Sustainability Committee
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CONSERVATION of UPLAND MONTGOMERYSHIRE

Conservation of Upland Montgomeryshire is a voluntary organisation with a membership of over 300 drawn almost wholly from people resident in North Powys. Our primary activity is campaigning to protect the best of Montgomeryshire's unspoilt upland landscapes and wildlife habitats. We do this within a remit that calls for evidence-based decisions and this clearly leads us to recognise that our activities must give due weight to the importance of increased national energy security and reducing greenhouse gas emissions (primarily CO_2). This in turn dictates a requirement for rigorous analysis of landscape-based energy generating projects. Where there is unequivocal evidence that such projects would contribute to truly qualitative changes in energy security and greenhouse gas emissions we recognise that local sacrifice can be of national and indeed global value and we supported such developments However, where such evidence is absent, equivocal or fails to demonstrate significant value we oppose the sacrifice of treasured landscape to such projects. (See appendix 1 for a wider contextual statement).

1) Within the above remit we take the view that Britain's and indeed Wales' role in securing a really meaningful reduction in global greenhouse gas emissions must be set in the context of the fact that the UK produce only 2% of the world's emissions and that developing nations such as India and China are industrialising at an unprecedented rate. China alone is now building 8 major coal fired power stations a month, completely negating any CO_2 saving made by the UK's climate change policies. In the light of this we believe it to be self evident that we need a strategic energy policy that aims to set an example of how to achieve truly qualitative changes in greenhouse emissions (see appendix1). We need to set an economically compelling lead. If we cannot achieve this, then tinkering with a few minor components of our overall energy budget through unsustainable expenditure will not impact significantly on the twin problems of national energy security and global climate change. It is this context that informs our views of the value of wind turbines and these are itemised below.

2) The current drive towards renewable energy generating systems, based largely on wind turbines, carries with a number of implicit assumptions. The primary ones being that wind power displaces fossil fuel generation at an affordable price and without unacceptable environmental costs. There are two replacement elements in the assumption. The first being fuel replacement, whilst the second is displacement of generating plant as encapsulated in the cliché *wind is better than nuclear.* Whilst there are theoretical grounds for accepting that there is a degree of plausibility behind these assumptions it is also true that there can be significant differences been theory and practice. Such differences are founded in unforeseen, poorly understood or hard to quantify variables associated with real-world operating conditions.

3) Our response is in four parts:
the first deals with development, construction, maintenance and decommissioning;
the second with analysis of fuel and plant replacement values;
the third assesses the factors that should be considered when measuring the carbon cost of a wind farm.
The fourth is appendix 1, which sets the information presented here in a wider context

4) **Development, construction, maintenance and decommissioning**:
   a) **Development**: We have no evidence that any developer has yet accurately portrayed the number of journeys, quantity of concrete and aggregate, removal of hedgerows, widening of roads. In every case of which we are aware these figures have been underestimated to the tune of at least 15%.
   b) **Construction:**
      i) **Access routes**: to reach isolated hills requires road widening along miles of country lanes, this is not always done in a way that provides safe passageway and generally is carried out in a way that has no regard for local features and the soft, gentle character of country lanes. Wind farm traffic is unlike anything that has arrived in these isolated areas previously, local people cannot visualise the impact and therefore find it difficult to make informed judgement on what effect wind farm development will have. Many cottages are built alongside these roads long term damage through increased, larger traffic or vibration occurs and the owners have no recourse, as it is difficult to prove and identify the occasion when it happened. These wider, faster roads increase traffic and vehicle speeds
      ii) **Mynydd Clogau**: Following Public Inquiry and reduction and changes made to the scheme the wind farm was built. There was considerable effect upon the adjoining common, which provided some of the access, storage and a dump for excess materials. Far more concrete had to be used to make turbine bases than envisaged; in the case of one turbine we understand that this was so excessive that it cost more than £10,000 for the concrete alone. An area was allocated for washing the vehicles to reduce the area of pollution; this was not always used and pollution covered much of the site and onto the surrounding area. The site manager / engineer made it clear to a visiting ecologist that the peat was a huge inconvenience and his aim was to get as much water off the site as possible, as quickly as possible, this was done with large ditches, which he was asked to back-fill to reduce the drying out of the site. In essence; there is disregard of the value of the composite soil structure. Carbon sinks are still not valued.
   c) **Maintenance:** We have considerable evidence that wind turbines break; for example fires, blades coming off, electrical faults stopping them generating; a BBC camerman was seriously injured by a breaking blade, whilst filming a wind farm in Wales and is now wheelchair bound.
      i) Turbines at Cefn Croes have repeatedly broken down; and are sent back to Eastern Europe for repair.
      ii) We have no evidence of a wind farm that has been trouble free, although some have undergone far more incidents.
      iii) We have no evidence of a wind farm that has been maintained working for 25 years as claimed by developers. To our knowledge wind farms are dismantled after about twelve years following an application for "repowering".

iv) Repowering is a misnomer – it implies that the existing infrastructure will be utilised, the old turbine unbolted and a new one popped on. Ref. statement made to County Times by the developers of Llandinam proposed ‘repowering’ of the wind farm; they assured the paper that everything was in place and just new turbines would be needed, this is not the case and at every stage new development would be required.

v) When CO_2 savings of wind farms are calculated an assumption is made that they don’t breakdown, don’t get shipped around the world for repair and that they effectively generate on that site for 25 years. There is no evidence to support these assumptions.

d) **Decommissioning:** Despite initial planning permissions being granted for twenty five years, we have always been aware, that planning permission is in perpetuity. Local people were misled.

i) It is not generally understood that the concrete bases, access tracks etc will remain when finally the turbines are not of political or financial interest.

ii) Under each turbine there is, according to the developers 300cu m of concrete.

The amount of concrete and aggregate required to build the basic infrastructure for 800MW installed capacity (2MW WTGs) would cover over 1000 acres (This is enough to cover an area twice the size of Newtown) and would include 120,000cu m of concrete. This would provide an intermittent electricity supply of 224MW (assuming 28%)

Lightfoot Enterprises has carried out household energy surveys in selected towns in Powys and the Marches. In Bishops Castle over a twelve month period they worked with 350 households (under than 25%) and achieved a total theoretical saving of 2500 tonnes of CO_2. A 2.5 MW turbine theoretically saves (according to BWEA) a similar amount. The cost of this sustainable project was for a part time trainer and local volunteer support; the cost of purchasing a 2.5MW turbine is in the region of £2.3M.

5) **Fuel and plant replacement value of turbines**

a) As far as the assumption that wind turbines have significant replacement value for other generating plant is concerned our evidence indicates that this is not so. Met Office data shows that the UK is occasionally subject to stable high-pressure systems that result in wind-free conditions over most of the British Isles. Under these conditions wind turbines have little or no generating plant replacement value. Their potential output must therefore be supported more-or-less on a Watt-for-Watt basis by more reliable generating plant; this view is supported by real world data - see para. 3d and para. 4 below. So long as conditions are likely to occur where the whole of Britain experiences still air conditions we see no convincing evidence for accepting that wind turbines have significant generating plant replacement capacity. As such, wind power represents a significant cost burden to the national economy and to individual consumers of electricity. It has a bearing on factors such as fuel poverty and economic competitiveness of industry and services.

b) Regarding the fuel replacement value of wind turbines, it seems self-evident that under the right circumstances it should be possible to replace output from fossil fuel generators with wind generated electricity but we find the evidence quantifying the true value of wind turbine fuel replacement value equivocal. It is of course obvious that any action or mechanism that reduces fossil fuel consumption has a fuel replacement value. Given the diversity of such actions and mechanisms that are open to us we argue that decisions should be based on verifiable cost-benefit analysis (see para. 8 below). In this context we have found it surprisingly difficult to find objective studies designed to both test and quantify the key assumptions on which deployment of wind power is based. An extensive literature search revealed only one that modelled costs along with fuel, CO_2 and generating plant displacement from real World data (Irish Electricity Supply Board (ESB, 2004) Impact of Wind Power Generation In Ireland on the Operation of Conventional Plant and the Economic Implications) Although there are significant limitations to the ESB study which includes the assumption that wind power generation can be predicted with a high degree of accuracy, which of course it cannot. The results nevertheless establish the importance of examining underlying assumptions associated with wind power.

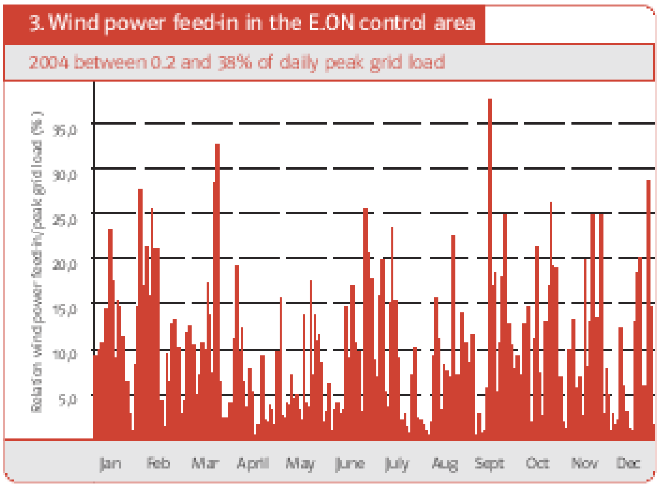
i) The strategically important findings of the ESB study are summarised below
ii) The ability of the national grid to make use of wind power generation (WPG) is contingent on the presence of significant levels of more predictable generating capacity.
iii) Grid systems can be managed to accommodate WPG so that a unit of wind generated power replaces a unit of thermally generated power.
iv) The extent to which any given capacity of WPG replaces fossil fuel and therefore an equivalence of CO_2 emissions is dependent on the mix of other generating systems on the grid. It does not achieve CO_2 displacement equivalence because the variability of WPG has an adverse impact on thermal plant. This is caused by a variety of factors including increased shut-downs and start-ups and reduced operating efficiency so that fuel consumption does not decline in proportion to the decreases in output. Indeed, it's clear from this study that CO_2 savings are system specific and can vary considerably.
v) WPG has very little potential to replace other generating capacity and as the proportion of WPG increases its generating replacement capacity (GRC) tends to zero.
vi) There is a financial premium to be paid for WPG. In the Irish model, total grid generation costs increases by €196m per annum. Whist this is clearly a system specific estimate it serves to emphasis the need to compute costs.
vii) The cost of using WPG as a CO_2 abatement method is high compared with many alternatives.

c) The German power company E.ON Netz GmbH, is responsible for the electricity transport grid of the E.ON Group in Germany. It manages 32,500 kilometres of high-voltage and extra-high voltage lines covering approximately one third of Germany, and is one of the largest electricity grid operators in Europe (in the UK, the E.ON group owns Powergen). Within E.ON Netz's German control area there is 6,250 MW of wind power, or about a third of that country's installed capacity, which makes it one of the world's most experienced companies in integrating a stochastic power supply such as wind generated electricity into a grid distribution system that demands both stability and reliability of supply. E.ON publishes their wind power experience in annual reports that are available on their web site (www.eon-netz.com/EONNETZ_eng.jsp). In the latest report they reveal several key facts illustrating the considerable problems they have integrating Germany's growing wind energy capacity into the electricity supply system under their control and, as a consequence, the extremely limited value of wind power in mitigating CO_2 emissions and delivering usable power. The italicized sections below are direct quotations from their report.

i) Wind energy is only able to replace traditional power stations to a limited extent. Their 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.*

ii) *On very windy days, normal operation of the transmission grid is sometimes no longer possible…….There is therefore a risk that even simple grid problems will lead to the sudden failure of over 3,000MW of wind power feed-in. In this case, the reserves maintained in the Integrated European Transmission System, in order to cope with problems, would no longer be adequate to safely tackle such failures. At the present time, it is not known how to confront this risk.*

iii) Regarding the value of widely distributed turbines in buffering geographical variations in wind speed; the figure below, taken from E. ON's report, clearly calls this into question. In every month of the year the integrated wind power outputs over the whole E.ON wind-carpet area show huge output variations.



iv) This fact creates such major difficulties in supply management that it is specifically emphasized in a speech by E.ON's CEO, Martin Fuchs, who illustrates the huge swings in wind power with a particularly timely example - *Maximum wind power output in our control area was achieved on the morning of 24 December, with an absolute figure of 6,024 MW. However, the supply on Christmas Eve fell to under 2,000 MW within just ten hours. By Boxing Day – on 26 December – the figure had slumped to under 40 MW, a negligible value to all intents and purposes*.

d) Both the Irish and the German data indicate significant limitations to the fuel and, hence by association, the CO2 replacement value of wind turbines. Most significantly The E.ON experience indicates a requirement for so called hot spinning reserve to be backing up wind power to a very significant degree. Whilst we recognize that this is an area of contention and precise fuel replacement values and costs will be system specific E.ON's real world information indicates that fuel replacement value of wind turbines may be significantly lower than some protagonists claim. Furthermore, although real word data on this critically important issue seems difficult to find, the annual digest of UK energy statistics (DUKES) produced by BERR provides a comprehensive 'broad brush' data set of relevant information. In considering the impact of fuel replacement generating technologies on the UK's electricity supply system, it is self evident that ratio of fossil fuel burnt to electricity produced provides an objective overall measure of this key information. It is also self-evident that as effective fuel replacement technologies are deployed the ratio will widen. Thus, taking the annual total of electricity produced (TWh) by all generators on the grid and dividing this by the total fossil fuel consumed by generators (millions of tonnes) provides a ratio which, if fuel replacement generating technologies prove to be effective, should are widen over time (i.e. grow numerically larger). BERR data shows that in 1998 the ratio was 6.54 whilst in 2007 (the last year for which data is available) it was 6.09. This narrowing of ratios is the opposite of that expected if fuel replacement generating technologies were working effectively. Indeed, the average ratio for the 5 years 98-02 was 6.32 whilst for 03-07 was 6.19. Indicating that in recent years the grid system delivered less electricity per unit of fossil fuel consumed than it did previously. This data should be set against the fact that the installed generating capacity of wind turbines has risen from around 400MW in 1998 to 2,500MW in 2007.

i) Although BERR data can be difficult to synthesise and interpret (perhaps deliberately so) some of it is also presented as simple pie charts showing the fuel used in electricity generation on a percentage of total basis. This allows the information in the preceding paragraph to be cross-referenced to an easily interpreted database. BERR pie chars show that in 1999 the main fossil fuels (coal, gas & oil) accounted for 68% of generation whilst in 2007 they accounted for 78%. Confirming that we now use proportionally more fuel for electricity generation than we did previously. Much of this is accounted for by decline in nuclear power (In 1998 nuclear installed capacity was 12,960MW with output of 90.59TWh. In 2007 installed capacity had fallen to 8,569 with output of 42.00 TWh). However, the key question here is, if the UK continues to decommission its CO_2-free nuclear generating capacity what will replace it? The totality of UK wind turbines show annual variations in load factor ranging from 23.15% (2003) to 28.7% (2006 – offshore only; BERR data); in contrast current data shows that nuclear generated electricity has a proven record of high total capacity (France derives around 80% of its electricity from nuclear) and predictably high load factor; whilst a system such as wind has a predictably low load factor and hence an equivocal fuel replacement capacity. Whilst the question of nuclear waste is undoubtedly an important consideration it's not technically insoluble. Finland is currently, constructing a 500-metre deep disposal facility in stable, two billion year-old igneous rock. This is scheduled to be operational by 2020 and will constitute the solution for disposing of the waste from Finland's nuclear facilities, which generate 40% of its electricity. In the UK context it's worth considering that simply replacing the CO_2-free nuclear output of 90,590,000MWh (1998 value) would require installation of around 41,000 MW of wind power, which represents 64% of the entire current UK installed generating capacity of 63,540MW. Furthermore, it would be difficult to predict the true fuel replacement value of this capacity under real-world operating conditions, but the E.ON data (para 5a) suggests it would be a small fraction of its average load factor of around 25%.

e) Turning now to cost benefit analysis of a range of CO_2 abatement actions and technologies. In 2007 The Confederation of British Industry (CBI) commissioned an authoritative analysis of this entitled Climate Change Everyone's Business. The table below shows the potential amounts of CO_2 equivalents (mega tonnes per year) that could be achieved by the UK in adopting the actions/technologies listed. It's clear that the potential of wind is small in comparison with a range of other technologies. Furthermore, some of the technologies represent significant year-on-year cost savings (highlighted in red) whilst deployment of wind represents an additional year-on-year cost. Interestingly the CBI data shows new-build nuclear to be additional cost neutral.

Annual savings of CO_2 equivalence emissions in mega tonnes per year

Building structures	35
Electrical appliances & lights	32

Nuclear power	32
Carbon capture & storage	16
Fuel efficiency technologies	24
Biofuels and electric vehicles	25
Control of non Co2 GHG gas emissions	14
Improved motor systems	6
Fuel substitution	6
Total	**190**
Wind	13

f) Conclusions on fuel an plant replacement values

i) Wind Turbines have little capacity to replace other generating plant and therefore represent an additional capital cost burden to the national electricity supply system.

ii) Wind turbines have some fossil fuel replacement value but the precise extent of this is equivocal and there is evidence that it is likely to be significantly lower than expected on theoretical grounds.

iii) The cost of using wind turbines for CO_2 abatement is high compared to other technologies and it delivers relatively small savings when compared to other options.

iv) When deploying CO_2 abatement measures consideration needs to be given to cost implications because expensive solutions adversely impact both industry and individual consumers.

v) In 1998 the UK generated over 90TWh of electricity from nuclear power. Replacing this with wind-generated electricity would require an installed turbine capacity of 41,000 MW, (25% load factor) which represents 64% of the entire current UK installed generating capacity. From all available current data it is apparent that this would result in a net change in CO_2 output from electricity generation of ZERO.

6) **Assessing the total carbon cost of wind turbines.** In a Position Statement to the Welsh Assembly Government, CURB (Conservation of Upland Radnorshire and Breconshire) presented arguments supporting claims that wind farms may produce more carbon than they save. It is important to note that BERR have stated *"it is unlikely that wind farm development will proceed should it not be proven to be carbon friendly."*

a) In assessing the carbon cost of wind farms the following factors should be taken into consideration:

i) carbon cost of building and construction;
ii) carbon cost of grid connection;
iii) carbon cost of conventional power stations running less efficiently;
iv) carbon cost of new and upgraded highways
v) carbon cost organic soil displacement leading to oxidation to CO_2
vi) carbon cost of transmission losses and grid reinforcement
vii) carbon cost Integration of wind energy into the National Grid
viii) turbine lifespan
ix) carbon cost of subsidy.

b) CURB have requested the relevant figures from the WAG, the Sustainability Commission, the National Grid, BERR and the Carbon Trust. Some of these bodies have replied, but most of the questions have yet to be fully responded to. Areas for consideration are

c) **Carbon cost of building and construction.** A widely quoted paper (Milborrow 1998) states that the carbon cost of manufacturing turbines, transporting them to their site and erecting them is recouped in six to nine months depending on the output of the wind farm. We have yet to see any paper that provides a scientific rationale for this. Furthermore, more recent papers contradicting these figures. The House of Lords' Science and Technology Committee Report estimated a carbon pay back time for building and construction of 1 to 3 years. The reason for this wide range is not clear but the higher figures probably include a component for transportation of the turbines by sea and lorry and mining iron ore for steel manufacture.

d) **Carbon cost of grid connection** This is currently the subject of questions to the National Grid and the WAG. We are not aware of any relevant calculations but its obvious that additional grid connections and grid reinforcement are likely to incur significant carbon costs.

e) **Carbon cost of fossil fuel back up (conventional power stations running at reduced efficiency)** Energy suppliers have no choice but too accept wind generated electricity when it comes on stream. To do this other generators must be taken off line. In doing this, some generators are likely to run slower and therefore less efficiently. This also causes more wear and tear. The carbon cost of this has yet to be calculated but is likely to be substantial.

f) **Carbon cost of highways** many areas of upland Wales have particular problems because the road transport system is not sufficient to bring in the large components of turbines, nor the volume or weight of traffic required for building and construction. This also needs calculation in terms of carbon cost. This has been the subject of a question to the WAG but calculations have yet to be published. The carbon cost of highways with respect to building and construction, soil displacement and cost is likely to be substantial.

g) Carbon cost of high organic matter soil displacement. At Whinnash a carbon equation was drawn up by Dr Mike Hall of Renewable Energy Systems. Compared to many sites in Wales and Scotland it has a shallow peat covering and patchy areas of blanket bog. The carbon payback time is calculated at 2.35 years. There appears to be no evidence of a carbon payback equation having been made for peat despite the Scottish Government having made an algorithm to calculate this. (Ref: The Scottish Government Calculating carbon savings from wind farms on Scottish peat lands – http://www.scotland.gov.uk/Publications/2008/06/25114657/9 It should be noted that when defining their strategic search areas (SSAs), no consideration was given by the Welsh Assembly Government to the peat issue. Furthermore in their recent Interim Development Control Guideline, *Onshore Wind Farm Developments Consultation Draft May 2008*, it is not considered necessary to undertake strategic environmental assessment in order to assess the peat burden. Production of substantial amounts of CO_2 from disturbed organic soils is a well established phenomena and should be a material consideration in accounting the carbon costs of wind farms

h) Carbon cost of transmission losses and grid reinforcement. BERR statistics show that transmission and distribution losses are *"about 6-7% in Wales. This loss may well be accentuated by the energy market in terms of supply sites and demand locations"* This illustrates the point that power stations are normally sited close to consumers. Distal wind farms sites will suffer substantial grid losses before electricity gets into the National Grid. (Ref personal communication Dr Harvard Prosser WAG technical adviser 3.11.08). Where grid reinforcement is necessary the full carbon costs should be accounted.

i) **Carbon cost of integrating wind energy into the National Grid.** This has been a major problem in other countries and has been the single most important factor in curtailing wind farm development. The problem is that energy from wind is very unpredictable. National Grids cannot store much energy (relatively small amounts in pumped storage systems), they require a regular and constant supply of energy in order to prevent power cuts and voltage drops. Fossil fuels, hydropower, tidal power and nuclear power deliver relatively predictable outputs but all but many of these energy generating sources have a momentum – they simply cannot be switched on and off rapidly. This makes it difficult to accommodate wind energy coming on tap unpredictably. The current position in Germany is a system whereby energy producers other than wind are obliged to buy electricity generated from wind, whether or not they can use it. This makes wind generated power expensive and wasteful. In Denmark, energy is being dumped into the Swedish grid at no cost. The ability to incorporated electricity into the National Grid is quantifiable and is called the CAPACITY CREDIT. The following quote from E.ON illustrates the problem *"Wind energy is only able to replace traditional power stations to a limited extent. Their 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 other words the capacity credit is 10% of the installed capacity (according to EON) and 15% according to BERR. The WAG has yet to state what the capacity credit of Welsh wind farms is.

j) **Lifespan of Turbine**s. Environmental statements usually state the expected life span of a turbine is 25 years, but this is rarely the case in practice. Most are decommissioned before 15 years. The House of Lords Science and Technology Committee Report states that the average life of turbines is 9-12 years. This indicates that a wind farm takes a minimum of three years to pay back the carbon cost just for building and construction.

k) **The carbon cost of subsidy.** We can find no evidence that this question has been addressed, but it deserves serious consideration. Wind energy is not subsidised by governments or the European Union, it is entirely subsidised by the consumer through a price levy on electricity. Indeed it has been estimated that to meet our European Renewables Obligation (20% energy from renewables) UK electricity bills will rise on average by £400 per annum. It could argue that the increasing cost of electricity to the consumer will result in reduced consumption but if this were the political imperative it would be more cost effectively achieved through a carbon tax on electricity. We argue that the generation of any profit carries a carbon cost. This is currently the subject of a question to the *Carbon Trust* to which they have yet to respond. Tim Jackson, Professor of sustainable development at Surrey, has calculated a carbon weighting on profit. The global population is 7 billion and the average level of affluence $8,000 per person. The technology factor is 0.5 tonnes of carbon dioxide per thousand dollars of GDP – in other words every $1,000 dollars of production releases 0.5 tonnes of carbon dioxide into the atmosphere. (Ref New Scientist "What politicians dare not say" 18.10.08). So in a situation where each turbine generates approximately £100,000 worth of electricity and £400,000 worth of subsidy annually (ref. Financial Times). This amounts to approx $600,000 and therefore 300 tonnes of carbon dioxide.

l) **Calculating total carbon costs.** In our view the Carbon Cost Equation, should include the positive value of carbon-free generation and the carbon costs associated with the following factors

i)	Carbon cost of building and construction	1-3 years
ii)	Carbon cost of grid connection	unknown
iii)	Carbon cost of conventional power stations running less efficiently	unknown
iv)	Carbon cost of highways	unknown
v)	Peat displacement	2.35 years
vi)	Losses in transmission	6-7% of installed capacity

vii) Grid integration | Capacity credit 10-15%
viii) Lifespan of turbine | 12 years
ix) carbon cost of subsidy | tonnes carbon per turbine

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x) Bearing in mind that the carbon cost of building and construction and peat displacement is calculated relative to the load factor (25% ref BERR), not the capacity credit, these figures need doubling up to 2-6 years and 4.7 years respectively. The weight of the above factors suggest that a turbine with a practical life of 12 years, may spend 8 years repaying its full carbon costs especially on high organic content soils. Of the remaining 4 years turbine life span, allowing a generous capacity credit of 15% of installed capacity, minus 6-7% of that in grid losses then around 14% of installed capacity will be the net consumption. If the installed capacity of a turbine is 2.3MW our estimates indicate that around 2,800MWhours per annum will reach consumers. (Per head of the population we consume 6.065MW of electricity per annum so this is sufficient to sustain 198 people for one year). The carbon saving for this would be 2,800 x 0.43 (tonnes of carbon saved per megawatt generated) = 1,204 tonnes saved per year i.e. for the remaining 4 years of generation, 4,816 tonnes of carbon will have been saved. However, turbines have been subsidised for 12 years and this costs approx 3,600 tonnes of carbon. So the overall carbon saving in terms of what can be quantified is minimal (the difference between 4,186 tonnes saved and 3,600 spent in subsidy). When one adds in what has yet to be quantified (items L ii-iv & ix), it is probable that turbines cost as much carbon as they save.