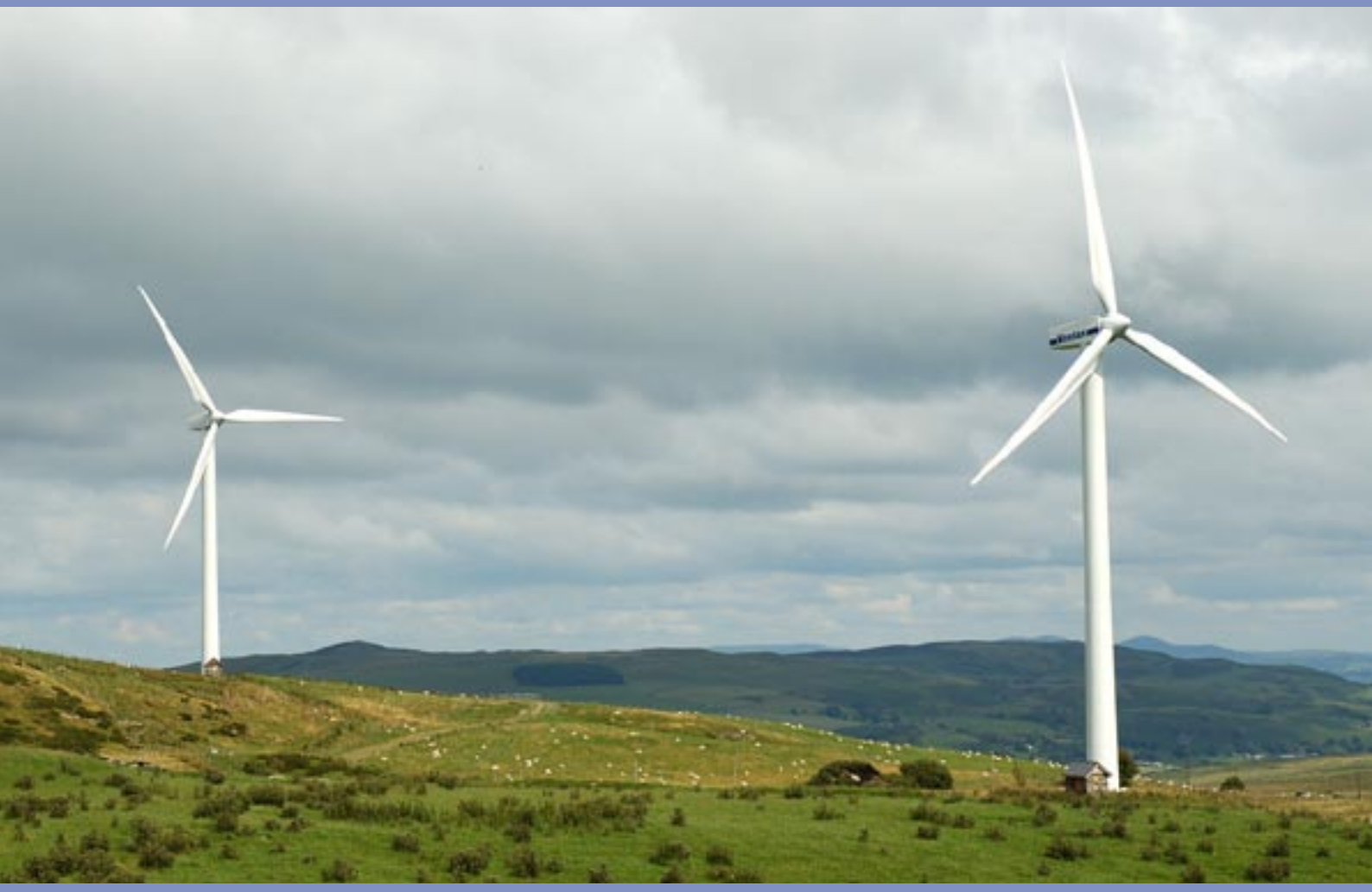
THE BRITISH WIND ENERGY ASSOCIATION

February 2005



Blowing Away the Myths

A critique of the Renewable Energy Foundation's report:
Reduction in carbon dioxide emissions: estimating the potential contribution from wind power

Introduction

In recent months there has been much written in the press about wind energy. This report is intended to put straight a few myths that have been propagated by organisations that do not support the development of wind energy as a means to tackle climate change and improve the nation's energy security. The most recent example of this was the publication of a report by the Renewable Energy Foundation (REF) on the role of wind energy in reducing carbon dioxide (CO_2) emissions. In the report the REF make three claims:

- The emissions saved by wind energy are much smaller than claimed
- Considerable amounts of extra backup plant will be required (exactly how much is unspecified)
- The performance of wind energy installations is worse than anticipated, and it is expensive.

This BWEA report, *Blowing Away the Myths*, considers each of these myths in turn.

The press release accompanying the REF report claims that it is "*derived from reports from professional bodies and companies around the world*" and that "*there is a consensus...*" that CO_2 savings are "*uncertain...[and] costly*". However, citations from the very wide range of technical reports in the international literature, are, in practice, relatively few in number. This critique will demonstrate that several studies show that the consensus is quite the reverse of that claimed by the REF.

One central theme of the REF report is that the carbon dioxide savings associated with wind energy are much less than those claimed by the British Wind Energy Association (BWEA). Although there is a lengthy discussion of this issue, including some criticism of the stance taken by Government agencies, no alternative figures are put forward for emission savings. In practice, fairly straightforward technical reasoning leads to the conclusion that the emission savings from renewable energy sources are those associated with the carbon dioxide emissions from coal-fired power stations. Although the REF argues that these savings will be counterbalanced by extra emissions from backup plant, no data are produced in support of this assertion, and an examination of the available evidence suggests that any abatement is extremely small.

A second theme of the report is that "*wind generated power [is] variable, unpredictable, and uncontrollable*" and that it therefore needs substantial amounts of fossil-fuelled back up capacity, which dilutes the carbon dioxide savings. However, the report appears to be very selective in its choice of references. It does not, for example, cite the Department of Trade and Industry (DTI)/Carbon Trust *Renewables Network Impact Study*, which includes an Intermittency Literature Survey citing 74 references to studies relating to the variability of wind energy. The overwhelming consensus in the literature is that the variability of wind energy is manageable by system operators and that any additional operating costs are very modest.

The REF report draws heavily on a recent report on the performance of wind energy in Germany, but the REF does not acknowledge that wind speeds in the UK are significantly higher than those in Germany, making such comparisons of limited value. Neither does the REF acknowledge that the net impact of wind on an electricity network needs to be assessed by taking into account, in addition, the combined impacts of conventional plant failures and variations in consumer demand.

Carbon dioxide savings

There are two issues at stake under this heading:

1. The appropriate level of carbon dioxide savings that should be assigned to electricity generated by wind energy (or any renewable source)
2. Whether the extra backup needed for wind plant generates emissions which dilute these savings. This question is addressed under the heading "Wind and the grid" in this document.

The REF report has a long discussion (paras 1.1-1.3) on the appropriate level of carbon dioxide savings that should be ascribed to wind energy plant. The key question is:

Does renewable energy in the UK save on the emissions from coal-fired plant, or are the savings related to the average emissions from all electricity generation?

The REF criticises Government figures (mostly based on average emissions) for being somewhat arbitrary, and the BWEA, for using a value "*at once too high and inexplicably too low.*" In practice, the BWEA figure (based on the average emissions from coal-fired plant, around 860g/kWh) is robust, and founded on what is actually happening in the real world. It is about 10% lower than the figure quoted by the Parliamentary Office of Science and Technology, and is therefore conservative.

There is some confusion over this issue, but a clear and concise analysis of the relevant issues comes from an authoritative, but neutral, source in a submission to a Parliamentary Select Committee in 1989[1]. The principles of the analysis have not dated, although some of the numbers are now incorrect, simply because the Central Electricity Generating Board (CEGB) underestimated the magnitude of the "dash for gas". However, the conclusions were quite clear: emission savings from wind energy would be around 860g/kWh, a figure that was quite different from the emissions associated with the forecast generating mix.

The logic behind this figure was (and is) quite clear: viewed in the short or long term, renewable energy in the UK saves on emissions from coal-fired plant. The reasoning is also consistent with a generalised analysis by a respected American Laboratory[2].

The DTI appeared to accept this logic but in 1999 proposed three scenarios for assessing the range of carbon savings associated with renewable energy[3]:

Option 1. Renewables displace combined cycle gas turbines
Option 2. Renewables displace modern coal plant; and
Option 3. Renewables displace the current generating mix.

The DTI's analysis suggested that Option 1 was unlikely in practice, but did not comment on the scenarios further. The logic behind using it appears to be that renewables will inhibit the construction of new gas-fired plant, although what is far more likely is that renewables will force the early closure of old coal-fired plant. Moreover, the recent increases in gas prices may mean that construction of new gas plant slows down or stops. This demonstrates the illogical nature of the assumption.

Option 3 is frequently used but does not reflect reality. It implies that renewables displace coal, gas and nuclear in equal measure, which is simply not the case. Nuclear, for example, being baseload plant, is completely unaffected in its daily operations by the addition of new generating plant.

Option 2 as noted above, was generally accepted within the UK until quite recently. In December 1999 there was implicit confirmation that the upper bound of the DTI estimates

for emission savings from renewables was consistent with "coal substitution"[4]. The reasons for the change of heart by the DTI (to option 3) have never been satisfactorily explained. When asked by a House of Lords Select Committee[5], the Government did not seek to justify the (lower) DTI figures on carbon savings, but argued "*it is a complex subject in which there are no definitive answers*".

Option 2 is consistent with the realities of system operations. In the day-to-day running of the UK power system it is coal plant which is taken off load when additional base load plant, such as nuclear or renewables, start to generate. This is clearly demonstrated in data published by The National Grid Company which describes the make-up of plant on the system at various times[6]. The nuclear and Combined Cycle Gas Turbine (CCGT) plant operates continuously throughout the day and the output of the coal plant is changed to meet changes in demand. It should be noted, as discussed earlier, that the output from coal plant will not change in response to every fluctuation in wind output. It will be adjusted in response to the aggregated change in demand, of which wind only contributes a small proportion.

Option 2 is also consistent with longer-term trends. As the older coal plant become uneconomic, or become surplus to requirements, due to the construction of new gas or renewable plant, it is shut down. This was also the conclusion reached by a study from another neutral source[7] which, incidentally, suggested that the costs of carbon dioxide avoidance were around $30/tonne CO_2, considerably lower than the figures quoted by the REF.

To sum up: electricity generated from wind energy (and the other renewable sources) saves around 860g/kWh of carbon dioxide. That figure is consistent with what is actually happening, in the short or long term, and with other international studies.

Wind plant performance and economics

The report makes much of the fact that a recent estimate of the average capacity factor of wind in Germany in 2003 was 15% and that the average capacity factor in the UK was 24%. It fails to acknowledge that:

- Average wind speeds in Germany are significantly lower than those in the UK, and
- 2003 was a low wind year. The average capacity factor of UK wind has varied from the 2003 low to 31% in 1998[8]. It is quite incorrect to say (REF, para 4), "*this figure [30%] has never been achieved*"
- Assessments of the economics of generating plant invariably use load factors that are realistic for the particular plant, but may well be higher than national averages. The load factor of UK nuclear plant, for example, varied between 72.6% and 80.4% during the 10 years from 1994 to 2003 and yet the Royal Academy of Engineering report cited by the REF suggests that "*.. availabilities exceeding 90% should be achievable*"
- Several wind farm operators have reported capacity factors significantly greater than 30%. Scottish Power, for example, expects its best sites to have capacity factors between 35% and 40%[9]. npower renewables has reported long-term capacity factors between 36% and 40% for five of their wind farms[10] each. The output from the npower wind farms at times of peak electricity demand was above average, which contradicts claims in the REF report that wind power is not available at times of peak demand
- The increasing number of developments in Scotland, where sites are known to be very windy, and in offshore waters is likely to increase UK average capacity factors.

On economics, the report notes "*the capital cost of wind power is between two and*

three times that of CCGT capacity." This is correct, but it completely ignores the fact that generating costs depend also on the cost of the fuel. In 2004, gas prices rose to unprecedented levels and so there is now very little difference between generation costs from gas and those from wind[11], a point recently recognised by the American Federal Energy Regulatory Commission[12]. These gas price increases also put a question mark over the assertion that carbon dioxide mitigation can be achieved at lower cost with combined cycle gas turbine plant.

Wind and the grid

There are numerous instances where the REF report discusses the (alleged) difficulties of managing the electricity network with wind energy and to the impact this might have on any emission savings. However, the REF does not mention the DTI/Carbon Trust *Renewables Network Impact Study*[13] which includes an Intermittency Literature Survey citing 74 references to studies relating to the variability of wind energy. Of these, about half stem from utility studies and there is a clear consensus that the impacts of wind, and the associated costs, are very modest at small to moderate penetrations (up to 20%) of wind energy in electricity networks. A wide-ranging review of American utility studies has drawn a similar conclusion[14].

There is such a wealth of misunderstanding over these issues, and over reserve needs, that it is worth quoting the views of the UK System Operator, National Grid Transco[15]:

"However, based on recent analysis of the incidence and variation of wind speed we have found that the expected intermittency of wind does not pose such a major problem for stability and we are confident that this can be adequately managed…

It is a property of the interconnected transmission system that individual and local independent fluctuations in output are diversified and averaged out across the system."

A similar point has been made in an American study[16]:

"A key feature of the present analysis [of the effects of variability] is its integration of wind with the overall electrical system. The uncontrollable, unpredictable, and variable nature of wind output is not analyzed in isolation. Rather, as is true for all loads and resources, the wind output is aggregated with all the other resources and loads to analyze the net effects of wind on the power system. Aggregation is a powerful mechanism used by the electricity industry to lower costs to all consumers. Such aggregation means that the system operator need not offset wind output on a megawatt-for-megawatt basis."

Extra backup plant

The REF suggests that the (allegedly high) needs for extra backup plant will degrade the emission savings from wind energy. This issue has been dealt with in a joint paper by four authors, all heavily involved in such studies[17]:

"With 20% wind energy, the extra capacity of the reserve is about 5% of the rated capacity of the wind plant….Taking a conservative estimate of 10% for the reduced efficiency [of the backup plant]….. this suggests that the emission savings from the wind will be reduced by a little over 1%."

The report only obliquely refers to the fact that unpredictable changes in demand from consumers and in the output from thermal power stations determine the current needs for back up capacity and will continue to do so for some time to come. The huge benefits

of an integrated electricity system can only be realised if it is operated as an integrated system, and it does not make economic sense to treat individual technologies or consumer demands in isolation. What matters to system operators is the overall uncertainty and numerous authors[18, 19, 20] (there are many others, none referenced by REF) have examined and explained the principles behind the calculation of the additional uncertainty imposed by wind.

A number of related issues recur frequently within the REF report and may be addressed briefly:

Winter anticyclones

These, it is alleged, frequently becalm the whole country and will cause problems for the system operator, due to the absence of any wind power, especially at periods of peak demand. Two points need to be made:

- **Neither the Renewable Energy Foundation, nor any of the references cited by them, have ever produced evidence that this occurs regularly**
- **The Environmental Change Institute at the University of Oxford, was quite clear, in appearing before a House of Lords Select Committee[21] that "we have looked at that [stationary anticyclones in the middle of winter over the British Isles] occurring in the wind data and the wind data does not show it."**

It follows that wind does have a "capacity credit", that is it can displace thermal plant, although not on a megawatt-for-megawatt basis. Broadly speaking, 1000 MW of wind plant will displace about 350 MW of thermal plant, although this ratio declines with increasing wind energy penetration. Several analyses have addressed this issue, including National Grid Transco, and all have reached very similar conclusions[22, 23, 24, 25].

Impacts of NETA

In section 3 of the REF report, there appears to be some confusion over the impacts of the New Electricity Trading Arrangements and the impacts of wind. The quotation (top of page 15) about the impacts of NETA outweighing the benefits of the renewables programme is a criticism of the trading arrangements, not of wind energy. No one has suggested that the modest amounts of wind currently installed on the UK electricity network have any significant impact on the operation the network.

To summarise:

- **Neither wind, nor any other generation source, should be viewed in isolation; that simply increases electricity costs unnecessarily**
- **Although wind may impact slightly on the operation of electricity networks, these effects are small.**

Conclusions

This analysis has examined a number of the principal criticisms of wind energy included in the report by the Renewable Energy Foundation. Claims that issues such as the amount of backup required, or the carbon dioxide savings achievable are poorly understood are shown to be without foundation. Numerous studies now testify to the fact that wind energy is now close to being competitive, in some cases cheaper than, the conventional sources of generation. It is variable, but not totally unpredictable and, again, numerous studies have examined the impacts of variability and shown them to be manageable at modest cost.

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THE BRITISH
WIND ENERGY
ASSOCIATION

British Wind Energy Association
Renewable Energy House
1 Aztec Row, Berners Road
London N1 0PW, UK
t: +44 (0)20 7689 1960
f: +44 (0)20 7689 1969
e: info@bwea.com

www.bwea.com

embrace the revolution

www.embracewind.com