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Wind Power

Wind farms have the potential to generate a significant proportion of the UK's electricity, though their contribution is currently small. This paper discusses the technology and economics of wind power, and the environmental factors which will strongly influence the scale of further development. A recently published DTI consultation paper addresses the question of how to meet, by 2010, 10% of electricity needs using wind and other renewable sources.

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Summary of main points

- Government policy to ensure diverse, secure and sustainable energy supplies, together with commitments to reduce carbon dioxide emissions, have maintained interest in alternative energy sources.

- In the short to medium term, wind power is poised to make a significant contribution to UK electricity supply. Currently, its contribution is a fraction of one per cent.

- Advances in technology, and financial support from the Fossil Fuel Levy have encouraged the development of wind farms. These can now generate electricity at prices which are competitive with more conventional fossil fuel and nuclear sources. However, the economics depend heavily on the chosen site.

- The operation of wind farms produces no greenhouse gas emissions, though environmental concerns remain; chief among these is the visual impact of wind turbines. The development of off-shore wind farms may be one answer to this. These have been the subject of a specific government consultation.

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I Introduction

The annual *Energy Report*[1] published in September 1997 provided the Labour Government, which came to power in May 1997, with the first opportunity to set out the main aims of its emerging energy policy. In the Foreword, the Minister for Science, Energy and Industry, John Battle, said "The simple statement of our energy policy is to ensure diverse, secure and sustainable supplies".

To this end the new administration initiated a number of reviews. One of these was an appraisal of new and renewable sources of energy.[2] Last year, the then Secretary of State (Peter Mandelson) set out the Government's aims in answer to a written parliamentary question from John Redwood.[3]

> The Government are committed to a new and strong drive to develop renewable energy sources in line with our manifesto commitment. To this end, I am reviewing policy towards new and renewable sources of energy, including consideration of what would be necessary and practicable to achieve 10 per cent. of UK electricity needs from renewables by the year 2010 and how renewables can make an effective contribution to meeting requirements for future greenhouse gas reductions. The review, which is nearing completion, is examining the status of all the new and renewable energy technologies and the UK industry and their future prospects in both home and export markets. It is also considering what further research, development, and demonstration is needed for the longer term.

In answer to a written parliamentary question Energy Minister John Battle explained the part that wind power would play in the review:[4]

> As part of my current New and Renewable Energy Policy Review, I am considering both the status of the UK wind industry including its prospects in both the home and export markets and its potential contribution to meeting industrial and employment goals, and the need for further research and development.

Though publication was originally expected by the end of 1998, a DTI consultation paper setting out the results of the review was only released on 30 March 1999. *New and Renewable Energy – Prospects for the 21st Century* has been styled a "blueprint for the future of renewable energy";[5] it demonstrates the feasibility of meeting 10% of UK

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1 DTI, *The Energy Report*, Vol 1, *Shaping Change*, 1997
2 HC Deb 6 June 1997 c 273W
3 HC Deb 31 July 1998 c 763W
4 HC Deb 19 October 1998 c 1039W
5 DTI Press Notice P/99/275, *"Renewable energy powers the future" – John Battle launches Renewables Review document*, 30 March 1999

electricity from renewables, examines the hurdles confronting their development, and presents options for support mechanisms while renewables gain a market foothold.[6]

The above-mentioned target of 10% of UK electricity requirements met by renewables by 2010 should be seen in the context of the 2% contribution when the present administration came to power, and its projection to 5% by 2003.[7]

Additionally, the European Commission has proposed a much more ambitious target of a 12% contribution from renewables to EU gross inland energy consumption by 2010. The sectors of the energy market referred to by these two targets are very different and should not be confused. The House of Commons Trade and Industry Select Committee differentiated between the two and examined the feasibility of the UK achieving both:[8]

> 79. In 1996, only 2% of UK electricity was generated from renewable sources, mostly from large Scottish hydro-electric schemes. In view of divergent opinions on the prospects for reaching the target, we devoted a morning of oral evidence to renewables. Witnesses suggested that the Government's 10% target for the generation of electricity from renewable sources by 2010 was ambitious, but achievable. In November 1997 the European Commission published a White Paper setting out a "Community Strategy and Action Plan" aimed at securing a 12% contribution from renewable sources to EU gross inland energy consumption by 2010. The two targets are quite different, the EU's referring to all energy consumption, including heating and transport, while the Government's target is restricted solely to electricity generation. Dr. Mitchell described the EU target as a "significantly harder target to meet...we should keep ourselves to the 10% target of electricity". The Government has described the 12% target as "very ambitious" involving "far reaching policy implications" and has stated that the "UK will argue against the endorsement of any unrealistic targets and the adoption of measures which would impose disproportionate costs on consumers, industry or the taxpayer". **Sectoral targets are meaningless without detailed consideration of the policy measures required to achieve them, and the costs and benefits thereof. We welcome the study made by the Government of the feasibility of their 10% electricity generation from renewable sources target and urge the swift publication of the conclusions reached. We concur with the caution expressed by the Government towards the EU's 12% target for total energy consumption from renewable sources, the feasibility of which remains unproven.**

So far as specific renewable energy technologies are concerned, those poised to make a significant contribution in the short term include waste incineration, energy crops, and wind farms. The first of these was discussed in Library Research Paper 97/42, *Energy from Waste*. Short rotation coppice, such as willow or poplar, is seen as having great

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6 HC Deb 30 March 1999 c 577W

7 HC Deb 2 July 1998 c 238W

8 Trade and Industry Committee, *Energy Policy*, 2 June 1998, HC 471-I 1997-98, xxxix, para 79

potential, though technical problems related to the development of gasifiers and the vulnerability to disease and drought of monocultural wood coppices have impeded development, so far.[9] By contrast, wind farms have already become established as a proven and increasingly economic technology. Germany is the world's largest producer of electricity from wind turbines, over 5,600 in all,[10] having 2,800MW of *installed* capacity.[11] Danish wind power capacity exceeded 1,000 MW by the end of 1997, providing some 7% of electricity production.[12] As at August 1998 there were over 749 individual wind turbines operating in the UK, with a total installed capacity of 325MW (see Appendix 1 for details).[13] Though equivalent only to a small conventional gas-fired power station, the growth of wind farms seems set to continue, notwithstanding some reverses at public planning inquiries. This paper focuses on wind farms, set in the context of the Government's developing policy on new and renewable energy.

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9 Bob Everett and Godfrey Boyle (eds), *T265 (Open University) Renewable Energy – Update Supplement*, 1999, pp 17-22

10 "Running out of steam", *Guardian*, 14 October 1998, p 4

11 "Wind Energy: Germany is World Leader", *Europe Environment*, 16 March 1999, p 5

12 Bob Everett and Godfrey Boyle (eds), *T265 (Open University) Renewable Energy – Update Supplement*, 1999, p 32

13 http://www.bwea.com/, 18 May 1999

II The Technology

Wind power has been harnessed by people for over 2,000 years in windmills. Modern machines convert the power of the wind to rotating shaft power by turning propellor-like rotor blades. This power can be converted into electricity. These wind turbines may be of the horizontal (like a windmill) or vertical axis type. The horizontal version is at a more advanced stage of development and is currently more cost effective. The vertical axis type, however, may prove more successful where relatively large turbines are required, such as in offshore developments. Even so, the horizontal axis design has proved popular in offshore facilities in Danish and Dutch waters.[14]

Wind turbines have been developed with a range of power ratings from a few kilowatts (kW) up to multimegawatt (MW) capacity. The larger machines are, however, almost all research prototypes. Typical commercially available turbines are now rated at around 600kW. The technology is well established with over 20,000 grid-connected machines world-wide. Current research and development work is concerned mostly with improvements in reliability, cost and noise reduction, and performance.

Large scale generation of electricity requires a number of turbines for economy and ease of generation. In the UK groups of about 20 horizontal axis machines may be seen in a typical wind farm. The turbines are usually erected 5-10 rotor blades apart to reduce aerodynamic interaction which impairs their efficiency. Consequently a wind farm of 20 turbines often occupies 3-4 square kilometres of land. The actual ground space taken up by the turbine bases, however, is minimal and the remaining area may be used for agriculture or recreation.

Since wind turbines are available "off the shelf" the time from conception to operation of a wind farm may be as little as a year. Existing designs aim at a machine lifetime of about 25 years. At the end of this, decommissioning is simple, requiring only the removal of scrap material and cabling. The concrete bases, which are only a few cubic metres in volume, are usually buried but can be removed. Unlike many other forms of electricity-generating plant (eg a nuclear power station) there is no residual waste or land contamination following decommissioning.

The European market for wind turbines is largely met from established manufacturers, mostly in Denmark and Germany. Nevertheless, the manufacturing skills required to build and install wind turbines are widely available in the UK. This, coupled with the UK's expertise in working on offshore developments, places it in a favourable position to exploit the future market potential of offshore wind developments both in the UK and abroad.

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[14] European Commission, *Wind Energy – The Facts*, 1999, p 90

III Economics

A. General Considerations

Notwithstanding government policy to promote renewables, the development of wind power will depend heavily on its cost in comparison with other sources of electricity. A variety of cost measures are in common use, including the accounting cost and the avoidable cost. However, a useful measure (particularly for comparative purposes, and when contemplating new build) is the *lifetime levelised cost*. This is the total cost (in pence) of the power station or wind farm, divided by the total output (in kilowatt-hours) over its operating lifetime. Because the costs and outputs are spread over many years, one takes inflation into account by using consistent units of money (such as 1999 pounds). Furthermore, the *time value of money* is taken into account by *discounting* (see box) future costs and outputs to the present day, the start of the project, or some other suitable date. Accordingly, the lifetime levelised cost is strongly dependent on the chosen discount rate which, in turn, reflects the level of real interest rates and the perceived investment risk of the project in question.

Time Value of Money

Even after allowing for inflation, money has a time value – this is what discounting allows for. A bird in the hand is worth two in the bush. £100 in the hand are worth £110 next year (assuming real interest rates are 10%). £110 next year are worth £100 today (assuming discount rates are 10%). Future costs, and outputs, are worth less in present value terms. Using this kind of analysis, developers wishing to finance a project through debt are going to prefer costs to be incurred later on, and outputs to flow early. In wind farms, and even more so tidal barrages, the costs are incurred disproportionately in the early years, so discounting has relatively little effect. At the same time, the outputs (units of electricity) are valued less and less the further one looks to the future. In gas-fired power stations the costs are spread more evenly over the years, and discounting these has a beneficial effect on the economics. One can argue for lower discount rates on social grounds, or even that this widely-used economic analysis is fundamentally flawed.

Wind farms, which are relatively capital intensive, are often less attractive to investors than projects such as gas-fired power stations, where the costs are spread more evenly over the operating lifetime. One should also retain in mind that projects are likely to be financed over shorter time scales (say, 8-15 years) than the full operating lifetime (of the order of 20-25 years for a wind farm).

Estimating costs, including those of fuel, over the lifetime of a power station makes it difficult to come up with definitive, and current, figures. Different calculations might also assume varying values for the load factor, a measure of the proportion of the available time over which a power station is generating electricity. Some plants only operate during periods of peak demand, so their lifetime levelised costs tend to be high. In the particular context of wind farms, where the "fuel" costs nothing, a particularly important factor is the average wind speed. This varies considerably from place to place, making the economics of wind power strongly site-dependent. Typically, the total

installed cost of a single 600 kilowatt machine is £480,000.[15] The annual costs come to about £18,500, half of which is attributable to operation and maintenance, the rest being local rates, land rental, insurance and on-site electricity usage. On a typical site, such a turbine would produce some 1.6 million units (kilowatt-hours) of electricity per annum.[16] The capital cost (£480,000) can be *annuitised* over a period of years for a variety of discount rates. To take a simple example, if the wind turbine was financed over a ten year period, with a zero discount rate, then the annuitised capital cost would come to £48,000. Adding this to the recurrent annual costs (£18,500) and dividing by the output implies an electricity cost of 4.2 pence per kilowatt-hour (p/kWh). The table below is designed to give an indication of the dependence of wind turbine economics on repayment period and discount rates.

Repayment period (years)	Discount Rate (%)	Cost (p/kWh)
10	0	4.2
10	8	5.6
10	15	7.1
20	0	2.7
20	8	4.2
20	15	6.0

Table 1: Cost of electricity from a typical 600 kW wind turbine, as a function of repayment period and discount rate.

The above figures should be taken as indicative, actual costs depending very much on the chosen site. A wind farm comprising several (say, 20) wind turbines will also benefit from economies of scale. A wind power developer was recently able to submit a *price* bid as low as 1.89 pence per unit (kilowatt-hour), as part of the Scottish Renewables Obligation.[17] In evidence to the Trade and Industry Committee,[18] the British Wind Energy Association commented that further price reductions would be possible, though this trend is limited in part by the availability of high wind speed sites (often in scenic areas).

B. Non-Fossil Fuel Obligations

Under section 32 of the *Electricity Act 1989*, the Secretary of State may require by order that public electricity suppliers arrange to have available to them generating capacity from non-fossil fuel sources. Thus the following fuels are excluded: coal, coal products, lignite, natural gas, crude liquid petroleum or petroleum products. The order may specify non-fossil generating stations of a particular description such as wind farms and different

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15 ETSU, *New and Renewable Energy: Prospects in the UK for the 21st Century – Supporting Analysis*, March 1999, p 176

16 multiplying the power rating by the number of hours in a year, and assuming a capacity factor of 30%

17 HC Deb 24 January 1999 cc 325-6W

18 Trade and Industry Committee, *Energy Policy*, 2 June 1998, HC 471-II 1997-98, p 86

energy from waste technologies. Nuclear power, by far the primary beneficiary in the past, no longer receives levy payments.

A recent example of a non-fossil fuel obligation is the *Electricity (Non-Fossil Fuel Sources) (England and Wales) Order* SI 1998/2353. This is the fifth renewables order (NFFO-5) for England and Wales, and like the other four its purpose is to support various renewable energy technologies by requiring the public electricity suppliers to contract for specified power capacity. A premium price (determined by a bidding process involving prospective generators) is paid for electricity generated from these energy sources.

Details of the procedure have been summarised in an earlier edition of the Government's annual *Energy Report.*[19] Essentially four steps are involved in making a NFFO renewables order in England and Wales:

> 1. A DTI Minister makes an announcement of the basic policy proposals for a new NFFO Order, including its overall size (in megawatts) and the technology bands [e.g. wind farms, landfill gas] likely to be included. The DTI publishes further guidance to the 12 Regional Electricity Companies in the form of a *Renewable Energy Bulletin.*[20]
>
> 2. Prospective NFFO generators prepare proposals to supply electricity, using technologies specified in the Bulletin, and submit these to the Non-Fossil Purchasing Agency which acts on behalf of the RECs. These proposals are scrutinised by the Office of Electricity Regulation (Offer) which applies to them a "will secure" test to assess their prospects of technical and economic feasibility.[21] Generators who pass the test can then submit formal bids to the NFPA.
>
> 3. After consulting Offer and the RECs, the Minister makes an Order setting an obligation on each REC for each technology band (e.g. wind farms above a certain capacity) for each year of the Order. The NFPA signs sufficient contracts so that individual RECs *will secure* the specified capacity.
>
> 4. Before they can begin generating electricity, the contracted projects must obtain the necessary consents: local authority planning permission in the case of wind farms. Operational projects sell their electricity to the RECs at an above market price, the difference being funded by the Fossil Fuel Levy.

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19 DTI, *The Energy Report – Change and Opportunity*, 1996, p 127

20 DTI, *Renewable Energy Bulletin No 6: Fourth Round of Bidding - NFFO, 4* December 1995

21 Offer, *Fourth Renewables Order for England and Wales,* January 1997

Similar procedures exist in respect of a Scottish Renewables Obligation[22,23,24] (SRO) and a Northern Ireland Non-Fossil Fuel Obligation[25] (NI-NFFO). However, in the latter case, a formal levy is not applied, general electricity tariffs providing for the premium price.[26]

The Fossil Fuel Levy is payable by all licensed suppliers, and passed on to consumers as a percentage of their electricity bills. Condition 3 of the PES licence, which sets out the restrictions on charges made by the public electricity supplier, makes provision for the levy. All electricity generated from fossil fuels and nuclear fuel, and under NFFO contracts, is leviable.

The levy rate for England and Wales is determined according to the prescription given in the *Fossil Fuel Levy Regulations* SI 1990/266 (as amended by SI 1996/1309). In Scotland, the relevant regulations are the *Fossil Fuel Levy (Scotland) Regulations* SI 1996/293 (as amended by SI 1996/1512). The Director General of Electricity Supply collects the levy, using the proceeds to reimburse the public electricity suppliers for the excess costs involved in purchasing renewable electricity from generators. Section 33 of the *Electricity Act 1989* provides the general terms of reference under which the levy operates.

In England and Wales, the Fossil Fuel Levy rate currently stands at 0.7% (applied to electricity bills).[27] For 1999/2000, the Scottish fossil fuel levy rate is actually 0%, the result of a build up of levy funds and delays in the commissioning of contracted renewable electricity schemes.[28]

C. NFFO and Wind

Most present day UK renewable energy output is in the form of electricity (just over 2% of UK electricity in 1997), the main source being large-scale hydroelectricity. Waste incinerators and landfill gas provide the next largest output. Wind turbines contributed only 9% to the supply of renewable electricity (1997 figures), though their contribution is set to rise as new plant comes on stream. Detailed information is available from a number of sources, most particularly the *Digest of United Kingdom Energy Statistics 1998* (DTI/Government Statistical Service July 1998) and the Renewable energy statistics database.[29]

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22 HC Deb 13 March 1997 cc 313-4W

23 Energy Division of the Scottish Office Industry Department, *Outline Proposals for a Scottish Renewables Obligation*, May 1992

24 Scottish Office Industry Department, *Scottish Renewables Obligation: Bulletin*, Information about the Scottish Renewables Obligation for Generators of Electricity from Renewable Energy Sources, October 1993)

25 HC Deb 24 July 1996 cc 474-5W

26 DTI, *The Energy Report – Transforming Markets*, 1998, p 163

27 Offer Press Notice R71/98, *Fossil Fuel Levy Reduced*, 29 September 1998

28 Offer Press Notice R103/98, *Fossil Fuel Levy Rate in Scotland Reduced*, 21 December 1998

29 http://www.etsu.com/RESTATS/index.html

With the exception of the well established large scale hydroelectric installations, most of the electricity from renewables, and especially wind, has relied heavily on the Non-Fossil Fuel Obligation, and its Scottish and Northern Irish counterparts. This mechanism has been criticised on the grounds of it being oversubscribed, and of it taking too little account of delays that can occur in the separate planning process.[30] However, the competitive bidding process and, significantly, longer contracts have led to a progressive reduction in prices bid by developers. The table below shows how the price, in pence per kilowatt-hour, of wind-generated electricity has fallen, in the context of the Non-Fossil Fuel Obligation in England and Wales. Data is given for successful bids for NFFO contracts in money of the day.[31,32,33]

Obligation and year	Number of projects	Capacity(MW DNC)	Bid price (p/kWh)
NFFO-1 (1990)	9	12.21	5.75 – 10.00
NFFO-2 (1991)	49	84.43	6.39 – 11.00
NFFO-3 (1994)	55	165.62	3.98 – 5.99
NFFO-4 (1997)	65	340.8	3.11 – 4.95
NFFO-5 (1998)	69	368	2.43 – 4.60

Table 2: Details of successful bids for wind generation contracts under the non-fossil fuel obligations for England and Wales.

Electricity generating capacity is given in terms of *megawatts, declared net capacity* (MW DNC). For wind, this is defined by regulation as being 43% of the rated (or installed) capacity, and represents an attempt to account for the intermittency of the wind.

The latter two non-fossil fuel obligations have two technology bands for wind power, distinguished by the electricity generation capacity. Economies of scale result in the larger projects having lower bid prices. It is interesting, if a little misleading, to compare the bid prices in the above table with the electricity pool selling price – 2.60 p/kWh in the calendar year 1998.[34] The actual situation is complicated by *contracts for differences* reached by the generators and suppliers, with the result that the average price paid by a regional electricity company in England and Wales tends to be higher (last year this was 3.5 p/kWh[35]).

Of the 247 NFFO projects in Table 2, forty six have been commissioned representing a declared net capacity of 103.2 megawatts. A further 12 are operational in Scotland and Northern Ireland, providing 34.4 MW DNC.[36] Appendix 1 gives details of operational wind farms in the UK, together with individual turbines which have received NFFO support.

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30 "Beyond fossil fuels", *Science & Public Affairs*, Winter 1996

31 Offer, *Fourth Renewables Order for England and Wales*, January 1997

32 "Richard Page turns up the heat for renewable electricity", *DTI press release P/97/116*, 6 February 1997

33 DTI Press Release p/97/116, *John Battle makes greatest commitment ever to renewable sources of energy*, 24 September 1998 - addendum

34 DTI, *New & Renewable Energy – Prospects for the 21st Century*, 30 March 1999

35 *ibid*. p 60

36 "NFFO news", *New Review*, May 1999

IV The Resource

A. Onshore

Weather patterns over Europe result in the UK having one of the best wind resources in this part of the world.[37] As wind speed increases with both height above sea level and elevation of land, the most favourable areas lie in hilly regions. There are, of course, certain limitations on the availability of land which restrict the siting of wind farms. These include physical barriers such as land already occupied by towns, villages, lakes, rivers, woods, roads and railways. Since turbines can only be sited at some distance from many of these features the effective size of the latter is greater than their physical measurement; this restricts still further the available space for development. Institutional barriers also exist in the form of land protected for scenic or environmental reasons.

B. Offshore

Offshore, the potential wind resource is very much greater than onshore. Average wind speeds tend also to be higher. Restrictions on useable area occur in regions allocated for other purposes such as fishing and shipping, and where water depths exceed 30m which is too deep to be practicable. There are certain technical problems to be overcome due to the more hostile environment but in the long term offshore wind power is likely to make a significant contribution.

C. Potential

The Energy Technology Support Unit (ETSU) has estimated the potential contribution that wind power could make to annual UK energy needs.[38] It estimated a total onshore accessible wind resource in the UK of about 340 terawatt-hours[39] hours per year (TWh/yr). The estimated offshore resource is potentially greater at 380 TWh/yr. Theoretically, offshore and onshore wind farms could, separately, provide for all of the UK's electricity consumption: 317.5 TWh/yr (1997 figure). However, when planning consents, and the need to restructure the electricity grid system to take into account the intermittent nature of the wind resource have been considered, a *maximum practicable resource* is obtained. For onshore wind this is 49 TWh/yr by the year 2005 at prices under 10p per kilowatt-hour (assuming a commercial discount rate of 15%). With the same economic assumptions, offshore wind power is expected to have a negligible maximum practicable resource by 2005 since there remains insufficient time to establish a substantial build rate. Its large potential, together with improvements in technology, could make it a good longer-term bet.

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37 European Commission, *Wind Energy – The Facts*, 1999, p 6

38 ETSU, *An Assessment of Renewable Energy for the UK*, 1994, pp 45-46

39 1 TWh (terawatt-hour) = a billion kilowatt-hours

More realistically, the British Wind Energy Association (BWEA) has told the Trade and Industry Committee that wind turbines could supply 6% of the UK's electricity demand by 2010.[40] It suggested that a 25% contribution would be feasible by 2025.

This compares with 665 GWh[41] of electricity generated by UK wind farms in 1997, which is about 0.19% of all electricity generated.[42]

[40] "Renewable projects face closure at year end, MPs warned," *ENDS Report 277*, February 1998

[41] 1 GWh (gigawatt-hour) = a million kilowatt-hours

[42] DTI, *Digest of UK Energy Statistics*, 1998

V Environmental Aspects

The principal benefits of wind power are that electricity is generated without dependency on nuclear fuels or the use of finite fossil fuel resources and the pollution that these generate. There is no radioactive waste, no residual ash and no production of particulates, NO_x, SO_2, or CO_2. This is important because particulates have been implicated in lung disease,[43] the gaseous oxides of nitrogen and sulphur are sources of acid rain and carbon dioxide contributes to the greenhouse effect.

While offshore wind energy appears to have few environmental problems, it would be a mistake to think that the same is true of onshore wind farms. The most intrusive features of these are their visual impact and noise.

A. Visual Impact

The Welsh Affairs Select Committee which examined the issue of wind energy in 1994 concluded that "concerns over visual impact are the most deep-seated and firmly held objections to the development of wind energy".[44] Unlike other unacceptable aspects of wind power such as noise generated or fears about safety, which may be reduced by technical means, the visual impact is unavoidable. To operate effectively a wind farm must be in an exposed, often elevated, position which is likely to be visible from many locations in the vicinity. The windiest parts of the country are in the north and west where many National Parks and areas, protected because of their scenic qualities, are found. This has led to fears that wind farms located nearby will reduce the amenity of these areas.

The technical design of the turbines is the most obvious factor affecting the visual quality of a wind farm. The size and colour of the turbines, their shape and the number of blades are important features. The turbine towers are typically 25-30 m tall with blade diameters of 30-35 m. For comparative purposes, the height is shorter than the standard 44kV pylon of 50m. The number of turbines and their layout on a wind farm also affects their visual impact. A typical farm has between 10 and 30 turbines spread over a few square kilometres. Several differing opinions were expressed to the Welsh Affairs Select Committee:[45]

> 84. An important consideration, however, to any individual approach to the issues of visual impact is an aesthetic assessment of the turbines themselves. The Planning Inspector at Cemmaes described the turbines as "elegantly designed, having clean lines with no extraneous features or visual clutter". Mr Backhouse,

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43 Committee on the Medical Effects of Air Pollutants, *Quantification of the Effects of Air Pollution on Health in the United Kingdom*, 1998

44 Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxix, para 83

45 Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxix, para 84

> Director of Planning, Montgomeryshire District Council told us that in his view, the shape of wind turbines is generally "aesthetically pleasing". In some circumstances "a well-designed wind farm can actually add to the landscape". Such views would, however, be rejected by the many opponents of wind farms who take the view that turbines are intrinsically ugly disfigurements of the landscape. The Ramblers' describe them as "alien [and] ... 'industrial' features which mar the rural landscape". The National Trust stated that "rotating blades cause the attention to be focused on the turbine, thus detracting from the landscape as a whole".

This illustrates that the overall aesthetic assessment is not only based upon the visual aspects, but is a somewhat subjective judgement. It is influenced by an individual's view of the usefulness of wind power, its place in providing a clean environment for the future, the level of understanding of the technology, the degree of involvement with it, and by how the media portray it.

The difference in views is typified by two EDMs on the issue. Frank Cook tabled EDM 134, session 1994/95, which unequivocally supported the development of the Humble Hill wind farm in Keilder Forest, Northumberland. By contrast, while recognising the advantages of renewable energy, EDM 611, session 1995/96, tabled by Colin Pickthall, "urged the Secretary of State for the Environment to respond to the Countryside Commission's suggestion that [the relevant Planning Policy Guidance Note] PPG 22 be revised and strengthened to prevent the permanent defacing of many of this country's most attractive areas".

There are frequent press reports about the concerns associated with the visual impact of proposed wind farms. For example, one report expresses the fears of Scottish National Heritage which has carried out a case study of the potential cumulative impact of five separate wind farm proposals within 30km of each other on the Kintyre peninsula.[46] Another article reports on opposition to a wind farm proposed for a picturesque part of North Pembrokeshire in Wales. The Campaign for the Protection of Rural Wales vowed to fight the plans at a public enquiry.[47]

A number of surveys have been conducted, however, which indicate growing public acceptance, indeed approval, of wind farms. For example, a survey of public attitudes indicated that only a minority viewed wind farms as having a negative effect on the landscape, and another revealed that public attitudes around the Delabole wind farm in Cornwall improved markedly after it began operation:[48]

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46 C Cairns, "Wind farm 'beauty wreckers' warning", *Scotsman*, 19 July 1998, p 9

47 C Jones, "Windfarm opponents to continue battle", *Western Mail*, 21 August 1998, p 3

48 Godfrey Boyle (ed), *Renewable Energy - Power for a Sustainable Future*, 1996, p 300

> A public attitude study conducted in the UK (Lee *et al*., 1989) indicated that only 35% of the respondents felt that a wind farm would spoil the view, 75% of respondents felt that, like electricity pylons, wind turbines are 'just there' and 90% of respondents preferred turbines to be painted in neutral colours.
>
> More recently, a public attitude survey was carried out around the Delabole wind farm by Exeter University and funded by ETSU (Edwards, 1993). The survey was carried out in two phases. Phase one was carried out before construction of the wind farm and phase two after the wind farm had commenced operation.
>
> The phase one survey indicated that 17% approved of the concept of a wind farm, 32% disapproved and 51% were not sure. The phase two survey indicated that a marked change of opinion had occurred since the wind farm had commenced operation. This time, 85% approved of the concept of a wind farm, 4% disapproved and 11 % were not sure.

Research in Wales has also indicated a high degree of support for wind power in the region.[49]

The Welsh Affairs Select Committee summarised the position about the visual aspect of wind turbines in one of its conclusions:[50]

> Whether they become accepted as other man-made structures in the countryside have become accepted (from pylons to railway viaducts) will crucially depend both on the sensitivity with which they are sited and on their being seen as a genuine contribution to clean, renewable and economically viable electricity generation, rather than as evidence of the greed of developers for a generous subsidy.

B. Noise

The noise generated by wind turbines is from two sources. One is the *aerodynamic noise* caused by the movement of the rotor blades relative to the air, and would commonly be described as a 'swish'. This noise is largely unavoidable. It relates to the shape of the blades, and increases with wind speed and turbulence. Aerodynamic noise is not audible over long distances and as wind speed increases is drowned by the noise of the wind itself. This type of noise is not a major cause of complaints. The second type is *mechanical noise* caused by the operation of the gearbox within the turbine. This category also encompasses the noise of electrical equipment in the generator. Complaints occur about the persistent tonal quality of this type of noise, although it can be more varied with clunks, thuds and grinding, presumably as a result of the operation of the gears. Careful design, siting, and operation and the use of acoustic enclosures and gear-less turbines continue to mitigate the impact of mechanical noise.

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49 Godfrey Boyle (ed), *Renewable Energy - Power for a Sustainable Future*, 1996, pp 300-301

50 Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxx, para 86

Most wind farms are subject to noise limits as part of their planning consent. The relevant Planning Policy Guidance Note is PPG 22, *Renewable Energy*, issued in February 1993. This contains an annex on wind energy which includes a section about noise. By reference to PPG 22 noise levels are typically required to be below 40 dB(A)[51] at 400m from the site. Noise levels which have provoked complaints are, however, below this level.[52] Another avenue open to those troubled by wind farm noise was set out by the Welsh Affairs Select Committee:[53]

> 65. Where the planning conditions relating to noise are not being breached, or where there are no such conditions, a complainant's only alternative is to seek to persuade the local authority that the noise constitutes a statutory nuisance. If the local authority takes up the case, the "onus of proof" that a nuisance has been caused rests with it. In seeking to establish that proof it would call upon "various different standards, such as BS4142", although that, as we have seen, is unlikely to be of much assistance. As far as we are aware, there have been no cases of complaints of noise at levels similar to those caused by wind farms leading to a successful prosecution as a statutory nuisance. The problem, it was suggested to us, was not with the statutory nuisance provisions themselves, but with "categorising this sort of noise as a statutory nuisance".

The Committee concluded "that it is essential that indicative limits are clearly stated in national guidance":[54]

> We recommend that such limits should be set both in respect of a standard distance from the development and separately for all dwellings within a certain radius (say 1.5 km). It should be the intention of those limits that wind farm noise of mechanical origin is inaudible at any neighbouring dwelling.

C. Electromagnetic Interference

If a wind turbine is positioned between a transmitter and receiver used in telecommunications it can reflect some of the radiation. This then interferes with the original signal distorting it as it arrives at the receiver. Consequently, wind farms may interfere with telecommunication links. The most likely form of interference is with television reception. The BBC has carried out an investigation and concluded this is not a significant problem.[55] The Welsh Affairs Select Committee also stated that it was not

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[51] The unit of noise is the decibel (dB). The decibel is a measure of the magnitude of the pressure variations in the air. Environmental noise is usually measured in decibel (A), dB(A), which includes a correction for the sensitivity of the human ear

[52] Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxv, para 64

[53] Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxv, para 65

[54] Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxvi, para 71

[55] EUREC Agency, *The Future of Renewable Energy*, 1996, p 162

aware of any insoluble problems regarding electromagnetic interference.[56] Planning Policy Guidance (PPG 22): *Renewable Energy*, contains information about electromagnetic interference and in practice during the planning phase of a wind farm, areas where turbines could cause interference are avoided. If it does occur it is relatively easily rectified by technical means. The Welsh Affairs Committee concluded:[57]

> we believe that wind farm developers do have a responsibility to take any necessary measures to protect the television and radio reception of local communities… We recommend that such an obligation should be a routine planning condition on wind farm developments.

D. Safety

Accidents involving wind turbines in which people have been injured have been confined to operational staff who have failed to observe manufacturers' or operators' instructions.[58] There have been no known cases of injury to the general public. There have been a few cases of turbines shedding part or whole rotor blades in extreme weather conditions, but there were no injuries caused.[59,60] These incidents must be seen in the context of the successful operation of tens of thousands of wind turbines world-wide. Insurance companies in the USA, where there is the most experience of operating large wind farms, consider that wind turbines have a good safety profile in comparison with other energy generating operations.

E. Birds

Studies in a number of European countries have concluded that wind turbines pose little hazard to birds.[61] There have been a few cases of bird deaths following collisions with turbines, but these are few compared with background mortality and bird deaths caused by collision with radio masts, electricity pylons, aircraft etc. Disturbance of breeding or resting birds could be a problem in coastal regions as noted by the Welsh Affairs Committee:[62]

> … the Countryside Council for Wales advised a "precautionary approach to the siting of wind farms in areas of high ornithological importance". The RSPB particularly identified sites with breeding hen harriers (of which there are only 20 to 30 pairs in Wales) as unsuitable for wind farm developments.

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56 Welsh Affairs Committee, Wind Energy, 13 July 1994, HC 336-I 1993-94, xxvii, para73
57 Welsh Affairs Committee, Wind Energy, 13 July 1994, HC 336-I 1993-94, xxvii, para73
58 ETSU for the Department of Trade and Industsry. Wind Energy Fact Sheet No 4, *Environment and Safety*, May 1994.
59 *ibid*
60 Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxviii, para77
61 EUREC Agency, *The Future of Renewable Energy*, 1996, p 161
62 Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxix, para 81

VI Offshore Developments

A. Technology

Offshore turbines share the basic technology of onshore machines, but there are differences in design and maintenance requirements mainly as a result of the more hostile environment. It is expected that the size of offshore wind turbines will be substantially larger than those currently installed onshore, and that with time the size of turbines in new developments will increase. Tower heights of 60m and blade lengths of 35m are being predicted on turbines with a multi-megawatt capacity.[63] The reason for using larger turbines offshore than onshore is related to the cost of foundations and cable connections to the grid.

Onshore, foundation and grid-connection costs are each typically of the order of a few percent of the project budget. In the most recent Danish offshore wind farm at Tunø Knob the foundation costs per turbine and grid-connection costs were 23% and 14% of the budget respectively.[64] The factors that decide the required strength and weight of the foundations, and therefore the cost, are the waves or pack ice and not the size of the turbine. From an economic standpoint it is, therefore, wise to install turbines that are as large as possible on the foundations. This has the added benefit that for a given wind farm generating capacity it is less expensive to attach fewer turbines to the grid. An exciting development in offshore technology is the possible use of steel as opposed to concrete foundations with an associated decrease in foundation cost of 35%.[65]

Other design features that are specific to offshore developments include those that reduce to a minimum the need to access turbines during operation. These include features that reduce maintenance costs such as:[66]

- corrosion protection from sea spray;
- refined control equipment - to enable a higher degree of control to reduce maintenance requirements;
- integration of lifting equipment - to reduce the need for floating cranes;
- adaptation of foundation design to suit site conditions (with the potential to recycle for a possible second generation of wind turbines);
- adaptation of health and safety requirements.

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63 Greenpeace, *Offshore Wind Energy*, 1998, p 11

64 S Krohn, "Offshore wind energy: full speed ahead", *CADDET renewable Energy Newsletter*, December 1998, pp 16-18

65 i*bid*

66 Greenpeace, *Offshore Wind Energy*, 1998, p 11

B. Government Policy

Currently there are no offshore wind farms operating in UK waters, unless the nine 300 kilowatt turbines on Blyth harbour wall are considered to fall within this category. These were supported in the second round of the Non-Fossil Fuel Obligation (NFFO), which is the Government's main vehicle for financial support for renewables during the market stimulation period. The fourth round of NFFO includes support for offshore wind, though this was not identified as a specific technology band. In the fifth round of NFFO offshore projects were excluded in the technical specification probably because the Government was intending to carry out a consultation on offshore developments.

The Government's level of interest in offshore wind power was illustrated in a closing speech by the energy minister, Mr John Battle, at the Council of Europe Parliamentary Conference on the Oceans.[67]

> 17. For the UK, and for other countries, a new and major technical challenge is exploiting offshore wind. I am pleased at the growing interest in utilising the UK's significant offshore wind resource.
>
> 19. I have been confidently assured by the UK wind industry that it can build, operate and maintain offshore wind farms economically and with minimum environmental impact. For the UK Government's part we are developing a set of planning arrangements that will aim to ensure both the capability of prospective developers to operate offshore wind farms, and also that establish suitable environmental protection measures.

Subsequently at the British Wind Energy Association meeting in Cardiff on 2 September 1998 John Battle launched a consultation document inviting views on how best offshore technology could be supported by Government by incorporating the development of offshore projects into the NFFO process. Mr Battle appraised offshore wind as one of the UK's greatest untapped, natural, sustainable and pollution-free resources. He hoped that offshore wind will succeed in making a substantial, cost-effective, contribution to electricity needs. The extent of this will depend upon its environmental acceptability and comparative cost. Furthermore, a recent Greenpeace study has argued the case for offshore wind power on employment grounds: over 30,000 jobs could be created if the Government committed to an initial target of providing 10% of UK electricity from offshore wind in the next ten years.[68]

The government consultation will consider arrangements for a first offshore wind band in future NFFO rounds. Initially, it is expected that five or six projects will be supported by this means. In the past NFFO Orders have been based upon competitive bidding and it is

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67 19 March 1998, http://www.dti.gov.uk/Minspeech/oceans.htm

68 Greenpeace, *Offshore Wind, Onshore Jobs*, February 1999

likely that this approach will continue. This implies that wind power will have to compete on cost-effective terms with other renewable resources:[69]

> The main purpose of the consultation paper is to give the British wind industry an opportunity to comment on possible arrangements for incorporating offshore wind energy into NFFO, although views received from others will be considered. The paper is a further step in an industry dialogue and reflects BWEA's earlier submission to the DTI. Any arrangements will be reviewed on a continuing basis.
>
> The document is not intended to be an all-encompassing outline of how offshore wind should be developed. More specifically, the consultation document excludes from its scope the development consent regime (and concomitant environmental assessment) on which DTI expects to develop separate guidance on the options available later in the year.
>
> In parallel with this consultation exercise, the DTI has been working on separate guidance for the range of consents and planning approvals required for developing offshore wind farms, to be issued shortly.
>
> The first offshore NFFO will be announced following completion of the renewable energy review, by when the DTI, Office of Electricity Regulation (OFFER), Non-Fossil Purchasing Agency (NFPA) and the Crown Estate, owner of the seabed, should have finalised their procedures, including the Crown Estate agreeing standard lease agreements with the BWEA and guidance issued on development consent.

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[69] DTI Press Release P/98/663, *John Battle Aims to Boost Offshore Wind for Electricity Generation*, 2 September 1998

VII Parliamentary Debates

During the last decade four major debates about wind farms and wind turbines have taken place in Parliament. The most recent was in the Lords,[70] and the previous three in the Commons.[71,72,73] These have provided a forum for general debate of the issues, in particular the Lords debate was very wide-ranging. The penultimate debate, which is the most recent in the Commons, addressed the position in Scotland. Although all of the debates took place during the Conservative administration there was no great hiatus in policy when the Labour government came to power and many of the issues which were topical at the time are still relevant.

A recurrent theme in the debates was planning policy and its suitability for ensuring adequate control of wind farm development in rural environments. In England the principal guidance is Planning Policy Guidance Note (PPG 22), *Renewable Energy*, issued in February 1993, which includes an annex about wind energy. The Scottish position, which is different, was set out by George Kynoch, the then Paliamentary Under-Secretary for Scotland, in one of the Commons debates.[74] A succinct resume of relevant planning guidance for England was included in another of the debates:[75]

> PPG 22 reiterates the fundamental principles of planning, and deals with particular issues raised by renewables. It states that planning decisions have to reconcile the interests of development with the importance of conserving the environment - the issue at the heart of sustainable development. Specifically in relation to energy, it states that the Government's general aim is to ensure that society's needs for energy are met in a way that is compatible with the need to protect the environment, both global and local.
>
> PPG 22 says that planning authorities must weigh carefully the Government's policies for developing renewable energy sources with those protecting the environment, and draws particular attention to those relating to the countryside, PPG 7, and the coast, PPG 20. PPG 22 states that planning applications should be determined in accordance with the structure plans of the county council and the local plans of the district councils. Those plans are required to include policies for conserving wildlife and the natural beauty and amenity of the land. PPG 22 also requires that they now take account of the Government's policy on renewable energy.

There has been much concern and many calls for a revision of PPG 22. During the Lords debate Earl Ferrers, the then Minister of State for the Environment, noted "My noble

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70 HL Deb 13 February 1997 cc 381-398
71 HC Deb 30 October 1996 cc 563-583
72 HC Deb 1 May 1996 cc 1118-1126
73 HC Deb 16 February 1994 cc 1041-1048
74 HC Deb 30 October 1996 cc 580-582
75 HC Deb 1 May 1996 cc 1124-1125

friend Lord Marlesford said he wanted it redrafted. So too, I think, did the noble Baroness, Lady Nicol, and the noble Lord, Lord Chorley."[76] As the minister pointed out later in the debate, it is a question of whether PPG 22 draws the correct balance between the benefits of developing a clean and renewable energy source and any impact which that might have on the environment. At the time Earl Ferrers said, and this still appears to be Government policy, that:[77]

> The Government believe that Planning Policy Guidance Note 22--it was produced as recently as 1993--already provides pretty comprehensive and relevant advice on planning and renewable energy but, like all planning policy guidance, the relevance of its advice is kept under continuous review.

Planning policy is operated not only through national guidance but also through local development plans. This was illustrated in the Lords debate by reference to a request for a presumption against wind farms in environmentally sensitive areas:[78]

> If an applicant proposes something which is clearly in conflict with a development plan he will need to produce convincing reasons why the plan should not prevail. Each local authority has to produce a development plan. Planning applications for renewable energy projects have to be determined in accordance with the development plan. Development plans have to recognise that energy which comes from a renewable source can usually be developed only where it occurs. And development plans have to include policies about conserving wildlife and its habitats, and the natural beauty and amenity of the land; improving the physical environment; and taking account of the Government's policy for renewable energy.

Additionally the Government has addressed the issue of environmental assessments:[79]

> In the recent past the Government have amended the environment assessment regulations to include wind farms. Hence planning applications which are likely to have a significant impact on the environment have to be accompanied by an environmental statement…
>
> The present guidance indicates that a formal environmental assessment should be required where the proposed development exceeds 10 turbines or if the generating capacity exceeds five megawatts. It is possible, though, that an environmental assessment could be required for smaller developments--if, for example, the proposed development were to be in a sensitive location.

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76 HL Deb 13 February 1997 c 396
77 HL Deb 13 February 1997 c 396
78 HL Deb 13 February 1997 c 397
79 HL Deb 13 February 1997 cc 396-397

VIII The Renewables Review

The outcome of the review of new and renewable energy was announced in a written answer on 30 March:[80]

> Mr. Chaytor: To ask the Secretary of State for Trade and Industry (1) when he expects to publish his consultation paper on renewable energy generation; and if he will make a statement;
>
> (2) what targets he has established for the generation of electricity from renewable sources.
>
> Mr. Battle: I have today published a consultation paper "New and Renewable Energy--Prospects for the 21st Century" which reports on the outcome of the Government's review of new and renewable energy policy.
>
> The Renewables Review paper demonstrates that there is tremendous potential for renewables to become a fully competitive part of UK energy supply. Renewables make an important contribution to secure, sustainable and diverse energy supplies in the UK. They are an essential element of a cost-effective climate change programme and will help the Government meet their environmental objectives at the least cost to the customer. Renewables play a vital role in enabling the UK to meet its environmental targets of reducing greenhouse gases by 12.5% by 2012, and the goal of reducing carbon dioxide emissions by 20% by 2010.
>
> The document shows that producing 10% of UK electricity from renewables appears to be feasible. The Government intend working towards a target of renewable energy providing 10% of UK electricity supplies, cost effectively, as soon as possible. I want to achieve this by 2010. However, this should not be seen as an end in itself, but a step forward on the road to making renewables a strong, world-beating industry.
>
> There are already considerable benefits of the renewables industry. The UK industry employs 3,500 people. Through creating an export drive, and by further developing the industry and the UK market, up to 45,000 jobs could be created.
>
> The Non-Fossil Fuel Obligation (NFFO) has already provided over £600 million of support for renewables. Support for renewables under NFFO will accelerate in the first decade of the next century and could rise to around £150 million a year. NFFO has played a major part in stimulating the industry and bringing down the costs of renewables. As a result of NFFO, an industry of some 700 organisations has been developed. This is why the Government want to see how NFFO can evolve, and to see how it can help the industry to thrive even more.

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[80] HC Deb 30 March 1999 cc 577-8W

> The review document therefore presents options for possible ways to support renewables while they are reaching market prices. It looks at both the costs and benefits of moving towards a greater use of renewables. In particular, it looks at options for a revised NFFO in the competitive energy markets of the future.
>
> In addition, the Government have provided an increased budget for DTI's New and Renewable Energy Support Programme. They have allocated £43.5 million over the next three years for R&D to help achieve its aim.
>
> The Government are pressing ahead with reform--electricity liberalisation, for instance, is giving consumers the ability to choose their electricity supplier--including green electricity. Suppliers are now offering green tariffs and the Government hope consumers will take up this opportunity to stimulate growth in renewables.
>
> Solar energy also has real potential in the longer term. This is why the Government has recently asked for industry's involvement in taking forward three major new photovoltaic initiatives. In addition, last year I switched on the first solar panel system for a British school, as part of the Government's Foresight Scolar programme. I believe that such schemes can play a valuable part in the development of the UK renewables industry.
>
> This report identifies key issues and challenges which the Government and industry would need to pursue. Issues examined in the paper include: planning arrangements; opportunities for developing energy crops; and arrangements to ensure that embedded generators--those directly connected to local distribution systems, often the case with renewables producers--receive a fair price for their electricity. It seeks views on the issues raised to enable the Government to frame their future policy.
>
> I look forward to receiving those views, and plan to make a further announcement about the way forward in due course. The Government are committed to encouraging sustainable development, to ensure a better quality of life for all.

In order to find ways of achieving the above, views are invited (by 28 May 1999) on issues identified in paragraph 26 of the consultation paper:

> There are strong energy policy arguments for supporting renewable energy as a component of our overall energy system. In particular, renewable energies offer diversity and security as well as sustainability and other environmental benefits. In the short term renewables may need support to help achieve the necessary economies of scale, technological development and investor confidence. In the longer term, non-fossil sources may form an increasingly large proportion of our electricity and energy systems and those of expanding economies, at competitive prices. Furthermore, renewable technologies need to be considered individually as they have different environmental impacts and are at different stages of development.

Much of the above is uncontroversial. Indeed, the first sentence, alluding to support mechanisms, is the crucial one. At this stage it is unclear what the impact will be of the future Climate Change Levy (an energy tax on industry), currently the subject of consultation.[81]

Friends of the Earth issued a press release to coincide with publication of the renewables consultation document, criticising what they see as an unjustified delay in putting further support measures in place.

> The year long Government review of renewable energy has resulted in yet another consultation document without a clear view of the policies needed to ensure that the Government's renewable target is met. FOE believes that this continued delay reflects Treasury and DTI disagreements over the cost of supporting renewables, even though renewables are becoming increasingly competitive with fossil fuels. Renewables are already cheaper than nuclear electricity.[82]

Nuclear electricity shares with many renewables substantial "up-front" capital costs, which do not benefit from discounting (though the ultimate decommissioning of nuclear facilities does so benefit). The former is presently making a far greater contribution towards meeting the UK's carbon dioxide reduction targets. However, as the consultation paper recognises, renewables appear set to become a major national energy source in the coming century. And wind power, onshore and offshore, has the potential to be an important player.

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81 HM Customs &Excise, *A Climate Change Levy – A Consultation Document*, March 1999

82 "FOE groans at another Government consultation…", *Friends of the Earth press release*, 30 March 1999

IX Appendix I: Operating Wind Farms

The tables below, reproduced by kind permission of the British Wind Energy Association,[83] give details of all operating wind farms in the UK (up to August 1998). In addition, individual turbines supported by the Non-Fossil Fuel Obligation are detailed. Excluded are other individual turbines at sites such as Wansbeck General Hospital in Northumberland. Altogether the table refers to 749 individual turbines with a total installed (i.e. rated) capacity of 325 MW. To obtain a figure which can be compared with a conventional power station, one should use the declared net capacity – 43% of the rated value.

Wind Farm	Location	Contact	Comprising	Total Rated Capacity	Developer	Operation Started
Delabole	Cornwall	NFFO1	10 X Vestas 400 kW turbines	4 MW	Wind Electric	Nov-91
Haverigg (plus new extension, see bottom of list)	Cumbria	NFF02	5 X Vestas 225 kW turbines	1.125 MW	Windcluster	Aug-92
Carland Cross	Cornwall	NFFO2	15 X Vestas 400 kW turbines	6 MW	Renewable Energy Systems	Aug-92
Cemmaes	Powys	NFFO1	24 X WEG 300 kW turbines	7.2 MW	National Wind Power	Nov-92
Blood Hill	Norfolk	NFFO1	10 X Vestas 225 kW turbines	2.25 MW	Euros Power	Dec-92
Chelker Reservoir	Yorkshire	NFFO1	4 X WEG 300 kW turbines	1.2 MW	Yorkshire Water Services	Dec-92
Rhyd-y-groes	Anglesey	NFFO2	24 X Bonus 300 kW turbines	7.2 MW	EcoGen	Dec-92
Blyth Harbour	Northumberland	NFFO2	9 X WindMaster 300 kW turbines	2.7 MW	Border Wind	Jan-93
Great Orton	Cumbria	NFFO2	10 X Carters 300 kW turbines	3 MW	Carter Wind Technology	Jan-93
Llandianam	Powys	NFFO2	103 X Mitsubishi 300 kW turbines	30.9 MW	EcoGen	Jan-93
Coal Clough	Lancashire	NFFO2	24 X Carters 400 kW turbines	9.6 MW	Renewable Energy systems	Feb-93
Cold Northcott	Cornwall	NFFO2	21 X WEG 300 kW turbines	6.3 MW	National Wind Power	Apr-93
Goonhilly Downs	Cornwall	NFFO2	14 X Vestas 400 kW turbines	5.6 MW	Cornwall Light and Power	Apr-93
Llangwyryfon	Dyfed	NFFO2	20 X WEG 300 kW turbines	6 MW	National Wind Power	Jun-93
Ovenden Moor	Yorkshire	NFFO1	23 X Vestas 400 kW turbines	9.2 MW	Yorkshire Windpower	Jun-93
Taff-Ely	Mid Glamorgan	NFFO2	20 X Nordtank 450 kW turbines	9 MW	East Midlands Electricity	Aug-93

[83] http://www.bwea.com/

Kirby Moor	Cumbria	NFFO1	12 X Vestas 400 kW turbines	4.8 MW	National Wind Power	Sep-93
Royd Moor	South Yorkshire	NFFO2	13 X Bonus 450 Kw turbines	5.85 MW	Yorkshire Water Services	Dec-93
Bryn Titli	Powys	NFFO2	22 X Bonus 450 Kw turbines	9.9 MW	National Wind Power	Jul-94
St Breock	Cornwall	NFFO2	11 X Bonus 450 Kw turbines	4.95 MW	EcoGen	Jul-94
Caton Moor	Lancashire	NFFO2	10 X WindMaster 300 kW turbines	3 MW	New World Power	Dec-94
Dyffryn Broydn	Dyfed	NFFO2	11 X Nordtank 500 kW turbines	5.5 MW	New World Power	Dec-94
Corkey	Antrim	NI-NFFO1	10 X Nordtank 500 kW turbines	5 MW	B9 Energy Services	Mar-95
Four Burrows	Cornwall	NFFO2	15 X Bonus 300 kW Turbines	4.5 MW	New World Power	Mar-95
Rigged Hill	Limavady	NI-NFFO1	10 X Nordtank 500 kW turbines	5 MW	B9 Energy Services	Mar-95
Elliot's Hill	Antrim	NI-NFFO1	10 X Vestas 500 kW turbines	5 MW	B9 Energy Services	Apr-95
Bessie Bell	Tyrone	NI-NFFO1	10 X Vestas 500 kW turbines	5 MW	Colham Energy	Oct-95
Hagshaw Hill	Lanarkshire	SRO1	26 X bonus 600 kW turbines	15.6 MW	TriGen Ltd	Nov-95
Slieve Rushen	Fermanagh	NI-NFFO1	10 X Vestas 500 kW turbines	5 MW	Sean Quinn Group	Dec-95
Trysglwyn	Anglesey	NFFO3	14 X Bonus 400 kW turbines	5.6 MW	National Wind Power	Jul-96
Siddick	Cumbria	NFFO3	7 X Vestas 600 kW turbines	4.17 MW	WindProspect/ PowerGen	Aug-96
Oldside	Cumbria	NFFO3	9 X Vestas 600 kW turbines	5.36 MW	WindProspect/ PowerGen	Aug-96
Windy Standard	Galloway	SRO1	36 X Nordtank 600 kW turbines	21.6 MW	National Wind Power and Fred Olsen Ltd	Sept-96
Carno	Powys	NFFO3	56 X Bonus 600 kW turbines	33.6 MW	National Wind Power	Oct-96
Harlock Hill	Cumbria	NFFO3	5 X Wind World 500 kW turbines	2.5 MW	The Wind Company	Jan-97
Great Eppleton	Tyne and Wear	NFFO3	4 X Windmaster 750 kW turbines	3 MW	Border Wind	Jan-97
Rheidol	Ceredigion	NFFO3	8 X Bonus 300 kW turbines	2.4 MW	PowerGen	Jan-97
Owenreagh	Tyrone	NI-NFFO1	10 X Zond 500 kW turbines	5 MW		Jan-97
Novar	Highlands	SRO1	34 X bonus 500 kW turbines	17 MW	National Wind Power	Oct-97
Llyn Alaw (Lanbabo)		NFFO3	34 X Bonus 600 kW turbines	20.4 MW	National Wind Power	Oct-97
Mynydd Gorddu	Trydan Gwynt Cyfyngedig	NFFO3	20 X Nordtank/Zond 500 kW turbines	10 MW		Apr-98
Haverigg II (extension)	Cumbria	NFFO3	4 X Wind World 600 kW turbines	2.4 MW	Wind Prospect	Jul-98

Individual turbines with NFFO contracts						
Lynch Knoll	Gloucestershire	NFFO3	1 X Enercon 500 kW turbines	0.5 MW	Renewable Energy Company	
Centre for Alternative Technology	Machynlleth, Powys	NFFO3	1X WEG 500 kW turbines	0.6 MW	WEG	
Hafotty Ucha	Nr Bala, N. Wales	NFFO3	1 x Vestas	0.6 MW	Huw Smallwood	Oct 1998