25%

The calculation should be based on yield over a stated time (the Ofgem period is January to December.

Windspeed

A wind turbine cannot generate until there is sufficient wind, usually about 4 m/s, called the 'cut-in' speed. The machine does not reach peak generation until about 15 m/s. It then maintains a constant output with increasing speed (see *Physics of windpower,* below) up to a safety 'cut-out' speed of 25 m/s.

A rotor can be allowed to idle (generator declutched) at wind speeds well below cut-in speed to take instant advantage of periods of stronger wind (a 30 tonne rotor otherwise takes time to come to speed).

Above cut-out wind speed the turbine is shut down for safety, with blades 'furled' (feathered), i.e. edge-on to the wind and with generator de-clutched and the wind-shaft locking brake on.

Some examples are given below, from manufacturers' specifications.

Vestas V 66 1.75 MW turbine. Rotor d. 66 m cut-in 4 peak 16 cut-out 25 (metres/second)

Vestas V 80 2.0 MW turbine. Rotor d. 80 m cut-in 4 peak 15 cut-out 25 (m/s)

General Electric 3.6 turbine. 3.6 MW Rotor d.104 m cut-in 3.5 peak 14 cut-out 25 (m/s)

Conversion of speed units: 4 m/s = 8 knots = 14 km/h = 9 mph = B3 : 15 m/s = 29 kt = 54 km/h = 34-mph = B7 : 25 m/s = 49 kt = 90 = km/h = 56 mph = B10. Beaufort wind scale (B): 3 = Gentle Breeze; 7 = Moderate or Near Gale; 10 = Whole Gale or Storm

Prediction of the performance of a wind turbine may be obtained by previous anemometric recording of wind speed on the site but an approximate prediction of generating output may be made from maps of the distribution of wind speed in the UK. For example: - http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/wind/content/ukwindspeedmap.html

This map shows that average wind speeds in lowland Britain are 5-6 m/s, coastal and upland areas 6-7 m/s and exposed uplands 7-8 m/s. Only a few extreme sites in the uplands, west and north lie between 8-10 m/s average speeds. Note that the average wind speed, even in the windiest sites is below peak generating speed, suggesting that a wind turbine anywhere in the UK, exposed to a variable wind regime will spend much of its time well below maximum generation thus explaining the low load factor of about 26% (average for 2003 and 2004)

It is also this distribution of windspeed which makes high ground and coast the preferred target for wind developers.

Physics of wind power

i) Theoretical output is proportional to the square of the blade-length (radius).

A wind turbine converts the kinetic energy of moving air into mechanical work. The theoretical electrical output is thus related to the mass of air passing through the rotor. Doubling the area of the rotor doubles the amount of power available and, because the area of the swept circle is pi x radius squared, the output is proportional to the blade-length squared.

ii) Theoretical output is proportional to wind speed cubed so even a small increase in average wind speed should give substantially more electricity over the course of time.

Real wind turbines follow the first rule closely hence any increase in height allowing increase in rotor radius gives substantially more power. The practical consequence is that machines originally designed for offshore installation (both V80 and GE 3.6) have quickly migrated onshore.

The second rule is not followed closely by real wind turbines. At first as wind rises above cut-in speed the power output increases dramatically with speed (because of the cubic relationship a doubling gives 2 x 2 x 2 increase in power). However the output then becomes more or less proportional to wind speed up to peak generation (i.e. x 2 increment doubles power) and then between peak and cut-out wind speed the output remains almost constant (because the generator is running at maximum output).

This lack of conformity to the cubic relationship is a result of aerodynamic (stall) regulation, or pitch regulation of power conversion by the blades, of 'electrical-braking' and of the alternator reaching its peak capacity. In the first case the shape of the blades allows wind-flow to become turbulent over an increasing part of the blade as the speed rises, reducing theoretical power conversion. In the second case the whole blade pitch is varied, or control surfaces (ailerons) are moved to 'spill' wind with the same effect. The load imposed by the generator also controls rotor speed (just as an idling car engine slows if the headlights are switched on) - this loading, like pitch regulation, is under operator or computer control. Such modification of the aerodynamic and electrical-braking characteristics allows a modern wind turbine to harvest maximum power from fairly low wind speeds but also safely to continue operation in high winds up to gusts of almost 60 mph.

Rotor speed (and see section *9. The effect on birds*)

Wind turbines are so gigantic that the rotor appears to be travelling quite slowly but this is illusory. A big turbine like a Vestas V 80 2.0 MW machine rotates at 16 rpm and so, with a blade radius of 40 m, the blade tip velocity is 241 km/h (149 mph), over twice the motorway speed limit. The GE 3.6 turbine at its maximum 15.3 rpm has a blade tip velocity of 300 km/h (186mph), approaching the average speed of a Formula 1 racing car and its blade-swept area is substantially larger than that of the V80, at 8,495 m^2 [larger than a football pitch which is 7392 m^2]

A bird which just avoids a GE 3.6 blade tip has only 1.3 seconds to dodge the next blade, approaching from about 93 yards away on a strongly curved path! Further discussion of this in section 9. The effect on birds.

Spacing of turbine: area of land needed

To avoid “taking the wind out of each others sails”, wind turbines require spacing at 8 to 10 rotor diameters (downwind) and across-wind at c. 5 diameters (Manwell et al; 2002). Some authors suggest even greater spacing.

An example is Horns Rev off the Danish coast where 80 turbines (2.0 MW) are in a square array of 20 km^2, thus 0.25 km^2 per 2 MW turbine (or 0.125 km^2 per MW installed). This is rather more closely packed than the counsel of perfection above.

The biggest onshore windfarm in the UK has 39 turbines (1.5 MW) on a land area of 7.5 km^2 giving 0.2 km square per turbine (or 0.13 km^2 per MW installed).

For comparison a 1500 MW fossil fuel station with a load factor of 80% would occupy no more than about 2 km^2 and generates 1500 x 0.8 = 1200 MW. With wind load factor of 25% a 2MW turbine yields 0.5 MW - so we need 2400 turbines to equal this electricity and occupying 2400 x 0.25 = 600 km^2 of land.

Foundations

Onshore wind turbines, according to size and site conditions may require a wide range of different foundation types and sizes. The commonest is the gravity base comprising a ferro-concrete slab loaded with aggregate. Other options might be rock-anchors on a hard rock site, piled foundations or an embedded concrete cylinder in soft conditions (*Civil Engineering*, November 2005).The hole excavated for a turbine's foundation has a volume of 200 - 800 m3 depending on site conditions. This would need a maximum of about 1700 tonnes of concrete and aggregate for a gravity base. Only a quarter or less of the concrete will be cement - the energy intensive component which emits CO_2 in manufacture.

An average gravity base for a 2.5 MW turbine requires about 40 truckloads of concrete - up to about 250 m^3 compared with only 40 m^3 for the smaller 250 kW turbines, common a few years ago (*Civil Engineering*, November 2005).

Myths of our own making

Olympic swimming pool. Opponents of wind power have created a myth of their own, by suggesting that foundations are of "Olympic swimming pool size". That would be 50 x 25 x 2 or 3 m = 2500 to 3750 m^3. This is an average 12-fold exaggeration!

Failure to payback energy and CO2. It is often said that wind turbines fail to pay back the energy and CO_2 cost of their manufacture and erection, or even that the CO_2 emission from cement manufacture alone is enough to offset the lifetime saving of CO_2 by a turbine. All of these assertions are untrue. Don't repeat them - there is enough to complain about in wind power without resorting to easily exposed misinformation but for more detail see *Roads* (below) and *Payback time for energy and* CO_2 (section 5).

Wind turbines only operate 30% of the time. In fact the industry is quite correct in saying that wind turbines generate for near 80% of the time – but what they fail to say is that for a large proportion of that 80% the amount of generation is very small.

Wind turbines need back up so they don't save any CO_2. It is certainly true that the more wind power we install, the more backup will be necessary when wind speeds are low but there is a high demand for electricity. That backup will cost some of the saved CO_2 emission but it will certainly not negate all of it. Thus wind power undeniably displaces some fossil fuel burning and saves some CO_2 emission.

Roads and site clearance

Importing the turbine components requires access for very large low-loader trucks and a large mobile crane able to move 50 tonne or larger components. This is achieved by construction of a network of access toads which themselves require excavation of overburden and infill with large quantities of crushed rock aggregate. This work and borrow-pit sourcing of aggregate can do an enormous amount of ecological damage in vulnerable habitats of semi-natural vegetation especially on deep peat soils. The photo gallery accessible on the Cefn Croes website is a remarkable illustration of this literal holocaust: -
http://www.users.globalnet.co.uk/~hills/cc/gallery/index.htm
Further discussion is posted at
http://www.users.globalnet.co.uk/~hills/cc/scoutmoor.pdf

Transmission lines

One gigawatt of generation by a large power station is a very different matter from a gigawatt's worth electricity from 1666 two-megawatt turbines spread over perhaps 500 km^2 of countryside! Yes it needs that number, given a load factor of 30%.

The large network of low voltage transmission lines results in substantial line losses compared with that of the single high voltage super-grid line linking a power station to often nearby industry. The wind 'farmers' say little about line losses but it is a matter of some importance if their electricity is supposed to be displacing carbon emission from fossil fuel stations. Attempts to suggest that 'local consumption' can mitigate this are patently daft – where do we find 600 megawatts' worth of consumers at peak wind generation on the Isle of Lewis? At present, even without the additional lines needed by dispersed wind generation, the grid and network system has a total delivery loss of over 30 TWh/y which is about 16 times as much as UK wind power (date from AAS, 2005 and DUKES, 2005).

Construction of the power lines raises another problem. – There is as much opposition to power lines in open country as there is to wind turbines – maybe more! The two are of course interdependent and numerous low power wind generators will inevitably create many miles more power line. The current proposal for a major super-grid power line from Beauly to Denny, in Scotland, had by February 2006 attracted some 18,000 objections and almost no letters of support (source Scottish Executive). The Highland Council, Stirling, Clackmannanshire and Perth and Kinross councils also objected in April 2006. These objections raise questions of landscape amenity, risk to birds which is proven, health-risks which are unproven but a matter of great public concern, and of course the vexed matter of transmission-loss.

8. Landscape quality of wind 'farm' sites' and value of landscape

"*The Government’s thesis that the countryside of upland and coastal Britain is “worth sacrificing to save the planet” is an insult to science, economics and politics. But the greatest insult is to aesthetics. The trouble is that aesthetics has no way of answering back.*" (Simon Jenkins, *Times* October 24, 2003 Like philistines, we desecrate our Landscape)

Guy Roots, counsel for the wind farm developers at the Public Enquiry into the Kirkby Moor wind "farm" in the Furness Peninsula of the South Lake District, said: *"It tends to be the higher parts of the country which are technically suitable for wind farms. These are too often prominent, scenically beautiful sites, and that causes a dilemma."*

Confirm this for yourself. The map of UK wind speed distribution is almost identical to a topographic map of the country with a superimposed rim of higher speeds around sections of the coast (http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/wind/content/ukwindspeedmap.html).

Man, beasts and crops fail to thrive when exposed to high wind, so these coasts and uplands are also our last remaining wilderness areas of semi-natural land: Britain's 'green-lungs' and havens of peace for the mending of broken souls. Of course it is no coincidence that our Designated Areas - National Parks, Areas of Outstanding Natural Beauty and many Sites of Special Scientific Interest etc are almost all within these precious pre-industrial landscape remnants.

Thus, the wind power developers generally target the most beautiful areas with the highest wind speed which give the greatest output and the highest return. The system of subsidy which operated throughout the 1990s, the Non-Fossil Fuel Obligation (NFFO) and now the arrangements for the Renewables Obligation (RO) make no reference to environmental acceptability, so encouraging wind power developments to threatened and damage much of our finest landscape. It has indeed been suggested that such places have deliberately been the first targeted - the rationale being that a despoiled landscape can no longer be advanced as an argument for protection.

In Wales, huge wind ‘farms’ have already been built in the Cambrian Mountains Environmentally Sensitive Area at Cefn Croes (b. 2005) and, from the summit of Plynlimon in this magnificent area of mid-Welsh hill country, many more than 200 turbines are now visible. Simon Jenkins wrote long ago in the *Spectator* (1995): -

"*There lies the complete Cader range: an unsullied panorama of British landscape from the heights above Bala round to the shores of Cardigan Bay. I have gazed on this view since childhood and even the Forestry Commission's set-square plantations failed to ruin it. Today the view has been defaced beyond belief. In the middle of the tableau and standing guard over the upper waters of the Dovey lies a mountain ridge known as Cemmaes. Across its summit now march 24 gigantic white wind-turbines. Like creatures from The War of the Worlds, they frantically wave their arms across the scenery as if semaphoring to some distant ally. Not only is it impossible to avoid them, placed as they are on one of the most prominent spots in mid-Wales, but their ceaseless movement draws the eye from wherever else it may rest. Nobody with an ounce of respect for the countryside could have permitted their erection. (Step forward, David Hunt, Welsh secretary at the time)."*

In England one of our classic low-key landscapes is about to be devastated by 26 wind turbines 370 feet high at Little Cheyne Court at Walland Marsh close to two of the Cinque Ports, Rye and Winchelsea. To quote Simon Jenkins again, they "*will dominate the view from the ramparts of Rye, Camber Castle and the slopes of the Sussex Weald... The decision is astonishing. Romney Marsh is still one of the most precious corners of England... If Wicks can put turbines on Romney Marsh, nowhere is safe. Where poor, flat-chested Romney goes today, the buxom Cotswolds go tomorrow.*" (*Guardian*, October 28 2005).

Scotland has perhaps paid the highest price, eloquently lamented by Cameron McNeish (*Sunday Herald*, April 2006): -

"*By the headwaters of the River Findhorn, lies Carn na Saobhaidhe, the cairn of the fox's den, arguably the remotest Corbett in the land... a vast, sprawling hill which I first climbed with my friend Peter Evans as part of a cross-Scotland walk many years ago... We couldn't have imagined, in our wildest nightmares, that these hills could be taken over by towering metal giants, like something from an HG Wells novel. How wrong we were. As I lay by the small summit cairn and allowed the vastness of this wild landscape to percolate my own spirit I'm afraid I cried. I wept tears of frustration at man's arrogance and greed. I wept tears of helplessness that people like me, to whom these wild places mean everything, couldn't effectively fight the political/corporate forces that are determined to steal Scotland's soul in the name of green energy. And I wept tears of genuine sorrow that my children's children wouldn't enjoy these places as I have done.*"

9. Wind 'farms' and the planning system

When the large-scale deployment of wind power started in the early 1990s it was initially subject to the same planning regulation as any development in open countryside.

In clarification, Minister for Planning Richard Caborn wrote in June 1998: "...*wind energy developments are subject to exactly the same planning controls as any other form of development ... The government wants to encourage the development of clean and renewable energy where that is economically attractive and environmentally acceptable*." (CG, 2000)

The Countryside Act 1968 imposed a responsibility to preserve the countryside and local government has become increasingly aware of the tourist and amenity value of unspoiled landscape. Local Development Plans consequently restricted industrial development to specific areas, usually those already industrialised which complicated matters for wind developers who usually targeted sites precluded by the local plan.

The only plausible "substantive material reasons" why restrictions should be set aside might be the reduction in fossil fuel pollution, but the reduction achieved by even the largest wind "farms" is so minuscule as to be in no sense substantive and this was often recognised by planners and PI inspectors.

This is precisely what British planning law was intended to achieve when it was battled for by brave and often lone campaigners in the 20th century.

By early 2000 the government had given licences for 2400 MW of wind power under the last three rounds of the Non-Fossil Fuel Obligation and the Scottish Renewables Obligation but only 200 MW had got through the planning process because wellinformed planners and inspectors considered the environmental impacts too big and the clean energy benefits too small to allow the rest. The wind industry began to howl in frustration and demand that wind be given a fast track through the system.

Lurking in the background was government's response to the 1994 Welsh Affairs Select Committee on Wind Energy. The Committee had advised that wind "farms" should be sited neither within Designated Areas nor where they would be clearly visible from such areas. Government rejected that 'general presumption" as it "would effectively preclude development from the greater part of Wales." From that view has grown the feeling that the wind power industry can force wind turbines onto almost any part of Britain.

Several other recommendations of the Select Committee were similarly rejected, with repercussions that echo to this day. The committee wrote: "*We would be concerned if wind turbine towers became significantly taller than at present* [c. 50 m!] *and do not see any reason for the foreseeable future that they should.*" Government did not accept this and responded that it: - "... *does not believe it to be advisable to rule out any particular form of structure or to impose limits on the maximum height of turbines."*

In response to the 'need' for fast-tracking, in 2000, government required all UK regions to prepare renewable energy assessments of their resources and set regional renewable energy production targets.

To ensure that the log-jam in the planning system should be broken, new planning advice guidance guidelines on planning for renewable energy have been imposed. In Scotland, *National Planning Policy Guideline 6* (NPPG 6) was revised in 2000, England's *Planning Policy Statement 22* (PPS 22) was adopted in 2004 and Wales followed with *Technical Advice Note 8* (TAN 8) a year later.

All of these documents are 'advisory' but presume in favour of renewable energy schemes in the absence of very strong arguments against particular schemes. In Scotland it has long been apparent that NPPG6 breached a dam and enormous numbers of projects are now under consideration and, following a few years later down the same route, England and Wales are on the way to becoming wind factories for no particularly good purpose.

Some provisions in these documents are disturbing to say the least. The Welsh TAN 8 ostensibly seeks to control wind deployment by confining it to a number of 'strategic search areas' (SSA) but careful reading reveals that outside these SSAs 'weasel words' may permit developments of less than 25 MW installed capacity. As of early 2006 there are only three wind 'farms' bigger than 25 MW in all Wales!

PPS 22 gives almost unlimited licence for onshore deployment of windpower: -

"The fact that a target has been reached should not be used in itself as a reason for refusing planning permission for further renewable energy projects."

"The potential to generate substantial amounts of renewable energy from offshore projects should not be used as a justification to set lower targets for onshore projects."

Prior to the adoption of PPS 22 in England, Yvette Cooper, MP, Parliamentary Under Secretary of State in the ODPM replied to the MP for Preseli Pembrokeshire, in response to an enquiry from the author of this article: -

"… decisions will continue to be made with due regard to planning policies and only after very careful consideration of all the relevant issues, such as, for example, the visual impact of the project and the views of the local population. I would also like to reassure your constituent that there is no intention to overrule the democratic processes in local planning." (16 February 2004): -

The last sentence rests uneasily with the view of the Committee of Public Accounts (CPA 2005) that the DTI: -

"… has, therefore, worked with the Office of the Deputy Prime Minister …and in 2004, a new planning statement was issued. The statement seeks to… increase the proportion of applications for renewable sites which are approved.... The statement increases the chances of hitting the 2010 target, but only by reducing local communities' influence on the planning process."

Not content with the almost free rein that the planning advisory documents now provide it is apparent that the developers are also seeking to employ powers of Compulsory Purchase Order (CPO) if they are baulked by dissident land-owners (Ofgem 2006).

Size of development - Section 36, Electricity Act

Many wind development applications are perhaps deliberately configured to exceed the 50 MW installed capacity threshold of s36 which transfers them from the Town & Country Planning Acts to the Electricity Act. Developments to be considered under s36 were originally intended to be large (100s to 1000s of MW), non-intermittent and of intrinsic strategic importance. Because of the intermittency of wind the effective threshold for such proposals is 15MW not 50MW. Many applications are now being manipulated so that upgrading to s36 capacity is easy – often by amalgamation of separate schemes (as happened at Cefn Croes in Wales). Applicants believe (probably correctly) that s36 gives an easier route to consent in cases where the LPA does not appear minded to recommend approval under the TCPA.

Objections and democracy

The ODPM wrote that *"there is no intention to overrule the democratic processes"* but within a year, the CPA (2005) considered that the process reduced "local communities' influence on the planning process."

What do the numbers tell us?

There are now almost always substantially more objections to wind power schemes than letters of support, despite the fact that the industry and green organisations have substantial financial support whereas the objectors are usually without resources.

A few examples will suffice.

In September 2001, Energy Minister Brian Wilson opened the Bears Down wind 'farm' in Cornwall despite 383 letters of objection and only 23 in support!

In mid-Wales' Cambrian Mountains, the huge Cefn Croes wind 'farm' was approved by the Ceredigion County Council against 253 letters of objection and 586 signatures on a petition. This was balanced by 130 letters of support and 130 collected signatures. Most of the objections were local and most of the support from "away" and a large number of the latter were from the employees of Cambrian Energy, Bangor, builder of the turbine towers. So there was a substantial majority against, and the CCC Senior Planning Officer also advised refusal in a 124 page report.

The installed capacity of Cefn Croes was to be more than 50 MW which meant that it was automatically referred to DTI for consent under S36 of the Electricity Act 1989. The DTI received 1350 objections or calls for a public inquiry but on May 23 2002 the DTI announced the formal consent for Cefn Croes. The 1350 objections were ignored and several hundred carefully drafted letters of objection were never mentioned.

Another example of the undemocratic overthrow of public opinion was the Scarweather Sand offshore wind ‘farm’, close to Porthcawl in the Bristol Channel. Scarweather was subject to the first ever Public Inquiry in the UK off-shore proposal and taking into consideration the 3,100 letters of objection to the scheme balanced against just nine letters of support written to Welsh Assembly, the Inspector recommended refusal, saying: -

“The visual impact of a windfarm in the specific location of this proposal would be so prominent when viewed from Porthcawl and its immediate area that I consider that the harmful effects on this view are sufficient to outweigh the benefits of this particular proposal.”

However a Planning Decision Committee, made up of four Welsh Assembly members, disagreed with the Inspector’s conclusion and recommended that permission should be granted. Who were these four planning experts? One farmer, one ex-hospital manager and two teachers who it transpired had been given a couple of hours coaching in the relevant matters of planning (and hopefully electricity supply).

As more schemes have been railroaded through ‘due process’, so the degree of opposition has risen. A total of 6,131 objections to the proposed 600 MW wind ‘farm’ on Lewis were been received by the Scottish Executive by 20 December 2005, of which 4,573 came from locals. For every person from the islands who wrote to support the joint Amec-British Energy project, 269 people wrote to object (*Press and Journal* 20/12/05).

10. Public opinion - Beauties or beasts?

Aesthetic judgements are subjective: some people find a wind turbine beautiful and some find them ugly. That is not the issue. A wind "farm" is an industrial site of vast proportions and a turbine is a huge and noisy machine – 300 to 400 feet high or more, the height of a 30 storey office block. A 30 storey building by a leading architect might be very beautiful, but planning controls would prevent its crowning the fells of the Lake District or dominating a Scottish loch.

“*Sir: It is irrelevant that **** thinks that wind turbines are beautiful. A 2 MW turbine is almost the height of Salisbury Cathedral, one of Britain’s most beautiful buildings, but planning law would prevent even such a magnificent structure from occupying almost any of the sites targeted by the wind power industry* (J. R. Etherington, *Independent*, 7.11.02)

Buildings of architectural merit are “one offs” – the interaction of the architect’s sensibilities with the environment of the building. A wind turbine by contrast is just one of a huge number of mass-produced identical steel and plastic machines, imposed upon landscape to exploit wind availability to maximum advantage and consequently to maximum visibility. Sir Martin Holdgate, a former scientific adviser to the UK Government, put it succinctly by saying: "*they have a huge spatial foot-print for a piddling bit of electricity."*

Even such committed supporters as Friends of the Earth (FoE) argue that windpower should be excluded from Designated Areas like national Parks, Areas of Outstanding Natural Beauty and Sites Of Special Scientific Interest. Jonathan Porritt, former Director of FoE, wrote in *The Daily Telegraph*: "*The modern wind turbine is a mighty intrusive beast. It's not into nestling, blending in or any of those clichés so beloved of rural romantics."*

Wind Power Monthly, the magazine for the wind industry and wind enthusiasts, has recognised that the reason for the growing unpopularity of wind power is that a heavy industry has tricked its way into unspoiled countryside in "green" disguise. The editor wrote (September 1998): "*Too often the public has felt duped into envisioning fairy tale wind "parks" in the countryside. The reality has been an abrupt awakening. Wind power stations are no parks.*" She went on to point out that in Denmark turbines are treated within the planning process in the same way as motorways, industrial buildings, railways and pig farms!

The Public Accounts Committee (CPA 2005) has certainly recognised that there is a general feeling that these machines have no place in the countryside: - *"... the likely rapid expansion of onshore wind power in the next five years could create a public reaction against renewable energy."*

The CEOs of the British and European Wind Energy Associations wrote to the *Independent* newspaper on 8 May 2006 suggesting that wind power equivalent to 20% of UK generation could be in place by 2020. This would require at least 30,000 MW of installed wind capacity, thus 15,000 2.0 MW machines requiring 6 square miles per turbine, if we all had our fair share. No one would be more than about 2.5 miles from a c. 400 foot turbine!

11. House prices, tourism and jobs

It is little more than a matter of common sense to realise that wind power may seriously affect property price. Given two identical rural houses, one with wind turbines on its horizon, in which would you invest your £200k? There is but one answer unless 'green' commitment has displaced all sense.

What 'they' say

"Myth: Wind farms devastate house prices" DTI Myths

A study of its members' opinions by the Royal Institution of Chartered Surveyors (RICS 2004) concluded that "*60% of the sample suggested that wind farms decrease the value of residential properties where the development is within view*..." and the report also concluded that "*Once a wind farm is completed, the negative impact on property values continues but becomes less severe after two years or so after completion*"

With outrageous misrepresentation, the DTI Myths website (above) dishonestly misquotes the RICS survey findings: - *"A study by the Royal Institution of Chartered Surveyors suggests that wind farms have no lasting impact on UK house* *prices"* and continues *"It shows that local house prices recover from any initial impact once a wind farm has been operating for two years."* Compare that with the very different original versions above!

DTI Myths then compounds the offence by writing *"People promoting fears of falling prices risk making them self- fulfilling."* I am sure that this was not the interpretation arrived at by the district judge who awarded substantial compensation to a family from Marton in Cumbria, because a vendor failed to disclose a wind farm proposal (*Times* January 10 2004)!

A valuer in mid-Wales has suggested a probable 25% reduction in house value caused by a proposed windfarm (Remax E.A. 2005) and at Lethbridge in Devon, two independent valuers predicted that a farm property will similarly lose £165,000 in value (*Sunday Telegraph* January 2005).

The wind power industry vehemently denies such impacts but facts and common sense speak louder than their words

Just as common sense predicts that wind power will influence property price it seems equivalently likely that it will deflect the rural tourist who comes for peace and quiet, to escape the constant movement and noise of the city and to recharge their mental batteries.

The deeply disturbing thing is that the wind power industry refutes this by saying there is no "proof" of impact on house prices, but unfortunately this is a classic Catch-22 situation in which the proof is the damnation – it will be too late and the precautionary principle is the only safe approach.

Tourism

Whether we like it or not, tourism is the future for rural Britain, and as Foot & Mouth disease sadly revealed, it is a substantially larger earner than agriculture. The following figures were compiled for Wales, but proportions will be similar in Scotland and England.

Tourism earns almost £2 billion a year for Wales. It contributes 7% to Welsh GDP and far outweighs agriculture, at less than 2%. Tourism is much more cost-effective in terms of jobs, than agriculture, which becomes less labour intensive each year. Farms, which employed a dozen men 50 years ago, often run on a man and his wife these days.

The conventional electricity industry contributes less than 2% to Welsh GDP and if the 2010 renewable generation target of 10% is achieved, it would represent at best, 0.2% of our country's GDP.

Thus we have a thriving and rapidly growing tourist industry worth more than 35 times the GDP which renewable electricity could ever realise, and because most of the generation will be wind power, its enormous landscape impact will almost certainly jeopardise tourism.

Of course, BWEA assures us that tourists don't mind the turbines and indeed will swarm to visit windfarms and their eco-centres. But they would say that, wouldn't they?

What 'they' say

Myth: Wind farms keep tourists away: Many wind farms are tourist attractions."
DTI Myths

The fact that the Gaia Centre at Delabole went bankrupt, the Swaffham eco-centre encountered serious financial troubles and Cold Northcott visitor centre near Delabole was forced to close, might just be bad luck or rotten management! Interestingly most of the wind 'farms' which are claimed to be tourist attraction are in fact visitor centres in their own right, all in areas where tourists are seeking indoor occupation in bad weather. The Wales Tourist Board summed-this up perfectly "*… there will only be a need for a very small number of wind farm visitor centres before this also reaches saturation point. The WTB believe that the case for wind farms as tourist attractions in their own right only has very limited appeal.*" (Letter to author from WTB May 2002).

The impact of wind power on tourism may in fact be substantial. In 2003 the Wales Tourist Board concluded from a survey of businesses in mid-Wales that "*Just over half of the respondents thought wind farms have already and will continue to have an adverse effect on visitors coming to the area."* And we have not even started building a lot of big ones yet!

Outside Wales, a survey by VisitScotland (2002) which was effectively conducted 'blind' was even more frightening about the impact on tourism; over a quarter of tourists saying they were unlikely to return to a 'turbinised' landscape.

A survey in the Western Isles arrived at a similar disturbing conclusion (Tourism Operators in North West Lewis, 2004).

Jobs

What 'they' say

Wind energy is the fastest growing energy sector in the UK creating jobs with every megawatt installed. To date, over 4,000 jobs are sustained by companies working in the wind sector, and this is projected to increase as the industry grows2. The Department of Trade and Industry3 has estimated that Round Two of offshore wind developments alone could bring a further 20,000 jobs for Britain.

Reality. During construction of Causey Mire wind 'farm', Caithness, in 2004, a Danish site engineer explained to a visitor that the Bonus turbines had been shipped complete from Denmark. Replying to a question about employment, he commented that no permanent staffing was needed as the day to day operation would be radio controlled from Denmark (a technology derived from managing offshore wind 'farms'). Maintenance would involve no more than occasional visits to the site by a roving engineer. Cefn Croes, the largest wind "farm" in Europe was predicted to need just four full-time employees (http://www.users.globalnet.co.uk/~hills/cc/) and at the Bryn Titli wind "farm" in Wales even the construction site workers were Danish - erecting Danish Bonus turbines in 1994.

Reality. In March 2002, Merfyn Williams CPRW said (in the *Western Mail*) that the tourism and leisure industry in Wales employs 23,000 people whilst renewable energy (most of which is not wind power) employs only 275.

Thus, though wind 'farms' threaten to destroy jobs in the tourist industry; they create few if any compensating jobs elsewhere.

The simple truth is that if the subsidies going into renewables were diverted to other CO_2-conservative projects, thousands of jobs would be created at a stroke, and far more emissions would be saved. For example Connah's Quay gas-fired power station (1400 MW) created or secured 8,000 jobs, and all of the 500 contractors and consultants were based in the UK (CG 2000). Gas-fired generation emits less than half as much CO_2 as coal-firing so just one station of this size potentially saves more CO_2 than all of the UK's wind turbines (at least 5 million tonnes CO_2 /y saving v. BWEA's current claim for wind of just over 3 million tonnes CO_2 /y).

12. Birds and bats

Early in the development of wind power it was reported from various parts of the world that birds were likely to be killed by rotor blades

This is hardly surprising. Wind turbines are so gigantic that, though the rotor appears to be travelling quite slowly, the blade tip velocity of a big machine often exceeds 150 mph – two or three times the motorway speed limit. Anyone who has struck a bird with a car will know that even a 20 mph collision is lethal.

A bird which just avoids a blade tip has only 1.2 to 1.3 seconds to dodge the next blade, approaching from about 80 yards to 90 yards away on a strongly curved path and probably outside the range at which many birds would be aware of a moving hazard, even in good visibility. For example a V80 machine gives about 77 yards sightline and 1.2 seconds until the next blade arrives - this might exercise a fighter pilot's skill! (See section 7. Technical aspects of wind turbines).

It did not take the developers long to realise that this was a potential publicity disaster.

What 'they' say

"Quite simply, birds are in far more danger from colliding with overhead power lines, or being eaten by domestic cats, or hit by vehicles than they are from wind turbines..." (BWEA website)

"The Royal Society for the Protection of Birds (RSPB) supports the sustainable development of renewable energy such as wind power because it helps mitigate climate change, which they believe "poses the most significant long-term threat to the environment..." (Yes2wind)

"Environmental assessments are required as part of the planning process, to ensure wind farms are properly sited and configured in relation to bird movements. These assessments have improved the understanding of bird ecology, helping conservation." (DTI Myths).

However, despite the RSPB's support for the deployment of windpower, the organisation has more recently acknowledged that a problem may arise. An objection has been lodged to Amec/British Energy's 600 MW scheme for the Isle of Lewis: - "*'We believe this wind farm proposal is not just bad for birds but bad for the development of renewables as well,' said Anne McCall, RSPB Planning and Development Manager. The area is "protected under European law for a variety of important birds, including golden eagles, merlins, black-throated divers, red-throated divers, dunlins and greenshanks."* (http://www.rspb.org.uk/policy/windfarms/objection.asp)

Not all RSPB objections are effective and at Edinbane on Skye planning consent was granted despite RSPB's contention that the site was too close to sea eagles and several breeding pairs of golden eagles, as well as merlin and hen harriers. An RSPB officer commented anonymously: *'The fact is we don't really know what will happen. Developers do environmental assessments but they own the research. And consultants are under pressure from the energy companies for the right answers."* (*Observer*, October 5 2003).

These reports highlight the main fear that the very large, slow flying raptors are most at risk and in the UK these are all rare and potentially threatened species. Many hunt for food on the ground below by 'telescoping' from above and may have no self-protective instinct at all against attack from the air (no survival of the fittest pressure until wind turbines came along). The fact that kite and vulture have proved the most likely raptors to die in European wind farms supports this interpretation - they are, par excellence, 'circling telescopers'. They may not even take great notice of the hurtling blades (note the crows and buzzards which are quite at home amongst [the slower!] traffic on a motorway).

By January 2006, 69 red kite and 56 buzzard had been killed in Germany (Brandenburg State Environment Office 2006). Nearer home, two red kite deaths have already been confirmed in mid-Wales, with only a relatively small number of turbines as yet.

The Brandenburg figures relied on scoring corpses found by the public. Many will be missed, and scavengers such as fox and badger may remove many more. Direct studies intended to detect bird death reveal frightening numbers in habitats similar to many in the UK. At three wind farms in Flanders (Belgium) the collision numbers varied from 0 to 125 birds per wind turbine per year. The mean number in 2002 was 24, 35 and 18 birds per wind turbine per year at the three 'farms' (*Natuur.Oriolus* 69 (3) 2003)."

In the US, "*Research by raptor experts for the California Energy Commission (CEC) indicates that each year, Altamont Pass wind turbines kill an estimated 881 to 1,300 birds of prey, including more than 75 golden eagles, several hundred red-tailed hawks, several hundred burrowing owls, and hundreds of additional raptors including American kestrels, great horned owls, ferruginous hawks, and barn owls. These kills of over 40 different bird species are in violation of federal and state wildlife protection laws*."
(http://www.biologicaldiversity.org/swcbd/programs/bdes/altamont/altamont.html
)

Smallwood and Thelander (2004) reported to the CEC: - "*The assertion that the APWRA is anomalous in its bird mortality is largely untrue... Whereas the available data suggest that the APWRA kills more raptors than do other wind energy generating facilities, the risk index demonstrates that the APWRA kills no more raptors relative to the number seen per hour than do most other wind energy facilities. Adjusting for local relative abundance, the existing data indicate that most wind energy generating facilities have an equal impact on the local raptors.*"

In September 2005, the *San Francisco. Chronicle* reported that half of the 5,000 windmills in the Altamont Pass will be closed for three months this winter to protect migratory birds following years' of protests from environmentalists.

Despite such evidence, the wind power developers and RSPB in the UK have attempted to dismiss the huge toll of raptors at the Altamont Pass Wind Resource Area (APWRA) in California, saying it on a migration route and irrelevant to the UK.

However if Smallwood and Thelander are correct about correction for abundance, once some of the big wind stations are built we are likely to see unacceptable losses.

BWEA's pathetic attempt to deflect criticism by suggesting that "*more birds are eaten by domestic cats or hit by vehicles*" does the organisation more harm than good. As I have written elsewhere: "*when did you last see a domestic pussy-cat wrestle a red kite to the ground for the coup de grace*?" And how many sea eagles are struck by cars compared with the 4 sea eagles killed in 5 months by 68 turbines and power lines at the Smola windfarm off the Norwegian coast (Alv Ottar Folkestad, Norwegian Ornithological Society 2005)?

Scottish National Heritage (SNH) has recently written to the Scottish Executive admitting that collision risk to sea eagles and golden eagles at the proposed Muaitheabhal Windfarm had been underestimated by a factor of about 54 times (Letter dated 5 December 2005). This alters a predicted kill of one golden eagle every 3 to 6 years to an outrageous, one per 3 to 6 weeks. SNH repeated in this letter that it was willing to continue to discuss, with the developer, any means of achieving an "acceptable collision risk."

Bats

It was not until early 2004 that news really spread about the vulnerability of bats to wind turbines. Wendy Williams, a journalist for *Windpower Monthly* published 'When Blade Meets Bat' in *Scientific American* (Feb. 2004) and recorded the death of at least 400 migrating bats at Mountaineer Wind Energy Center, Backbone Mountain, West Virginia. Other publications suggest that allowing for carcasses missed, or carried off by scavengers, over 2000 bats were killed and possibly many more at this site.

Bats navigate by echo location but cannot cope with the speed of wind turbine blades and are most vulnerable when the wind speed is low, which is when their prey is flying. One study has shown fewest bats killed on nights when wind speeds were above 13 mph. It is also apparent that some bats die of 'shock' and are found dead but uninjured beneath the machines, probably from being buffeted by wake vortices.

Bat deaths are also recorded throughout Europe with many hundreds of deaths despite the problem of finding and recording such tiny corpses in competition with scavengers. These numbers are the tip of an iceberg and will surely prove much greater. It is only within the last couple of years that bats began to be studied in EIAs.

It is of interest that UK law makes it an offence knowingly to "*Set and use articles capable of catching, injuring or killing a bat…*" or to "*Possess articles capable of being used to commit an offence, or to attempt to commit an offence.*" (Bat Conservation Trust information leaflet).

13. Noise

During the early days of the wind power industry in Britain most turbines were built at a substantial distance from dwellings. Despite this, there were complaints of that the machines made noise which was sufficient to disrupt sleep and to cause some annoyance during daytime.

The remarkable pressure which has been imposed by the regional planning advice notes (Section 9. Wind 'farms' and the planning system) will allow many more turbines to be built close to habitation and despite the statement in House of Lords (1998-99) it seems there will be a growing impact of noise on human health, happiness and prosperity.

What 'they' say

"Modern wind turbines are remarkably quiet, and are specifically designed to keep noise to a minimum. All wind farm noise assessments are undertaken using the methodology developed for the…DTI and published in 'The Working Group on Noise from Wind Turbines (1996): Assessment and Rating of Noise from Wind Farms' (ETSU-R-97)." (NUON Renewables. Website FAQs)

"…the noise produced by typical wind farms is so low that they would not be noticeable in most residential areas in the UK." (BWEA 2006)

There are two potential sources of noise: that of turbine blades passing through the air, and of the gearbox and generator in the nacelle. Blade design can reduce the first problem and sound insulation or isolation suppresses mechanical noise with the result that "typical noise levels are so low for a carefully considered site that they would normally be drowned out by a nearby stream or by a moderate breeze in nearby trees and hedgerows." (BWEA 2006).

This is a clever exercise in concealment! Yes, engineering can suppress mechanical noise but an aerofoil blade, the size of a jumbo's wing, travelling at 150 mph inevitably makes a considerable sound! The air passing through the rotor is swept into turbulent vortices, the source of much of the sound, and within a few feet encounters the obstruction of the tower and as a blade passes a tower every one to two seconds this imposes a pulsating quality to the aerodynamic sound which many people find deeply irritating.

The measurement of 'noise'

Noise is measured in decibels (dB). The decibel is a measure of the sound pressure level, i.e., the magnitude of the pressure variations in the air. The scale is logarithmic so an increase of 10 dB sounds roughly like a doubling of loudness. Measurements of environmental noise are usually made in dB(A) which includes a correction for the frequencies best-heard by the human ear.

The noise a wind turbine creates can be expressed in terms of its sound power level at source . Also expressed in dB(A), this is a measure of the 'noise' emitted by the machine. From a single wind turbine it is usually between 90 and 100 dB(A) and creates a sound pressure level of 50-60 dB(A) at a distance of 40 metres from the turbine (BWEA fact sheet).

BWEA claims that: "At a house 500 metres away, the equivalent sound pressure level would be 25-35 dB(A) when the wind is blowing from the turbine towards the house. Ten such wind turbines, all at a distance of 500 metres would create a noise level of 35-45 dB(A) under the same conditions. With the wind blowing in the opposite direction the noise level would be about 10 dB lower."

To put this in perspective some comparable noise sound pressure levels (dB) are: -

Rural background 20-40
Quiet home interior 35 - 40
Wind farm at 350m 35-45

Car at 40mph at 100m 55
Jet aircraft take-off at 100m 125

Use of the dB or dBA scale tends to confuse the lay person and this has been deliberately exploited in much of the wind industry's publication. It is useful to know that in the open air, a change of 3 dB is barely discernable but a 5 dB change will cause most people to comment and a 10 dB increase, a doubling of perceived sound, will result in complaints from most people.

The use of the dBA frequency scale, biased for human hearing, also implies an objective relationship with perception of sounds as unpleasant, neutral or pleasing – simply related to 'loudness'. This is not so, and one has to ask how a single noise-level reading relates to such subjective experiences as: -

"... *worst of all is the beat. An insidious, low-frequency vibration that's more a sensation than a noise. It defeats double-glazing and ear plugs, coming up through the ground, or through the floors of houses, and manifesting itself as a ripple up the spine, a thump on the chest or a throbbing in the ears. Those who feel it say it's particularly bad at night. It wakes them up or stops them getting to sleep*."
Hawkes Bay Today [NZ] 18.02.2006

The sound from a wind turbine can be subdivided into

A. Audible noise

i. Mechanical components giving tonal sounds (of specific frequency like a musical note). This can be reduced by engineering solutions – insulation and isolation..

ii. Aerofoil noise of which flow over control surfaces and the blade trailing edge is mainly tonal. Again good engineering reduces this.

iii. Aerofoil noise from trailing edges and blade tips is caused by turbulence effects and is a broadband sound (not a 'note'). Turbulence over the main blade also produces broadband noise. None of these sources are well understood or controllable.

Turbulence may be visualised as the formations of 'whirlpools' of air (vortices) which part company with the blade and travel downwind for ten rotor diameters or more (hence the necessary spacing of turbines - Section 7. Technical aspects of wind turbines). When these vortices encounter the tower a sound is produced and is inevitably synchronised with the blade passing frequency to produce the rhythmic 1-2 second 'whoomph, whoomph' which so disturbs some people. This is of very low but audible frequency – comparable to the base - 'woofer' speaker output of a sound system.

B. Sub-audible sound (infra-sound)

Sounds below the frequency range for human hearing have been the subject of controversy in the context of wind power. The BWEA has consequently felt need to provide a web-page on the subject
(http://www.bwea.com/ref/lowfrequencynoise.html) in which: -
"Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects, says: '*I can state quite categorically that there is no significant infrasound from current designs of wind turbines.'* "
However, a recent report from Keele University on infra-sound (Styles et al 2005) says:-

"*We have clearly shown that both fixed speed and variable speed turbines generate low frequency vibrations which are multiples of blade passing frequencies and can be detected by seismometers buried in the ground*"

This was at distances up to many kilometres AND in the presence of background seismic noise.

In the absence of peer-reviewed medical evidence concerning low frequency sound from wind turbines, these two statements make uncomfortable bedfellows and so, as with many other aspects of this industry, we have a 'Catch 22' in which proof of a problem can only come when it is too late. However it is significant that the few medical workers looking at low-frequency noise from wind turbines on three continents are in agreement to the extent of christening the health consequence "*Wind Turbine Syndrome*" (Pierpoint, 2006). Neglect of the precautionary principle seems characteristic of the wind power industry and governmental support for it!

Perception

In no part of the confrontation between the wind power industry and people have there been more attempts at misrepresentation than in relation to noise and visual intrusion. The following quotations from Pedersen & Waye's (2005) paper to the 1st International .Meeting on Wind Turbine Noise sums up the subjective feelings of countless people, that exposure to wind turbine noise, shadows and the rotating movement of the rotor blades, were an intrusion into the "private domain."

"The wind turbine noise was by some of the informants perceived as intruding into private domain, physically into the garden and the home, but also as intruder into themselves."

"The experience of lacking control, being subjected to injustice, lacking influence, and/or not being believed."

"The noise… was to those who could not mentally shut it out, an obstacle to pleasant experiences decreasing the joy of daily life at home… creating a feeling of violation that was expressed as anger, uneasiness, and tiredness."

That such feelings are not amenable to interpretation by noise metering is the crux of the problem. A dripping tap making a sound near the lower threshold of hearing can be more infuriating than the continuous hum of traffic on a nearby road.

Legislative control of noise.

Throughout the UK wind farm noise is assessed in planning applications using the provisions of ETSU-R-97 "The Assessment and Rating of Noise from Wind Farms". It is, for example incorporated into PPS22 in England.

ETSU-R-97 was written by a Noise Working Group (NWG) of developers, noise consultants, environmental health officers and others set up in 1995 by the Department of Trade and Industry through ETSU (the Energy Technology Support Unit).

The working group was formed from independent experts on wind turbine noise to define a framework which can be used to measure and rate the noise from wind turbines to protect to wind farm neighbours. It's success may be judged from the comment by Bowdler (2005): -

"The conclusions of ETSU-R-97 are so badly argued as to be laughable in parts (the daytime standard is based on the principle that it does not matter if people cannot get to sleep on their patio so long as they can get to sleep in their bedrooms). It is the only standard where the permissible night time level is higher than the permissible day time level…"

However the author believes that ETSU-R-97 is about to be replaced so no further comment is given here.

14. Quality of life and safety

What 'they' say

"No member of the public has ever been injured by wind energy or wind turbines anywhere in the world, despite the fact that there are now over 68,000 operational wind turbines." (BWEA website FAQs, March 2006).

This is indeed true and so it is perhaps not wise to over-stress the matter of safety except for situations where turbines are very close to homes, vulnerable industry or fire-prone vegetation.

Fire-risk has recently been highlighted by an accident to a 0.66 MW turbine at the Nissan motor works in Sunderland (UK). All three 75 foot blades burned through and dropped onto the factory site. There are serious implications for siting of turbines in fire-prone forestry or amongst refinery buildings (*Sunderland Today*, December 24, 2005)

There have been many turbine accidents involving fire, generally because of faults in the transmission train or wind-shaft braking system (Sunderland accident was caused by a loose bolt and frictional heating). It is almost always the case that they have to be allowed to burn out as fire fighting equipment often cannot reach to the top of the tower and there is plenty of fuel, provided by the transmission train oil-baths.

Another common cause of accidents has been the shedding of blades or control-surface elements. This may well become more common – these are the world's largest rotating structures, often in a hostile environment and with relatively little 'in-service' testing.

A 2.0 MW turbine rotor weights over 30 tonnes so a single blade is a near 10 tonne aerodynamically shaped object which can 'fly' in the wind and is akin to a small fighter aircraft crashing. Again this has connotations for future urban and industrial sites as government is promoting the concept of 'brownfield' wind 'farms' (for example in the Welsh Assembly's TAN 8 planning document – Section 9).

Finally, as with aircraft, the rotor blades are prone to icing in freezing conditions. Icing of the blades causes production losses from wind turbines and heavy icing can close-down turbines. Downtimes of several weeks with a single icing incident have been reported in Southern Germany.

Ice thrown off the blade may also pose a safety risk even in areas where icing is infrequent, specifically when the turbines are situated close to a public road, or by skiing resorts, for example. Ice shedding off the tower or the nacelle can also pose a similar though a more limited risk especially for the service personnel and the public. There are also cases when icing of the yaw gear has resulted in the damage of yawing motor (http://virtual.vtt.fi/virtual/arcticwind/index.htm).

In the UK icing is mainly a winter hazard in upland areas and occurs less frequently in the lowlands.

Visual effects – flicker

In situations where low sun is behind wind turbines near sunrise and sunset the blades cast shadows which may cause serious irritation and in some sensitive individuals, physiological responses. The flicker rate is low – one 'flash' every second or two with large turbines, and in hilly areas with large arrays of machines some properties may be exposed to flicker for substantial periods during the day.

A less intense flicker is also caused when the observer is between the sun and the turbines, if the blades have glossy reflective surfaces.

The likelihood of flicker may be assessed by considering the orientation of turbines to nearby properties and roads, coupled with the known compass bearing and elevation of the sun at different times of day and year (see Manwell *et al*, 2002).

The consequences of shadow and reflective flicker are also apparent at greater distances, making wind turbines much more obtrusive than static structures of similar height. For this reason the industry's repeated attempts to compare them with transmission towers ('pylons') are deceitful – pylons do not move and are of a half or even a third of the height of big turbines.

This is well summed-up in a statement by Mr David Sheers, the Inspector at the Public Inquiry into a proposed wind 'farm' at Jordanston in Pembrokeshire (2000).

"The movement of WTGs [wind turbine generators]… *has a discordant effect on the eye. The rotation of the blades of WTGs in a cluster, while in the same direction, is not synchronised and gives a constant restless quality to the overall experience of a landscape. Especially when several overlapping WTGs are in view at one time, this has a highly distracting and discordant effect that detracts from any sense of tranquillity that an area may have*."

The loss of tranquillity may be the least of the ills: -

"The sudden emergence of a giant blade from behind a hill-slope, or out of a cloud base, triggers that primeval 'corner of the eye' fright which saved our distant ancestor from leaping predators. I am not surprised that those who live in sight and sound of the wind-monsters have their tranquillity stolen and their health damaged." Letter from the author to *Press and Journal,* May 2005

Huge numbers of people object to much smaller, 'non-twitching' electricity transmission towers for example the near 18,000 objections to the Scot's Executive over the Beauly to Denny line

15. Television interference, radar and aviation

Telecommunications and television

Wind turbines can interfere with telecommunications signals including TV and radio, mainly by the multi-path effect, where there is corruption or distortion of the received signal by the secondary signal. Uniquely with wind turbines this may 'chop' the signal causing variable 'ghosting' or 'jittering' on the TV picture.

The effects of wind power fall into two main categories: effects on broadcast television and effects on fixed radio links, mostly at microwave frequencies. Wind turbine effects on television reception are generally found where the TV is situated between a wind farm and the TV transmitter. Modern composite blades have less effect than older metal rotors but embedded lightning conductor strips may negate the advantage.

Reception solutions may require the use of a more sensitive aerial or aiming it at a different transmitter. More expensive remediation may need a re-broadcasting mast, satellite or cable supply to affected householders. Once analogue TV is replaced by digital it is possible that transmission will be less vulnerable to interference.

The SDC (2005) report includes a useful case study of the Blaen Bowi wind 'farm' in Carmarthenshire where it is claimed the initial problems with TV reception have been solved.

Aviation and military considerations

"Aviation and radar issues have long been a major source of complaint for the wind industry. This is because wind turbines can interfere with radar systems and be a collision risk for low-flying aircraft. These concerns have resulted in a significant number of planning objections, particularly from the Ministry of Defence" (SDC 2005).

The main effect of wind turbines on air-traffic control radar is due to the rotation of the blades. The radar may 'illuminate' one turbine on one sweep, then a different one on the next sweep, producing shifting radar returns sometimes referred to as 'twinkling' on the radar screen. Usually this only occurs when the wind development is within line of sight of the radar. A planning objection is likely for any wind energy project within 67 km (37 nm) on such a line from air-traffic radar. Ground-based air-defence radar installations may lodge similar line of sight objections.

Interference with radar and remote sensing is not the only problem for military aircraft. Wind generators are now reaching 140m (500 feet) above ground level. This is not high compared to the normal flying height of most aircraft but for some it is. The military practise low flying for operational reasons (ground support and flying "under the radar"). Standard heights are 250 or 300 feet (Civil aircraft typically operate at 1000 feet around aerodromes except for approach and departure).

Developers are able to submit pre-planning enquiries to Defence Estates and out of the 4,000 pre-planning consultation requests received since 1996, around 2,000 have received "no objections" advice. In total nearly half of the wind farms proposed so far in Britain have been successfully opposed by the MoD because of their proximity to air-defence according to David Wallace, vice-president, Royal Society (*Nature,* 428, 2004).

Another link with aviation is the need for warning lights which are required on onshore structures exceeding 150 m in height (TAN 8 2005). There are currently none in the UK but turbine development may soon break this barrier. Offshore wind up to the seaward limits of the territorial water and which is 60 m or more above the level of the sea at the highest tide shall be fitted with at least one medium intensity steady red light as close as possible to the top of the fixed structure. Arrays of turbines require only peripheral machines to be lit (Directorate of Airspace Policy, 2003, The Lighting of Offshore Wind Turbines)

Military remote sensing may also be compromised in the context of the seismic monitoring of international compliance with the Comprehensive Test Ban Treaty. Wind turbines may generate vibration which can mask the seismic signals from nuclear weapons tests (see Section 13).

The report on aviation for the DTI, edited by Jago and Taylor (2002) is a useful source of information.

16. Some comparisons - odious and otherwise

Emission of CO_2 by a single Boeing 747 airliner exceeds the saving by a 50-60 MW wind 'farm'

Probably the most remarkable and damning comparison of wind power is to contrast it with aviation as a source of man-made CO_2. See Appendix 2 for calculations.

A Boeing 747 airliner on average during a year's operation emits much more CO_2 than is displaced per year by a 50-60 MW wind power station. The UK's biggest onshore wind 'farm' is Cefn Croes in mid-Wales (58.5 MW i.c.).

The airliner's daily emission is some 400 tonne CO_2/24 h compared with between 181 and 362 t CO_2/24 h displacement by a Cefn Croes-sized station depending on to fuel proportion in the wind displaced generating mix – see Section 5.

Ergo - each 747 crossing the British coast (every few minutes) is responsible for more continuous CO_2 emission than the displacement of CO_2 emission even by the UK's biggest wind 'farm'. A dozen or two jumbo jets indeed emit more CO2 annually than the whole British wind power fleet saves!

The 'greenhouse effect' of the aircraft is considerably worse than a ground level CO2-emitter. According to RCEP (2002) "The total radiative forcing due to aviation is some three times that due to the carbon dioxide emissions alone." This is a consequence, *inter alia*, of injection of the CO_2 into the high troposphere.

Thus in terms of CO_2, each Boeing 747 adds some 182,500 t CO_2 to the atmosphere each year but this has the warming effect of in excess of 500, 000 t of CO_2 generated at ground level.

Given that government's 2010 target for CO2 saving by renewable generation of electricity is 9.2 million tonnes, this is outweighed in greenhouse effect by less than 20 airliners! It is apparent that wind turbines are no more than a 'green' smokescreen to persuade the public that 'something' is being done.

Road traffic versus windpower

What 'they' say

"The avoided annual CO_2 emissions from a 100 MW wind project is equivalent to taking 34,000 cars off the road."
(www.eere.energy.gov/greenpower/conference/9gpmc04/high.pdf)

The instantaneous power output of a small car at motorway speed is about 50 kW (Hayden 2004). Thus a 2.0 MW wind turbine at 30 % load factor, producing an average power output of 600 kW corresponds to about a dozen cars driving on a motorway. However one has to be circumspect in comparing with the 'car at speed' figure as no car is driven continuously in this way. The annual average is a different matter as it takes into account the majority of the time when the car is stationary.

In terms of CO_2 emissions a small car will be emitting about 18 kg CO_2/h at average motorway speed and commercial vehicles. much more. A 40 tonne truck averages about 32 litres of diesel fuel per 100 km and emits about 70 kg CO_2 per hour (see Appendix 2 for sources).

Taking an annual average, with the vehicle stationary for much of the time, Hayden (2004) suggests that a small car dissipates a continuous 2.25 kW in which case the 2.0 MW wind turbine is equivalent to about 270 cars.

The UK total of cars alone exceeds 20 million and is forecast to grow by 7 million (35%) between 1996 and 2010 (http://www.cfit.gov.uk/docs/1999/nrtt99/index.htm). How many wind turbines would we have to build each year merely to keep pace with domestic traffic growth alone? The answer is some 26,000 large turbines this is unimaginable and paralleling it with the uncontrolled increase of aviation the ludicrously small contribution of wind power to CO_2-control becomes dramatically apparent.

What can a wind turbine support?

The wind power companies say that a 1.0 MW wind turbine "supports" 600 to 700 homes (Section 6. Homes supplied by a wind 'farm').

However, few people understand how this number is calculated and it is maybe better visualised in terms of familiar domestic appliances.

It is often said that a 2.0 MW wind turbine can boil only 300 kettles. This is a slightly misleading comparison as a kettle takes only 2 or 3 minutes to boil and so the average output of our turbine would heat, say, 7000 kettles an hour and tens of millions per year.

It is better to compare with a continuously operating appliance such as the old fashioned radiant bar fire, without a thermostat. Each bar consumes 1 kW continuously.

A 2.0 MW wind turbine generates an average of 0.6 MW, at 30% load factor (i.e. 300 kW) so on average during the year it could supply electricity for just 600 fires.

However because of intermittency, on many days it will supply none and on very windy days it would run maybe 2000 fires. The intermittency has to be 'ironed-out' by feeding through the conventional electric network which provides backup much of the time.

Saving consumption – an example of energy efficiency in lighting

Energy-saver lamps can be bought for £2.00 - £3.00. A lamp rated at 20 W is of equivalent brightness to a 100 W incandescent lamp and so each one in use saves the consumption of 80W.

The Energy White Paper (DTI, 2003) says that by 2010, the renewables industry will receive £1 billion per year from the Renewables Obligation and Climate Change Levy and all consumers will pay this. If we spent this sum to give free energy-saver lamps it would provide over a third of a billion! This is ludicrous number, as there are only 24.4 million homes in the UK.

However buying 24.4 million lamps a year would displace the equivalent of 325 MW of continuous generation if they were used for just four hours a day (see Appendix 2). This would represent a capital expenditure of about £50 million per year – less than the cost of the Renewables Obligation paid for the equivalent amount of renewable generation - and it would save considerable money for the consumer.

Wind power in 2004 provided an average of just 221 MW of generation (DUKES 2005). Thus, in ROC buy-out price subsidy alone this exceeded £62.5 million. One is reminded that CPA (2005) concluded that "The Renewables Obligation is currently at least four times more expensive than the other means of reducing carbon dioxide…"

17. How can the need for electricity be met?

"You oppose wind power - so propose an alternative."

A dishonest diversionary tactic, this is repeatedly used by politicians and green campaigners when wind power is criticised in debate.

The honest questions which should be asked are: - "How shall we provide ourselves with electricity when fossil fuel runs out?" and "Should we reduce CO_2 emission now as a precautionary measure and if so, how?"

Neither questions nor answers are black and white - more a dirty shade of grey and certainly not 'green'!

Our technological civilisation is entirely dependent on an uninterrupted supply of electricity, free from significant deviations of frequency or voltage. That we are provided with this near-miracle is a tribute to the generating industry and a triumph for the National Grid which is now almost 70 years old.

It was expressed political opinion after WW2 that the UK would not have survived without the safety-net of the grid which insures against localised failure of generating plant or transmission. It is the height of folly for influential organisations to persuade government that the grid system should be dismantled in favour of localised distribution and 'micro-generation (Greenpeace, 2005). The fate of the de-nationalised railways is an ever-present warning.

The world is centuries from exhausting fossil fuel reserves, in particular coal (e.g. British Coal's annual report for 1991/1992), so any urgency about replacing coal-fired generation with emission-free electricity has to hinge on the need to reduce or stabilise atmospheric CO_2. The writer's view is that Earth has but one atmosphere of which one parameter, CO_2 concentration, has already been modified by one third of its pre-industrial value. We should stop.

There are several possibilities.

1. Continue to use fossil fuel and sequester the CO_2 (burial seems to be the only practicable scheme). Fossil fuel at present supplies 74 % of all electricity.

2. Replace fossil fuel with renewables. In order of present supply these are: -

i. Biomass combustion; ii. Hydro-electricity; iii. Wind; iv. Wave; v. Photovoltaic and other direct solar energy; vii. Tidal. Renewables in total, at present supply 3.6% of all electricity (with bio-fuels, mostly waste materials contributing over ¾ of renewable electricity and hydroelectricity a tenth of this)

3. Replace fossil fuel with nuclear. This is already proven technology as 25% of UK electricity was drawn from nuclear for many years and even now it is 20%. Despite the hysterical opposition even to mentioning nuclear power in 'green' quarters, it is essential that we discuss this option (SDC 2006). Nuclear power at present supplies 19 % of all UK electricity (and in France, our immediate neighbour and only internationally linked electricity source, nuclear supplies well over 70%.

1. CO_2 sequestration

The only practicable scheme is injection of CO_2 into porous geological strata, most easily accessed in worked-out oil wells where the overlying formations are by definition gas-tight and assumedly will prevent leakage of CO_2.

Small scale experiments in the US and Norway indicate that geological sequestration is feasible, but in the UK we have a serious problem that the only suitable strata are under-sea, in the North Sea oilfield. Some years ago the DTI (pers. comm.) pointed out that such disposal was constrained by our obligations under the London and Ospar Conventions which govern dumping at sea. More recently the IPCC (2005) has reported: -

"No formal interpretations so far have been agreed regarding whether… CO_2 injection into the geological sub-seabed or the ocean is compatible with certain provisions of international law… Currently, there are several treaties (notably the London and OSPAR Conventions) that potentially apply to the injection of CO_2 into the geological sub-seabed or the ocean."

Alternative and probably ill-conceived proposals for disposal of liquefied CO_2 into deep ocean water appear to have been abandoned on environmental grounds.

2. Renewables

Most renewable energy sources are derivatives of solar energy – either harnessed directly via solar heating or conversion to electricity using solar cells - or indirectly by biomass combustion, hydroelectricity, windpower and wave energy. The latter all rely on secondary access to the sun's energy through the biochemical process of photosynthesis or solar heat-driven evaporation of water or atmospheric convection.

The only exceptions are geothermal heat derived from deep earth processes and tidal energy related to harnessing of the sun's and moon's gravitational energy by global water movement.

As will be shown, none of the renewable means of electricity generation produce significant amounts of power because the energy density of solar radiation is very low even when concentrated by a 'real time' trapping process. The reason why 'fossil' solar energy in coal, oil and gas can produce so much more instantaneous energy is that it has been concentrated over enormous periods of geological time - hence the fact that it is definitely not renewable.

2.i. Biomass combustion at present is largely of waste materials and is nearly at its maximum potential unless it is significantly increased by growing dedicated fuel-crops. This is both impracticable (RAE 2002) and would displace land from food production in a starving world. Its current promotion by government seems to be irresponsible and yet another symbolic gesture, as is wind power.

2. ii. Hydroelectricity in the UK is close to its maximum capacity as geologically acceptable sites have mostly been used, and small scale run-of-river schemes can provide only a very small additional yield.

2. iii. It was shown in Section 5 that wind power is unable to make more than a small contribution to total generation and could not measurably alter atmospheric CO_2 concentration sufficiently to influence climate.

2. iv. Wave power, like many other 'techno breaks' is always just around the corner. In the writer's opinion the problem of wave damage and winter storms will prove insuperable. Shore installations will suffer repeated damage (just as do coastal defences) and all moored offshore devices seem to be little more than madness. Reviewed in ICE (2005a)

2.v. Photovoltaic (PV) and other solar energy. Solar energy as a source of low grade heat is old - predating technological culture. The cultivation of plants such as vines on sunward, heat-trapping slopes and the Roman construction of primitive plant shelters was the beginning, but it was not until glass became available in quantity that the 'greenhouse'(15th-16th C) and solar heating was on its way. Despite our cloudy climate, solar heating panels providing hot water are a cost-effective addition to any domestic building.

Photovoltaic silicon cells have been available for some years but so far expense has been a serious limiting factor and even today it seems that without enormous subsidy the pay-off period may be between 45 and 70 years, which is two or three times the predicted life of the cells (ICE 2005b). However in future, solar PV coupled to hydrogen production in low latitude deserts may come to replace our present reliance on fossil fuels though Hayden (2004) gives another view.

2. vi Tidal. The only significant tidal generator in the world is the Rance estuary, a 240 MW impoundment scheme in Brittany. The only worthwhile UK site is the Severn Estuary which could provide in excess of 5% of UK generation from a major impoundment with 8640 MW capacity. The Severn barrage is at present in abeyance for reasons of environmental impact and high cost of electricity. All remaining potential for impoundments or for tidal current generators (still technologically undeveloped) is so small as to have little realistic impact in reducing total CO2-emitting generation. See review in ICE (2005a). At the moment tidal energy effectively provides no electricity in the UK.

3. The nuclear option. Until very recently it has not been possible to discuss nuclear power without a hysterical outcry from the ‘green’ organisations and individuals (Etherington 2003b). However, though the writer has for half a lifetime been convinced that it would be a safer future if the world could dispense with nuclear power it must be discussed in open forum.

The decision about nuclear also has to be taken in the context of risk from climatic change and the precautionary assumption that it is anthropogenic. The proponents of anthropogenic global warming assure us that thousands are already dying, for example the US charity, the Natural Resources Defense Council says: -

“Warning signs today: In 2003, extreme heat waves caused more than 20,000 deaths in Europe and more than 1500 deaths in India.”
http://www.nrdc.org/globalWarming/fcons.asp

Even more extremely, James Lovelock of Gaia fame, wrote: -

"... before this century is over billions of us will die and the few breeding pairs of people that survive will be in the Arctic." (*Independent* 16 January 2006). Lovelock has also said that the only hope is rapid deployment of more nuclear power.

Promotion of nuclear power has always provoked heated exchanges to the extent that the words 'Chernobyl' and 'Three Mile Island' are now synonymous with global doom. However, a recent UN analysis shows that the direct death toll from the Chernobyl accident was less than 50 (The Chernobyl Forum, 2003–2005). This is the only accident worldwide which has caused significant radiation deaths. The second most serious nuclear power accident at Three Mile Island, Pennsylvania, was held in check by safety measures and caused no deaths or exposure of the public to radiation.

We cannot discuss the nuclear option unless opponents and proponents are willing to have open debate based upon facts. Do we want nuclear power and is it a 'green' energy source - or do we tolerate climate change (if indeed we can do anything about it)?

The climate is changing – of opinion as well as weather. In early 2006, the Sustainable Development Commission, chaired by Sir Jonathon Porritt (former chair, FoE), hedged its dislike for nuclear power by saying that: -

"Nuclear power may be able to make a useful contribution to the UK's economy, by providing low carbon electricity at a competitive price."

However the SDC also raised many pertinent questions about relative cost and future safety but closed on the note of open debate: -

"Nonetheless, the majority of the Commission also believes it is right for the Government to continue to assess the potential contribution of new nuclear technologies for the future, as well as pursuing answers to our nuclear waste problems as actively as possible."

More recently the *Financial Times* (March 30 2006) reported that Government Chief Scientific Adviser, Sir David King "believes 40 per cent of Britain's electricity should come from nuclear generation."

However, Sir David has however missed a trick. We could have a lot more than 40% nuclear, as does France, thus meeting the 2050 target of 60% carbon-free as early as 2015-20. It is patently obvious that no renewable technology, least of all wind power, could approach such a saving. The reason for setting a 40% limit is the risk of over-generation because nuclear plant cannot easily be 'turned-down'. However with the surplus nuclear generation harnessed to hydrogen production, the gas could be used to fuel electricity generation at peak times, or the hydrogen could be diverted into transport fuel. The technology for all this exists at the moment, as proponents of wind power often tell us (Section 4. The problem of intermittency and need for backup).

Nuclear generation is most suited to providing base-load electricity supply as it runs continuously at peak output with infrequent interruption for maintenance.

18. Conclusion

Many politicians seem totally convinced that sea level will rise massively within a few decades as a result of 'global warming' and use this as justification for 'green' measures some of which may be sensible and others such as wind 'farms' which seem on critical analysis to be nothing more than money-making ventures as they would have no effect on climate change and sea level even if the worst predictions prove true..

One has to ask in any case whether the ‘warming’ scenarios are believed by the politicians – for example the Welsh Assembly has just completed its new Cardiff headquarters, almost at sea-level. Governments do not believe their own *Day after tomorrow* scenarios and yet reiterate the ‘green vote-catcher’, that wind turbines are "essential to tackle global warming"!

We have already seen that wind power cannot in the near future displace more than a few ten-thousandths of world CO_2 emission. Just what would they achieve other than filling a wind power salesman’s order book?

So, returning to our introductory criteria: wind ‘farms’ cannot be developed in sufficient numbers significantly to reduce CO_2 emissions and they cannot significantly slow the depletion of other fuels nor produce a reliable and sufficient amount of electricity to replace nuclear power stations.

It is almost unimaginable that anyone can believe that windmills might change the weather. But many still do!

I close this account with sympathy for the thousands of people, worldwide, who could write, as has the Marton, Askam & Ireleth Windfarm Action Group (MAIWAG): - “*The windfarm is noisy, it is a visual blight, it does create shadow flicker, it has resulted in very little benefit to the local economy, it has not resulted in an increase in tourism and negotiating with PowerGen Renewables and Wind Prospect to try to resolve the problems has been a most unpleasant experience for all those involved. Simply put, we want our quality of life back.”*
(http://www.windfarm.fsnet.co.uk/index.htm).

Appendix 1. Climatic change, Kyoto and the future

Introduction

No sensible person denies the fact of climate change or indeed the fact that climate is warming at this time. It would indeed be rather odd if it were not. We are in the midst of an interglacial warm period, one of many which are embedded in a cyclic succession of cold periods, some of them ice-ages, which have repeated inexorably many tens of times during the past 1.5 to 2 million years.

The fact of man-made global warming is more controversial, but as noted in Section 5 (Calculating CO_2 emissions and saving), whether or not one accepts the tenets of a simple, one-factor CO_2 -driven model of climatic warming it can be shown that wind power in particular cannot provide a significant or cost effective means of displacing CO_2 emission, or limiting fossil fuel consumption sufficiently to alter climate.

However the assumption that man-made CO_2 will cause the world to become a warmer place is advanced as a prime reason for limiting the burning of fossil fuel. One approach has been the introduction of several sources of renewably generated electricity. At the moment wind power is the fastest growing of these.

What ‘they’ say

"Harnessing the natural power of the wind is essential to tackle global warming."
Yes2wind Home-page http://www.yes2wind.com/

The above claim is untrue, but it is advanced so often that a brief discussion of the nature of global warming is presented in this Appendix for interested readers.

The Kyoto Protocol

In response to fears of man-made global warming many governments have adopted the terms of the Kyoto Protocol which is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify the protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases (see notes), or engage in emissions trading if they maintain or increase emissions of these gases.

The targeted reduction of collective emissions of greenhouse gases will be 5.2% compared to the year 1990 (compared with the emissions levels that would be expected by 2010 without the Protocol, this target represents a 29% cut).

In 2002, all fifteen then-members of the European Union ratified the Protocol at the UN. The EU produces around 22% of global greenhouse gas emissions, and has agreed to a cut, on average, by 8% from 1990 emission levels.

The UK chose to adopt a more stringent target of a 12.5% reduction in greenhouse gas emissions (from 1990 baseline) by 2008 to 2012. However, the government subsequently affirmed a domestic goal of 20% by 2010. The contribution from the British power generating industry is set to be 10% of total electricity generation from renewables by 2010.

The major global emitter, the USA, has however failed to ratify the Protocol, as has Australia, whilst the two developing countries, China and India have ratified the protocol but are not required to reduce carbon emissions under the present agreement though their fossil-fuelled emissions are rising at a formidable rate which will make them second only to the US by mid-century (the US currently contributes about a quarter of global CO2 emission).

Emission trading.

The UK Emissions Trading Scheme is a voluntary scheme covering emissions of greenhouse gases... The idea is that businesses reduce their emissions and receive tradable 'allowances' in return. One Allowance Unit equals one tonne of CO_2. These allowances can be traded in a 'virtual' open market hosted on a website overseen by Defra. The revenue from selling allowances is an incentive to businesses to reduce their emissions.
http://www.netregs.gov.uk/netregs/275207/1018642/?version=1&lang=_e

The Netregs website says the process "... is complex, and a full explanation of its working is beyond the scope of this website."! It is. More detail can be found at http://www.defra.gov.uk/environment/climatechange/trading/uk/index.htm?lang=_e .

The mechanism 'works' as a money generator. The UK recently announced their option to sell an 8% 'over-achievement' against the UK's emissions reductions commitment to the US for around £100 million! Rather like the RO arrangement it seems that money may be as important as emission control in this matter.

As I finally proof-read this document (May 2006) there are rumblings that many power companies have benefited from increases in electricity prices brought about by the EU carbon credit scheme, without needing to make any extra investment in return with the possibility that the unwarranted profit could reach around £1bn (BBC News, May 1). Despite this, carbon prices continue a collapse that has wiped up to 50 percent off the value of carbon during late April. Watch this space!

What is 'global warming'?

A simplistic answer to this requires a little bit of physics. Energy from the sun reaches us as short-wave radiation (a mixture of visible light, ultraviolet and infra red). The atmosphere and earth's surface absorb some of this radiation, the balance being reflected back to the cosmos.

This absorption of radiant energy warms earth's surface and atmosphere, and without a balancing process earth would rapidly heat up to a lethal temperature. The balance is provided by loss of long wave infra-red radiation (radiant heat).

It is a matter of geological history that these two processes have maintained an equilibrium temperature in the very narrow 'window' for the molecular structure of life for over 3.5 billion years. Living processes cannot continue much below 0^o Celsius and above about 60^o to 70^o C almost all organisms die.

That I am here to write this, and you are reading it at this moment in geological time is of great significance to the controversy about 'global warming' and the future!

The 'normal' state for the earth is that balance between incoming and outgoing radiation maintains a life-supporting temperature within these extremes. The balance is governed by the composition of earth's atmosphere. Without atmospheric gases the surface of a planet shows dramatic temperature swings well down toward absolute zero (minus 273^o C at night and up to several hundred ^oC during the day.

The presence of an atmosphere both ‘shades’ and 'blankets' this effect. Incoming short wave radiation is attenuated by the gases of earth's atmosphere and a substantial proportion is reflected back to space from cloud tops (cloud being a mist of very fine water droplets). The net income of solar radiation warms the earth and its atmosphere.

This warming is balanced by the long-wave energy loss from surface and atmosphere to space. Water vapour and carbon dioxide in the atmosphere are particularly effective at 'blanketing' long wave loss. Water vapour is the major greenhouse gas accounting for some 95% of the infra-red blanketing and its concentration is barely affected in the short term by human activities because the greatest sources are evaporation from ocean surfaces and from vegetation (though the atmosphere can hold more water vapour if it is warmer).

Carbon dioxide CO_2 is a minor constituent of the atmosphere despite its overwhelming importance to life as the source of carbon for photosynthesis. Its concentration was less then 280 parts per million by volume (ppmv), or 0.028% v/v, prior to the Industrial Revolution. The burning of fossil fuels has increased this by about a third, to 373 ppmv in 2002, thus it is still a very minor component by volume or mass.

However CO_2 is a very active 'greenhouse gas' being transparent to the short wave income but strongly absorbing the upward flux of long-wave thermal infra-red. As a result it has been assumed from the early 19th century that increasing atmospheric CO_2 concentration would cause temperature increase - often known as 'global warming'. Fourier (1807) first advanced the 'greenhouse' analogy and Arrhenius in 1896 attempted to calculate temperature changes related to different CO_2 concentrations.

Has global temperature been constant in the past?

Most certainly not. Through deep geological time, the earth's mean temperature has fluctuated widely but always within the 'window' for life to persist. The latest geological Period, the Quaternary, covering the past 2 million or so years has seen a cyclic repetition of many warm and cold periods - the coldest becoming full glaciations ("Ice Ages"). We know from ice-core records that CO_2 and another greenhouse gas, methane (CH_4) rose and fell in concentration synchronously with warming and cooling - possible even slightly preceding the temperature changes. There could of course have been no ‘anthropogenic’ effect on CO_2 concentration during any of these oscillations.

The present time is a mid- to late-interglacial, of which there have been many cyclic recurrences. The peak temperatures at our latitude became sub-tropical last time (fossil evidence) and almost certainly this will happen again. ‘Chemical fossil’ evidence from ice-cores in the Antarctic and Greenland tells us that atmospheric CO_2 and CH_4 increased in concentration during these interglacial warming periods and then declined again as the following glacial periods ensued. There were no industrialised humans burning coal at these times!

During our current interglacial, the temperature of the Northern Hemisphere has been rising in sporadic fashion since the glacial maximum (c.18, 000 years ago). Warming was faster during the final de-glaciation (ended c.10,000 years ago) but has continued sporadically ever since - much more slowly in the past 2,000-3,000 years.

By the middle of last interglacial period the sea level had risen several metres above present OD, as a result of thermal expansion and partial melting of landlocked "ice-caps". Wales has some spectacular remains of "raised-beaches" which record the last such event which, it is certain, will recur. As part of this natural geological process, the sea will reach a similar level within possibly hundreds, and certainly thousands, of years. We can do nothing to prevent this and need to plan for it.

It is indeed possible that the human contribution to CO_2 enrichment may speed the warming process but before embarking on policy decisions, the proponents of warming must explain how CO_2 and CH_4 increased previously without human intervention. More crucially, how did the concentration decline again as the climate cooled into the succeeding glaciation? What physical process flip-flops warming and cooling in the absence of human interference. We do not know.

Not only have we the geochemical and physical record of very large, cyclic temperature oscillations causing the glacial-interglacial periods, we also know in some detail that our present interglacial has repeatedly warmed and cooled to a lesser extent. The Bronze Age temperature optimum in N Europe began with warming in c. 2700 BC, lasting until c. 650 BC when a deterioriating, wetter and colder climate introduced the Iron Age. The Medieval Warm Period (750-1300 AD) marked the next temperature increase allowing Norse settlers to colonise Greenland where there are the archaeological proofs of burials amongst tree roots on surfaces which are now tundra-covered permafrost and could not, today, support trees. According to pioneering climatologist, Hubert Lamb, sea ice was unknown south of 70^o north between 1026 and 1194.

The MWP was followed by the plummeting temperatures of the Little Ice Age (LIA) spanning the mid-1500s to the early 1800s. The settlements in Greenland died, and by the late 1800s, montane snow lines were 100 m lower than in the 1970s. One remarkable historical and artistic record was provided by the frost fairs which were held on the Thames in London from about 1500 to the last, in 1813-14. The middle of the LIA coincided with the Maunder Minimum of low sunspot activity (some years having no sunspots at all).

Beginning around 1850, the world's climate began warming again and the Little Ice Age may be said to have come to an end at that time. It is possible that the Earth's climate is still recovering from the Little Ice Age accounting for the sporadic rise of temperature throughout the 20^{th} century. It has indeed been suggested that the LIA was the beginning of a Rapid Climate Change Event (RCCE) which the ice core record suggests should last 1000 years or more: this is discussed below.

Despite the remarkable body of evidence for considerable historical and earlier climatic change, with CO_2 and CH_4 fluctuation unrelated to human activity, we now assume there is a CO_2-mediated warming problem which should be 'stopped' even though we do not understand how the mechanism works. We cannot even suggest causes for its functioning in the geological past when CO_2 and CH_4 increased and decreased without human intervention. Removing gear wheels in a clock, to make it keep time, comes to mind!

Is there a true consensus on 'global warming'?

What 'they' say.

"To capture the public imagination, we have to offer up some scary scenarios, make simplified dramatic statements and little mention of any doubts one might have. Each of us has to decide the right balance between being effective, and being honest."
(Dr Stephen Schneider, leading US proponent of ‘global warming’ in an interview for "*Discover*" magazine, Oct 1989)

“Scientists don't have a Hippocratic oath, but we have to tell the truth. Everybody's truth is relative.” (Dr Stephen Schneider in an interview for PBS (Public Broadcasting Service website 2006)

"On one hand we have the Intergovernmental Panel on Climate Change, the rest of the world’s major scientific organisations as well as the Government’s major scientific organisations all pointing to the need to cut emissions. And on the other, we have sceptics... who deny that the scientists are right." (President of the Royal Society, Sir Robert May 2005)

And the 'other side'?

"We have some concerns about the objectivity of the IPCC process, with some of its emissions scenarios and summary documentation apparently influenced by political considerations." (HoL Select Committee on Economic Affairs 2005)

“Much of the billions of dollars earmarked for implementation of the protocol in Canada will be squandered without a proper assessment of recent developments in climate science... If, back in the mid-1990s, we knew what we know today about

climate, Kyoto would almost certainly not exist, because we would have concluded it was not necessary." (Open letter to Canadian Prime Minister, signed by 60 senior scientists – April 2006 – see note on Canada - Kyoto)

The doubt about human induced global warming is not a matter of denying climate change but of questioning the mathematical modelling process which relies largely on a single factor: CO_2 concentration. The IPCC presents 19 sophisticated models of the climate system that give 19 different answers as to what would happen if the CO_2 concentration were to double. This does not inspire confidence in the IPCC's conclusion. Many analyses neglect, or are unable to allow for, the potential negative feedbacks (see notes) caused by several other factors such as cloud (i); some ignore the non-linearity of rate controlling relationships with e.g. CO_2 concentration (ii); many neglect the known variations of solar income related to orbital and other astronomical and atmospheric processes (iii) and no attention is paid to the likely course of natural change (iv).

i. Cloud

Cloud is made up of water droplets which reflect a large amount of incoming sunlight back to space. It may also absorb some of it and become warmer. It may also serve as a 'blanket', preventing the escape of long wave infra red radiation.

Rising temperature causes more evaporation of water and increases the water holding capacity of air so inducing cloud formation which might cause warming - or it might cause cooling. Meteorologists don't know which and, in 2000, the IPCC wrote: -

"The sign of the net cloud feedback is still a matter of uncertainty."

This is still true and without knowing whether cloud causes a net positive or net negative feedback no climate-predictive model can give a valid output.

ii. Saturation of the long wave infra-red absorption curve of CO_2

Surface heating by the 'blanketing' of long wave infra red loss is not linearly related to CO_2 concentration

Imagine coating a greenhouse with shading-paint: it absorbs and reflects sunlight, reducing the intensity in the 'greenhouse below. Paint another layer and less light enters the greenhouse. Repeat several more times and the greenhouse becomes 'dark'. Addition of more shading has no further significant affect. CO_2 has exactly this effect on the outward transmission of long wave infra red from earth's surface and is already in near the 'last coat' concentration.

For this reason, doubling present CO_2 concentration would not of necessity double the equilibrium temperature change. Global warming protagonist Stephen Schneider, cited above, was thinking differently in 1971 when he wrote that: - "although the addition of carbon dioxide in the atmosphere does increase the surface temperature, the rate of temperature increase diminishes with increasing carbon dioxide in the atmosphere." (Schneider & Rasool, 1971). However our knowledge of atmospheric physics has not changed since then and yet Schneider told a BBC Channel 4 audience in 1990 that: -

"The rate of change [of temperature] is so fast that I don't hesitate to call it potentially catastrophic for ecosystems".

iii. The equilibration-time of CO_2 mediated 'warming' processes

Sir John Houghton, IPCC, recently told the Welsh Assembly Government that even if we totally stopped all world emissions (no industry, no transport, no fossil fuel and no electricity), it would take between 50 and 100 years before temperature increase and sea level rise stopped (Houghton 2002).

The *raison d'étre* of Houghton's statement is that ocean water contains both dissolved CO_2 and also chemically combined CO_2 in the form of the bicarbonate anion, both in contact with geologically large amounts of calcium carbonate. The equilibration time of atmospheric CO_2 with ocean water is long but the 'buffer' action of the CO_2 – carbonate – bicarbonate is much longer – many tens of years so any reduction of CO_2 input to the system will be balanced by CO_2 release from the ocean buffer.

vi. Astronomic and other external controls

Solar irradiance has more impact on climate than small changes in atmospheric chemistry. Doubling the amount of CO2 in our atmosphere would have the same effect as increasing input of solar radiation by 0.1% more or less... This is about what ACRIM has measured for the solar fluctuations. http://solar-center.stanford.edu/sun-on-earth/varsun.html .

Solar irradiance of the upper atmosphere varies naturally with both solar activity and earth's orbital changes whilst the heating effect on atmosphere and surface is also influenced by natural variations in cloud cover, volcanic dust and atmospheric chemistry, some of them cyclic. Further periodic and random changes of surface climate may be controlled by alteration in the circulation patterns of ocean and atmosphere.

In the very short term the 11-year sunspot cycle has relatively little effect on global weather but longer cyclic minima in solar activity can been seen around 1300 (Wolf Minimum), 1500 (Spörer Minimum), 1700 (Maunder Minimum), with a smaller excursion around 1800. A solar variation thus coincided with the close of the Medieval Warm Period and the onset of the Little Ice Age (see: Has global temperature been constant in the past?)

On a longer time scale, according to the founder of the Climatic Research Unit, UEA, the cyclic variation in earth's orbit "seems to put the thesis that these orbital variations control the timing of ice ages and interglacial periods beyond reasonable doubt" (Lamb 1995).

More recently evidence has accumulated from other parts of the solar system - for example, in 2005 NASA reported for, the third year running, a shrinkage of the frozen carbon dioxide 'ice-cap' near the south pole of Mars, which suggests that climatic warming is in progress (http://mars.jpl.nasa.gov/mgs/newsroom/20050920a.html). This is most likely to be a function of changing solar irradiance (unless we assume emissions from Martian canal-barges!).

Until much more information is available it is a dubious interpretation to suggest that the current warming trend on earth is controlled entirely by CO2 as a single driver.

v. What might be happening naturally?

A serious flaw in the application of temperature trend models to current events is that the starting point has been assumed to be an average temperature climate approximating that of the past century.

However Paul Mayewski gives another slant to this. Mayewski was the leader of the Greenland Ice Sheet Project 2 (GISP2) and his work has highlighted the common occurrence of Rapid Climate Change Events (RCCEs) during the recent warm period (Mayewski & White 2002).

Mayewski suggests that the Little Ice Age (see above) was a typical RCCE, in which case it should have lasted over 1000 years starting from the 1500s, as did the Younger Dryas period, and the many other RCCEs in the core and sediment records.

However, this did not happen and by the early 1800s the LIA cold had started to recede, which Mayewski interprets as the beginning of anthropogenic CO_2 warming.

In the event of Mayewski being right, then our industrial tampering has actually kicked the Northern Hemisphere into a climatic condition which is far more favourable for humanity than it would be if the 1000 year LIA were still running its course. Again, suggestions for interference with climatic processes seem akin to tampering with the gear wheels in a clock! Good thing perhaps that "windmills cannot change the weather"!

Appendix 2. Calculations for Section 16. Comparisons

Energy- saver lamps If switched on for just four hours a day the saving of electricity by one 100 W-equivalent brightness lamp would be 80 W multiplied by (4 x 365) hours - 116.8 kWh per year. With one such lamp per home in the UK, all 24.4 M lamps would save 2850 GWh per year, the equivalent of 325 MW of generation

Boeing 747 airliner Each aircraft carries a 150-170 tonne full fuel-load which is burned within a 24 hour operations cycle. It combines with a larger weight of oxygen to produce CO_2: -

Jet fuel contains c. 86% carbon. Thus 160 x 0.86 = 138 t carbon/24 h. This converts by molecular weight ratio 44/12 to the weight of CO2.

Thus a 747 emits, on average, more than 138 x 44/12 = **506 t CO2/24h**

The installed capacity of Cefn Croes is 58.5 MW. Allowing a generous 30% load factor, and also using BWEA's exaggerated CO_2 equivalence (Section 5.), the 24 hour saving will be: - 58.5 MW x 0.3 x 24 h x 0.86 t CO_2/MWh = **362 t CO_2/24 h**

Calculating with the more realistic 'mixed-fuel' CO2 displacement (Section 5) this 362 t CO_2/24 h would be reduced to 181 t CO_2/24 h – thus one aircraft would outweigh almost three huge wind 'farms'!

Truck and car fuel consumption

A MAN 40 tonne 5-axle truck returned an over-all consumption of 31.9 litres diesel per 100km in a road test report (*Motor Transport* magazine, 11 January 2001) and, at 2.68 kg CO_2 per litre (http://www.defra.gov.uk/environment/business/envrp/gas/05.htm), would emit 69 kg CO_2 /hour at 80 km/h.

An average sized car would consume much less hydrocarbon fuel, emitting, say, 18 kg to 20 kg CO_2 /hour. (NEF CO_2 calculator http://www.nef.org.uk/energyadvice/co2calculator.htm)

References and notes

ASA adjudication 21 December 2005 – misrepresentation of CO_2 emission control. Calculation as coal-fired or as mixed-fuel grid average? http://www.asa.org.uk/asa/adjudications/non_broadcast/Adjudication+Details.htm?Adjudication_id=40704

Bass, R.J. & Wilmot, P (2004) Wind Power may not be the answer. *UK Power* Issue 2.

Bowdler (2005) *ETSU-R-97 Why it is Wrong* – written for Whinash Public Inquiry.

Brandenburg State Environment Office (2006) *Vogelverluste an Windenergieanlagen in Deutschland Daten aus der zentralen Fundkartei der Staatlichen Vogelschutzwarte im Landesumweltamt Brandenburg zusammengestellt*: Tobias Dürr; Stand vom: 11. Januar 2006].

British Wind Energy Association (BWEA) (2006) Homes supplied – website data.

BWEA (2005) Website http://www.bwea.com/

BWEA (2006) Website fact sheet *Noise from Wind Turbines: the Facts*

Canada – Kyoto (2006) An open letter to Prime Minister Stephen Harper signed by 60 senior specialists, mostly in the climatological or related fields. The letter disputes scientific 'consensus' on the matter of CO_2-driven global warming. It is reproduced at http://www.canada.com/nationalpost/news/story.html?id=3711460e-bd5a-475d-a6be-4db87559d605

Cefn Croes (2005) Environmental Management Committee (Minutes 23 February 2005).

Chernobyl Forum (2003–2005 Second revised version) *Chernobyl's Legacy: Health, Environmental an Socio-economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine.*

Country Guardian (2000) *The Case Against Wind 'Farms'* (previous edition).

CPA (2005) *House of Commons Committee of Public Accounts report on the DTI*

Danish Wind Turbine Manufacturing Organisation (1997). The Energy Balance of Modern Wind Turbines. *Wind Power* 16 (Krohn, S. ed).

DEFRA (2004) *Consultation on the review of the UK Climate Change Programme* (the report actually gives a figure of 2.5 Mt carbon/year saved by renewable electricity generation [mainly wind]. This is equivalent to 9.2 Mt CO_2).

DTI (2005). *A Guide: Sale of power opportunities for distributed generators. Part B. The Guide*.

DTI (2005) *Annual Abstract of Statistics*

DTI (2005) Renewable Energy website Renewables explained FAQs Wind power: 10 myths explained (http://www.dti.gov.uk/energy/sources/renewables/renewables-explained/intro/intro-faqs/Wind%20power%2010%20myths%20explained/page16060.html)

DTI (1999 N&R Energy) *New & Renewable Energy Prospects for the 21st Century The Renewables Obligation Statutory Consultation*

DTI (2003) *Energy White Paper*

DUKES (2005) *Digest of UK Energy Statistics*

ESB, the Irish National Grid (2004) *Impact of Wind Power Generation in Ireland on the Operation of Conventional Plant and the Economic Implications.*

E.ON (2004 & 2005) *Windpower Report 2004.* Ditto *2005.*

Etherington (2003a) Windpower and saving of CO_2-emission. www.wind-farm.org (no longer accessible. Copy available from author).

Etherington (2003b) Opposition to Wind Power: The Nuclear Smear. www.wind-farm.org (no longer accessible. Copy available from author).

Feedback. The process of self-correction in which an environmental change triggers a correcting response. For example when a fridge gets too cold, its thermostat switches- off the electricity allowing it to return to the correct temperature before triggering 'switch-on' again. This is a negative feedback. A positive feedback would be one in which falling temperature increased the cooling process and the fridge would become progressively colder in a 'runaway' freeze.

Greenhouse gases. The six greenhouse gases embraced by Kyoto are: - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) – all largely from natural sources and - sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) mostly from human activity.

Greenpeace (2005). *Decentralising Power: An Energy Revolution for the 21st Century*

Hansard (18 November 2003) Column 1851 reply: Lord Sainsbury of Turville [for DTI]: “The calculations that I have given assume a load factor of 30 per cent onshore and 35 per cent offshore. They are realistic figures......”

Hayden, Howard C. (2004) *The Solar Fraud: Why Solar Energy Won’t Run The World*. 2nd edn. Vales Lake Publishing.

HMSO (2005) *Social Trends,* 34, Table 2.1. 24.6 million homes in the UK Social Trends.

House of Lords Select Committee on Economic Affairs 'The Economics of Climate Change', July 2005

House of Lords Select Committee on the European Communities, 12th Report, Session 1998-99, *Electricity from Renewables* HL Paper 78. BWEA fact sheet on noise cites this: - "thanks to improvements in technology ...., noise is no longer the issue it was."

House of Lords (2003-04) Science and Technology Committee - *Minutes of Evidence Session 2003-04* http://www.parliament.the-stationery-office.co.uk/pa/ld200304/ldselect/ldsctech/999/4021101.htm

ICE (2005 a) Kerr, D. Marine energy: getting power from tides and waves. *Civil Engineering* (Proceedings of ICE) 158, 32-39.

ICE (2005 b) AbuBakr, R. Solar photovoltaic energy: generation in the built environment. *Civil Engineering* (Proceedings of ICE) 158, 45-51.

IPCC – Intergovernmental Panel on Climatic Change.

IPCC (2000) *Special Report on Emissions Scenarios*. "The sign of the net cloud feedback is still a matter of uncertainty."

IPCC (2005) *Special Report on Carbon dioxide Capture and Storage: Summary for Policymakers.*

Jago, P & Taylor N (2002) *Wind Turbines and Aviation Interests - European Experience and Practice*. ETSU W/14/00624/REP DTI PUB URN No. 03/515

Lamb (1995, 2nd edn.) *Climate History and the Modern World*. Routledge.

Manwell, J. F., McGowan, J. G. & Rogers, A. L. (2002) *Wind Energy Explained.* Wiley, Chichester

Mayewski, P. & White, F. (2002) *The Ice Chronicles*. University Press of New England.

O'Brien, M. (2005) Letter of response to Ian Cawsey MP representing Humberhead against Turbines. DTI Ref 00523006. 15 March 2005. The relevant paragraph of an attached sheet of notes reads: "We agree with the paper that it would be appropriate to use an average generating mix when calculating CO2 savings from a wind turbine. This is consistent with DTI Wind Energy factsheet 14."

OECD Factbook 2005. *Economic Environmental and Social Statistics* (c. 24,000 Mt CO_2 total global emission p.a. of human origin – by ratio the UK renewable electricity target saving is 0.00038 – about four ten-thousandths)

Ofgem (2006.) http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/13428_0306.pdf Use of Compulsory Purchase Orders.

Oxford Environmental Change Institute (2005). *Windpower and the UK Wind Resource* ed Graham Sinden.

Pedersen, E & Waye, K. P. (2005) Human response to wind turbine noise – annoyance and moderating factors *1st Int. Meeting Wind Turbine Noise: Perspectives for Control,* Berlin.

Pierpont, N. (2006). *Wind Turbine Syndrome* Testimony before the New York State Legislature Energy Committee

PPS 22 (2004) *Planning Policy Statement 22: Renewable Energy* http://www.odpm.gov.uk/index.asp?id=1143908

Prices. Electricity prices are quoted in different units, most frequently pence/kWh for domestic charging, and £/MWh in commercial transactions. 1.0 p/kWh = £10/MWh i.e. multiply the digits by 10 to convert p/kWh to £/MWh. Wholesale electricity price fluctuates very widely on the short-term market, related to supply and demand. When the RO scheme was introduced in 2002 it averaged under £20/MWh but has now doubled in cost (2006), reflecting soaring fuel prices.

RAE (2002) *An Engineering Appraisal of the Policy and Innovation Unit's Energy review* prepared by The Royal Academy of Engineering for Mr B. Wilson MP, Minister of State for Energy and Industry.

RCEP (2002) *The Future Development of Air Transport in the United Kingdom: A National Consultation, Response by the Royal Commission on Environmental Pollution.*

Remax Estate Agency (2005). *Report on a sample of properties inspected near a proposed wind farm at Esgairwen Fawr*

Reserve capacity. The National Grid plc aims for a system margin of about 20% over peak demand thus insuring against generating plant or transmission failure. Some of this spare capacity would be on 'hot standby', i.e. connected to the network and operating at part load to ensure a stability of connection as in the case of steam plant, or available for instant start-up and connection as is the case for hydro and gas-turbine plant.

RICS Survey (2004) *Impact of wind farms on the value of residential property and agricultural land.*

Royal Society of Edinburgh (2005). Birkett, D. G. Submission to the Royal Society of Edinburgh Investigation of Response Times for Standby Generation Plant. http://www.royalsoced.org.uk/enquiries/energy/evidence/Birkett.pdf

Schneider S. & Rasool S., 1971. Atmospheric Carbon Dioxide and Aerosols - Effects of Large Increases on Global Climate". *Science*,173, 138-141

Smallwood, K.S. and Thelander, C.G., Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area, Public Interest Energy Research Program Contract No. 500-01-019, *Final Report to the California Energy Commission*, 2004, www.energy.ca.gov/pier/final_project_reports/500-04-052.html)

Styles, O. et al (July 2005) *Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibration from Windfarms: Recommendations on the siting of Windfarms in the Vicinity of Eskdalmuir, Scotland.* University of Keele.

Sustainable Development Commission (2005). Windpower *in the UK*
In May 2005 he Commission, chaired by Sir Jonathon Porritt, further supported the use of a lower CO_2 emission displacement figure. The following is cut and pasted from p35 of a corrected version dated November 2005 (http://www.sd-commission.org.uk/news/resource_download.php?attach_id=ENILFIX-SEUWJ78-N9277OA-BE2Y669): -

"... one must make some assumptions as to how much carbon wind energy output is displacing. There are large differences between the CO_2 emissions associated with coal (243 tC/GWh) compared to natural gas (97 tC/GWh), with none associated to nuclear power. As already explained, it would be unrealistic to assume that wind energy would displace any nuclear capacity, and it is most likely that it will displace coal in the short to medium term. However, the actual CO_2

displacement in 2020 is hard to estimate and so for the purpose of this report, it has been assumed that wind output will displace the average emissions resulting from gas-fired plant. This figure is likely to be conservative, as in reality some coal-fired generation is likely to exist in 2020. However, it is the figure that the DTI use and is used here"

[the conversion of 97 tC/GWh to t CO_2 /MWh gives a figure of 0.36 t CO_2 /MWh which is substantially less even than the 0.43 t CO_2 /MWh used by DEFRA/DTI]

Sustainable Development Commission (2006). The role of nuclear power in a low carbon economy.

TAN 8 (2005) *Technical Advice Note 8: Planning for Renewable Energy,* Welsh Assembly Government.

Tourism Operators in North West Lewis (2004) *North West Lewis Visitor Survey into Attitudes to Windfarm Development*

UKERC (2006) *The Costs and Impacts of Intermittency:* http://www.ukerc.ac.uk/content/view/259/953

Units and terminology. The fundamental unit of electrical generation or consumption rate is the watt (W). As the watt is a tiny rate, domestic usage is mainly reckoned in kilowatts (kW). The prefixes such as 'kilo-' are multipliers of 1000, so a kilowatt = 1000 W. In sequence we then have mega- (M), giga- (G) and tera- (T), thence MW, GW and TW – a terawatt is a million, million watts (10^{12} W). The total amount of electricity delivered or used is calculated by multiplying by time in hours – the watt-hour (Wh). Domestic total consumption is conveniently expressed in kWh (the domestic Unit) and the larger amounts of electricity from power stations in MWh, GWh or TWh.

VisitScotland (2003) *Investigation into the Potential Impact of Wind Farms on Tourism in Scotland*

Wales Tourist Board (October 2003) *Investigation into the Potential Impact of Wind Farms on Tourism in Wales.* Summary report;

Yes2Wind (Friends of the Earth, Greenpeace and WWF) www.yes2wind.com