THE DAVID HUME INSTITUTE

Tilting at Windmills:
The Economics of Wind Power

April 2004

David Simpson
(The David Hume Institute)

Hume Occasional Paper No. 65

The David Hume Institute
25 Buccleuch Place
Edinburgh EH8 9LN

ISBN 1 870482 65 4

Tilting at Windmills:
The Economics of Wind Power

April 2004

David Simpson

THE DAVID HUME INSTITUTE

2004

The Institute gratefully acknowledges the sponsorship of this publication by The Binks Trust

Professor David Simpson

David Simpson was educated at the Universities of Edinburgh and Harvard. He then worked for the Statistical Office of the United Nations in New York, where he prepared a manual on the compilation and use of input-output tables. Following a number of academic appointments, he became the founding Director of the Fraser of Allander Institute in 1975, and from then until 1988 he was a Professor of Economics at the University of Strathclyde. In 1989 he left academic life to become Economic Adviser to Standard Life, an appointment which he held until his retirement in 2001. From time to time he has acted as a consultant to various organisations including the European Commission and the World Bank.

Professor Simpson is the author of several books including *General Equilibrium Analysis* (1975), *The Political Economy of Growth* (1983), *The End of Macroeconomics*? (1994), and *Rethinking Economic Behaviour* (2000). He has contributed articles to periodicals ranging from *Econometrica* and *Scientific American* to *The Spectator* and *The Financial Times.*

Foreword

This paper, "Tilting At Windmills: An Economic Analysis Of Wind Power", presents the results of a research project conducted by Professor David Simpson on behalf of The David Hume Institute. The aim of this research is to investigate the underlying economics of wind power. From being a source of energy that until recently appeared only on the fringes of the energy supply system, wind power has, over recent years, moved centre stage in the government's energy policy. This paper asks whether the economic analysis of this source of energy really justifies such a major role and whether alternative policy options should be considered.

Energy policy in the United Kingdom is circumscribed by two government commitments. The first is a consequence of the Kyoto Agreement, whereby the United Kingdom is committed to cutting greenhouse gas emissions by the 2008-2012 period to levels significantly below those of 1990. The second is an internally defined policy objective of reducing UK carbon dioxide emissions by 2010 to 20% below the 1990 level. As a major (indeed, the major) policy instrument for attaining these targets, the government has chosen the production of energy from renewable resources. Most obviously, the switch to renewable energy sources is being brought about in Scotland through the Scottish Renewables Obligation (1995) and the Renewables Obligation Scotland (2001). These essentially mandate that a certain proportion of energy be produced by renewables by a specified date.

At the same time, nuclear energy, whose climate change credentials are remarkably strong, has been refused any prospect of re-investment for the foreseeable future. The remaining choices are among wind, wave, tidal, hydro-electric, and solar. Of these, wind power has emerged as the front runner. As a result of the Scottish Renewable Obligation there are already several wind farm projects in Scotland. One important question which Professor Simpson's research attempts to answer is whether by mandating that a certain proportion of energy shall be produced by renewables, the costs of which will be passed forward to the consumers, the government is, in effect, imposing a stealth tax. Professor Simpson attempts to quantify the size of this stealth tax and questions whether there might be less expensive ways of achieving the same ends.

In his Presidential Address, which was published as *Hume Occasional Paper* No. 63, our Honorary President, Professor Sir Alan Peacock, recently argued against seeing the government as the only possible source of solutions to the problem of providing economic growth consistent with sustainable development, and pointed to the resilience and efficacy of the market in finding appropriate solutions. Professor Simpson's work, as reported here, serves as an illustration that government imposed remedies may carry substantial economic costs and may not always represent the best way of arranging matters.

The David Hume Institute is extremely fortunate to have been able to enlist the help in this research project of Professor David Simpson, a distinguished professional economist. The Institute is also grateful to the Binks Trust for its financial support in conducting this research and in publishing the results. As always, however, it is necessary to emphasise that, as a charity, the Institute holds no collective views on the issues or the policy matters raised here, save the certitude that they are worth discussing.

Brian G M Main
Director
April 2004

CONTENTS

Page

Foreword

TILTING AT WINDMILLS: AN ECONOMIC ANALYSIS OF WIND POWER

Summary:

1. At the present time the cost of generating electricity from wind power is approximately twice that of the cheapest alternative conventional source. By 2010 the cost of subsidising wind and other renewable forms of energy is officially expected to be about £1 billion every year.

2. The principal instrument of Government policy for promoting wind power is the Renewable Obligations scheme. The cost of the scheme falls on electricity companies who pass it on to consumers in the form of higher bills. At the present time, the extra cost of renewables is thought to be adding about 2% to domestic electricity bills, and it is set to grow. Most consumers are unaware that they are paying this hidden levy, and they do not know what they are getting for it.

3. It is widely believed that wind power will eventually become competitive in price with conventional sources of power. But projections by Government advisers, using relatively optimistic assumptions, show that even by the year 2020 a generation portfolio containing 20% wind power will still be more expensive than a conventionally fuelled alternative.

4. Achieving a target of 20% of electricity generated by wind power in that year would cost consumers at least an extra £1.2 billion each year, and over £2 billion annually on less favourable assumptions, over and above the costs of a conventional generation portfolio.

5. It is most unlikely that realising the official targets for the output of renewables, of which wind power is the principal component, is the lowest cost way of achieving the desired reduction in CO_2 emissions. Achieving greater efficiency savings in transport, households and businesses would be more cost-effective.

6. Between now and 2010 overall CO_2 emissions from the UK are expected to resume an upward path. This reflects strongly increasing emissions from the transport and household sectors, as well as from power generation. Carbon emissions from power generation are expected to rise after 2010 because of the planned rundown of nuclear power stations.

7. Because of the cost of providing additional stand-by generating capacity, it is unlikely that wind power will ever account for more than 20% of electricity generation through the National Grid. That being the case, its development can make no substantial contribution to an overall reduction in carbon emissions.

8. No matter how large the amount of wind power capacity installed, the unpredictably variable nature of its output means that it can make no significant contribution to the security of energy supplies.

9. A 20% share for Wind and other Renewables in power generation capacity will require a major re-engineering of electricity transmission and distribution networks, costing an extra £2.5 billion to £4.5 billion.

10. Government should take advantage of the renewables review coming up in 2005/6 to reconsider the nuclear option. If they are approved as being safe by the Nuclear Inspectorate, the lives of some existing nuclear plants could be extended.

11. Nuclear power emits no greenhouse gases, avoids extra network costs, and as a baseload generator contributes to security of supply. But if nuclear power is to gain public acceptance Government needs to ensure that solutions are developed within reasonable timescales for the management and disposal of nuclear waste.

12. A serious attempt to address the issue of a reduction in CO_2 emissions in the UK has yet to begin. When it does, it may prove to be costly, raising wholesale electricity prices by perhaps 40 to 60% over a five year period.

13. The Government should move quickly to implement the EU scheme due to phase in from 2000 for the allocation of tradable carbon emission rights, preferably by auction, up to its chosen level of emissions. It could then dispense with most of the other policy measures it has put in place to achieve the environmental objectives of its energy policy.

14. On the basis of past experience, it seems likely that the energy technologies that will play an important part in the economy of 2020 do not feature prominently in current Government policy.

15. In energy policy, as elsewhere, government decisions taken on the basis of short-term political pressures have unforeseen long term economic consequences, usually unfavourable.

16. Since Intermittency is its greatest weakness, wind power will fully come into its own only when a cost-effective method of storing electricity is developed.

17. Meanwhile, when market prices reflect the costs of avoiding environmental damage a small but increasing number of windfarms should become profitable.

18. There are also income benefits to remote communities where wind resources are located. At present these come from subsidies; in future they may come from the attraction of power-using industries.

Introduction[1]

In his Foreword to the Energy Review, the Prime Minister wrote that he wanted the country to have “cheap, reliable and sustainable” sources of energy.[2] These three adjectives refer to the three main objectives of contemporary energy policy, namely economic efficiency, security of supply, and a reduction in carbon emissions. These are themes which will recur throughout this paper.

In Cervantes’ eponymous novel, Don Quixote mistook windmills for his real enemy, the giants. This paper suggests that the present Government’s preoccupation with renewables, and in particular with wind power, may likewise be a distraction from its real objectives in the field of energy.

The Government has set targets for the expansion of the output of renewables, notably wind power, to help meet its higher level targets for a reduction in carbon emissions. While much has been written on this subject, little has been said about the cost of promoting wind power or about the contribution it makes to security of supply. The two questions posed in this study are: (1) what are the costs of wind power? and (2) are there other ways of achieving a similar reduction in carbon emissions at lower cost?

It is not within the scope of this paper to discuss whether climate change is occurring, whether man-made CO_2 emissions are responsible, and if they are, whether it might be better to live

---

[1] I am very grateful for the advice and assistance that I received from the following people in the preparation of this paper: John Costyn, Jim Cuthbert, Lewis Dale, Sir Gerald Elliot, John Heasley, Robin Jeffrey, Paul Jowitt, Brian Main, Eileen Marshall, Neil Menzies, Sir Alan Peacock, Richard Ploszek, Colin Robinson and Christopher Wilkins. I should also like to thank my wife Barbara for her patience and persistence in assisting my researches. Responsibility for any errors of fact or opinion is mine alone.

[2] PIU (2002)

with the consequences.[3] Instead, the paper accepts as its working assumption the Government's stated goal of reducing CO_2 emissions to 20% below their 1990 level by 2010, slightly tougher than its Kyoto commitment to reduce 'greenhouse' gas emissions by 12.5%, ('greenhouse' gases being principally CO_2, water vapour, and methane). The Government has set these targets, not because of the impact they would have on climate change –the UK currently accounts for only 2% of the global total of such emissions – but in the hope of encouraging other countries to follow their example.

Over the last twenty years, British energy policy has changed markedly, as have British energy markets, and both look set to change again over the next twenty years. This paper begins with a section describing the changes in energy markets since the War followed by an account of the corresponding changes in energy policy. The third section describes current policies designed to promote the output of renewables, while the subsequent section is devoted to an investigation into the costs of wind power, now and in 2020. We then examine the impact of the growth of wind power on the environment, while the following section discusses the question of security of supply. Conclusions are drawn in the final section. Except in the section concerning the costs of wind power, data are, as far as possible, confined to an Appendix in order to make the paper easier to read.

---

[3] These issues have been expertly reviewed by Professor Sir Alan Peacock, see Peacock (2003). For a heretical view see Baliunas (2002).

Energy Markets and Government Policy[4]

Energy Markets:

Fifty years ago, coal accounted for almost 100% of UK fuel production. Both electricity and gas were produced from coal; oil was primarily a transport fuel; there was very little hydro power; and no nuclear power stations had then been built. But by 1995, electricity production was based on a diverse range of fuels. Nuclear power programmes began in the 1950s. North Sea gas production began in the 1960s, although gas was not used in power stations until after 1990. North Sea oil production began in the 1970s. Now another major change in fuel sources is taking place.

DTI projections[5] illustrate the remarkable shift in the proportions of these fuels now under way. Coal and nuclear are both phasing out, coal more rapidly before 2010, nuclear more rapidly thereafter. Regulations to limit carbon emissions and improve air quality are likely to force the closure of most older coal-fired plant, while in the absence of new build or life extensions all but one of the existing nuclear stations will be closed by 2025.

While the share of renewables is projected to grow slowly from its present level, the most significant feature of contemporary energy markets is the growth of gas to supply some 68-75% of all electricity generated by 2020, of which up to 90% is expected to be imported. The anticipated predominance of gas raises questions about security of supply that are discussed later. The shift in fuel shares is taking place within an expected

---

[4] This section draws heavily on the expert papers by Marshall (2003) and Robinson (2002). Those who would like a more extensive account of British energy policy in the last 25 years should look at the detailed and entertaining narrative by Helm (2003) upon which I have also drawn.

[5] DTI (2000b).

growth of electricity generated from 344 TWh in 2000 to between 372 and 390 TWh in 2010. The DTI's projection of a 25% increase in electricity demand by 2025 seems modest when compared with the 69% growth that has occurred since 1970.

Contrary to the popular impression, dependence on fossil fuels is going to increase over the next two decades as nuclear plant is retired, with the result that CO_2 emissions from the power sector are expected to increase after 2010, reversing the gains of the previous decade, which were themselves largely the result of the lifting of the government's ban on the use of gas in power stations. By 2020 CO_2 emissions from all economic activity are likely to be about 7% above current levels. See Data Appendix.

The renewable technologies of hydro, wind, biomass and solar account for some 1.3% of UK primary energy supply at the present time, or about 2.8% of electricity production. For reasons to be explained in the paper, they are unlikely to reach the official target of providing 10% of the electricity supply by 2010. Other emerging technologies are unlikely to make a significant contribution to electricity supplies before 2020.

Gas import requirements will exceed current pipeline capacity before 2010: major investment in gas interconnectors will therefore be needed simply to satisfy the present level of demand. At least six major connectors would be needed by 2020 to handle imports of gas at the levels projected by the DTI. Projects to import LNG are also under consideration.

Energy Policy:

From 1950 to 1980, what successive governments described as 'energy policy' was in practice "a series of protectionist measures intended to aid British coalmining, with a subsidiary objective of promoting British-designed nuclear power stations."[6] The arrival of Nigel Lawson at the Department of Energy in 1981 produced a fundamental change. The old planning culture of 'predict-and-provide' was gradually replaced by the principle of pricing fuel realistically, i.e. in competitive markets. The beneficiaries of the old style energy policy were producers. With markets, the beneficiaries of the new energy policy were consumers. Indeed, with fuel prices being decided in markets, there was no need for an 'energy policy' at all, and the 2003 White Paper was to be the first White Paper on energy policy for thirty five years[7]

The Liberalisation of the Electricity Markets[8]:

Between privatisation in 1989 and March 1998 domestic electricity customers were obliged to buy their electricity from their local retail supply company, who thereby enjoyed a guaranteed level of sales. The local supply companies were therefore willing to enter into long term fixed price power purchase agreements with generating companies. The availability of gas on long term contracts at a lower cost than coal favoured the building of gas-fired power stations. Between 1990 and 1997 gas fired generation rose from two percent to twenty four percent of all generation, the so-called 'dash for gas'.

Full supply competition for domestic customers was introduced progressively from March 1998. By mid-1999 all customers were free to purchase their electricity from any licensed supplier. Thus suppliers lost their secure demand, which made them less willing to enter into long term purchase agreements with generators for 100% of their power. They preferred a balanced portfolio of contracts. As business customers took up

---

[6] Robinson (2002), p.3.
[7] Robinson, ibid p.1
[8] NAO (2004), Appendix 3

the opportunity to negotiate with competing suppliers for the best price, the suppliers sought cheaper wholesale power and wholesale prices began to fall.

Ever since privatisation there had been growing dissatisfaction with the way that the wholesale Pool operated. Generators were able to distort prices in their favour. Following a review of trading arrangements, a new competitive market in wholesale electricity (NETA) was created in March 2001 in which generators have to contract directly with other market participants.[9] The increased competition in the wholesale market that resulted accelerated the fall in prices. It also caused more large generators to seek to mitigate its effects by buying retail supply companies, whose domestic customers had proved less inclined than business customers to switch suppliers. To do this, the two largest fossil-fuel generators, National Power and Powergen, were required by the Competition Commission to dispose of four Gigawatts of capacity each. This led to a considerable fragmentation of the generating market, leaving the nuclear company British Energy as the largest single generator, with about 20% of the market but with a relatively small retail supply business.

The Energy Review:

As long ago as 1990, the then Prime Minister Margaret Thatcher set a target of returning CO_2 emissions to their 1990 level by 2005. It was actually more of an aspiration: no thought was given to how it might be done. CO_2 emissions did indeed fall in the 1990s, mainly because of the contraction of the coal

---

[9] The creation of a functioning competitive wholesale market for electricity was a remarkable achievement. The peculiar features of that market include the requirement that supply must match demand at every moment in time, that a failure of supply would have an immediate and devastating effect on output in the rest of the economy, that the principal assets are sunk and long-lived, the networks are natural monopolies, and there are major environmental externalities.

industry. The UK Climate Change Programme[10] set out the Kyoto target of reducing green house gases to 12.5% below 1990 levels by 2008. The domestic target was more ambitious: to reduce CO_2 to 20% below 1990 levels by 2010.

The Royal Commission on Environmental Protection went further. In its Report[11], it warned that if the UK was to make a serious contribution to climate change it would have to reduce its emissions of CO_2 by some 60% by 2050. It went on to propose a number of scenarios that might achieve this, including a renewables and energy efficiency programme and a new nuclear programme. The Government’s response was to commission a review of energy policy from the Cabinet Office’s Performance and Innovation Unit (PIU), and this was published in Feb 2002[12] as ‘The Energy Review’.

One possible approach to conducting this review might have been an analytical one, specifying the objectives, identifying the trade-offs between them, and assessing the efficacy and implications of alternative policies. But this would have had the political disadvantage of producing clear losers: any sensible environmental policy would be bad news for the coal industry, new nuclear power stations would offend the green lobby, too many renewables would impose high costs, and a realistic carbon tax might upset voters. The PIU Report instead offered something to each of the several lobbies and interest groups. The business lobby was satisfied with the suggestion that climate change should only be addressed in the UK if other countries did likewise. The green lobby could take comfort from the target of a 20% Renewables Obligation by 2020, reinforced by an energy efficiency target, although there was no serious analysis of the likely costs of such measures.

---

[10] DETR (2000)

[11] RCEP (2000).

[12] PIU (2002)

The idea of a carbon tax was floated, but far enough into the future to avoid creating short-term political difficulties, and the nuclear lobby were encouraged by talk of “keeping the options open”, although no new build programme was recommended. The problem was that at the end of the Report, the Government was no nearer having anything which could be described as a coherent energy policy, [13]nor did the Report offer clear guidance on how to resolve the tensions between the three objectives of cheap energy, a reduction in carbon emissions and security of energy supply.

The White Paper:

In April 2002, the DTI tried again. It launched a consultation exercise, in which it asked the same questions as the PIU all over again. Not surprisingly, no new answers were forthcoming. The problems remained that the trade–offs between the three objectives were undefined, and the apparent inconsistency between relying on market–based policies to achieve security of supply while environmental objectives were apparently to be achieved by planned interventions did not seem to be recognised.

The White Paper[14], published in February 2003, set out four goals: to put the UK on a path to reducing carbon emissions by 60% by 2050 as recommended by the RCEP; to maintain the security of energy supplies; to promote competitive energy markets; and to ensure that every home is adequately and affordably heated. But it is for the first of these objectives that it will be most remembered.

To achieve this goal, it proposed four broad instruments of policy, two of which were market- based instruments and two of which were instruments of central planning. The two planning

---

[13] which requires “a specification of the objectives; an analysis of the nature of the problems; and a coherent set of policy instruments” Helm (2003) p.39

[14] “Our Energy Future – Creating A Low Carbon Economy” DTI (2003)

instruments were (i) physical targets for the output of renewables and (ii) the Energy Efficiency Commitment (EEC), a plethora of administrative schemes for reducing the demand for energy by households and businesses. These two instruments were directed to achieving the environmental objective of reducing carbon emissions. The two market-based instruments were (iii) the promotion of competitive energy markets and (iv) the introduction of a carbon emissions trading scheme. Competitive energy markets were directed implicitly to keeping down the cost of energy, and explicitly towards achieving security of supply.

Despite the dependence on gas anticipated to grow rapidly from 2010, the White Paper is relaxed about the implications for security of supply, (i.e. the possibility of a physical interruption of supply or an abrupt price rise. See section below). It endorses Ofgem's stated position that it "believes that the future uncertainties with respect to security and diversity of supplies are best resolved through the continued operation of competitive markets in electricity and gas", and that "such markets will ensure that participants face the correct signals and incentives to invest so as to deliver sufficient supplies" [15]

with the observation that:

"For the markets to work, firms need to be confident that the Government will allow them to work. Energy supply problems in other countries have demonstrated the risks of not doing so. We will not intervene in the markets except in extreme circumstances, such as to avert, as a last resort, a potentially serious risk to safety".[16]

The other market-based instrument that the White Paper advocates is the EU Emissions Trading Scheme. In fact, the scheme had already been agreed and is due to be introduced in

---

[15] Ofgem (2001)

[16] DTI (2003), p.77 para 6.7

2005.[17] In principle, such a scheme should have a number of advantages. Participants in both wholesale and retail markets will be able to deliver the government's environmental objectives in the most efficient way by incorporating the additional cost of carbon into their own decision-making. Using a single economy-wide transparent policy instrument would put transport and power generation, businesses and households on a level playing field, and make it more difficult for special interest group to influence outcomes.

Whatever the initial permit allocation, a price for carbon should emerge.[18] Trading should ensure that emissions abatement will come from the lowest cost marginal source, in the case of generation almost certainly coal, so one practical effect will be to speed up the closure of coal-fired power stations. The cost of achieving the CO_2 goals would become much more transparent to consumers. And the pursuit of environmental objectives by this method will complement not interfere with the other objectives of efficiency and security of supply. The problem, of course, for the government's renewables and energy efficiency policies is that an emissions trading scheme has the potential to render them redundant.

Instead of waiting for the emissions trading scheme, or even using a carbon tax, the Government has opted to set physical targets for renewables and energy efficiency, the net effect of which is to distort markets and make the consequences less transparent. Its centrally planned approach to trying to meet its CO_2 targets in 2010 and 2020 is to assign one half of the target to a reduction in the demand for energy, and the rest through a significant increase in Combined Heat and Power (CHP)

---

[17] Not to be confused with the voluntary British trading scheme which 'went live' in April 2002, but which excludes generators and renewables, and which Helm describes as little more than a game between large industrial users of energy.

[18] In doing so, it should reveal just how cost effective the Renewable Obligations scheme is. Ofgem have estimated that the RO scheme implies a value of between £210 and £380 per tonne of carbon.

schemes and in the share of renewable sources of energy in the generation of electricity.

Planned energy demand reductions are divided more or less evenly between savings from households and savings from the business and public sectors. To control energy demand by the targeted amount, the Government will employ a range of administrative instruments including building and product regulations, as well as the EEC introduced in April 2002. The latter obliges the major gas and electricity supply companies to meet targets to install energy efficiency measures in their customers' homes, financed by raising a levy from other consumers.

A similar approach has been adopted to increase the supply of renewables. A physical target has been set of supplying 10% of UK electricity from renewables by 2010 and 20% by 2020. As one commentator has remarked, these are suspiciously round numbers! The Government has however provided itself with an escape clause: the targets are qualified by the proviso that the costs of achieving them should prove acceptable to the consumer. This is presumably a political test. The review of renewables policy which has been promised for 2005/6 should give an opportunity to judge the extent of consumer resistance, if any.

Supporting Renewables

‘Renewables’ are usually defined as resources that are not depleted with use[19].

From the point of view of electricity generation in the next two decades, the relevant renewables are hydro, wind and ‘biomass’, (e.g. energy crops and gas from waste sites). All other ways of extracting energy from renewable resources are too far away from commercial development to make an impact before 2020.

At the present time renewables account for about 3% of electricity generation, of which just over half comes from hydro, about 30% from biomass and only about 15% from wind. Because there are limitations on the expansion of both biomass and hydro, almost all of the growth that has been projected for renewables in the UK over the next twenty years is expected to come from wind, currently the most efficient of the ‘new’ renewable resources.

It is the present Government’s firm commitment to have renewables contribute 10% of electricity generation by 2010 and 15% by 2015. There is an ‘aspiration’ to reach 20% in 2020, although an objective of 100% in 2100 has not yet been proposed. A range of policies is being used by the Government to promote renewables including price subsidies, capital grants, taxes on competing forms of energy, subsidies to transmission costs, and the selective waiving of planning rules. The principal instrument of policy at the present time is the Renewables Obligation (RO).

---

[19] This is only approximately true. For example, the availability of wind as a source of energy is theoretically reduced by the amount of energy transferred through a turbine, although the amount is negligibly small. Likewise willows grown for fuel are commonly treated as a renewable resource,‘biomass’, because it is assumed that they will be replanted and CO_2 drawn from the air. But if more coal is burned and more trees are planted the effect is similar. Helm (2003) p.348

The Renewables Obligation requires suppliers of electricity, i.e. the retail power companies, to procure 3% of their total requirements from renewable sources in 2002/3, rising according to a fixed schedule to 10.4% in 2010. If they fail to do this they must pay a penalty. Those generators who provide electricity from renewable sources are able to sell Renewable Obligations Certificates to the electricity suppliers at a price that varies according to supply and demand.

At present the value of a ROC is about £45/MWh, while the wholesale price of electricity, which corresponds to the cost of gas-generated supplies, is about £22/MWh. So the renewable generator receives about £70/MWh for his electricity while the supplier passes on the additional cost to the consumer in the shape of higher bills[20].

Another major instrument that the Government has used to promote the adoption of renewable technologies is exemption from the Climate Change Levy (CCL), a tax introduced in April 2001. The value of the exemption is equivalent to £4.30/MWh of electricity. Not only are most renewables exempt from this tax, so also are households and 'good quality' CHP plants but not nuclear, despite it being emission-free. Nor are hydro schemes above 10MW declared net capacity exempt. The CCL is misleadingly named because it is a tax on energy, not carbon. But most energy-intensive industries (i.e. those at which it might be supposed such a tax would be directed) are partially exempted as a result of a complex set of negotiated agreements intended to 'protect' their international competitiveness.

The range of energy sources that are deemed to be 'renewable' for the purposes of achieving the 10% target in 2010 is quite a broad one. They include landfill and sewage gas, energy from waste, hydro, wind, agricultural and forest residues, energy

---

[20] Following price increases by Powergen and npower in January and February 2004, on March 1st Scottish Power increased their domestic electricity tariff from 6.873p to 7.328p per kWh, i.e. from £69/MWh to £73/MWh, an increase of 6.6%.

crops, wave power and solar. But existing large scale (>20MW capacity) hydro schemes have been excluded from the RO incentive scheme on the grounds that they are already commercially viable. On the other hand, waste that has been converted into a fuel using an advanced conversion technology is eligible for the RO. Capital grants have hitherto been reserved for offshore wind farms and energy crops.

Renewables Results So Far:

The White Paper says that in the year 2000 renewables, excluding large scale hydro and waste, supplied 1.3% of electricity. It suggests that to reach the 10% target by 2010 will require installing 10GW of renewable capacity. By 2002 the total had reached 1.2GW. So an annual build rate of 1.25 GW is required for the next seven years.

The results of the schemes for promoting renewables have been modest so far. From 1991 to 2000 the total capacity contracted under NFFO, the predecessor of the RO scheme have been 3038 MW of which only 907MW turned into actual investment. In 1990 the share of renewables in electricity generation was 1.8%, by 2000 it had reached 2.8%. And meeting the target of 10% for renewables by 2010 will be particularly challenging if the demand for electricity grows in the first decade of the twenty first century at close to 1.8% per annum as it did in the last decade of the twentieth century rather than at the officially projected rate.[21]

Looking forward to the attainment of the 10% target by 2010, new large-scale hydro-electric sites are not available. Co-firing of bio-mass may yet be the means by which this target is achieved, but at present the major burden of expectations lies with the expansion of wind power.

---

[21] DTI (2000) Table 5.2

Wind:

The British Wind Energy Association (BWEA), is the trade association for developers. They estimate that there are now about 1100 wind turbines throughout Great Britain, delivering 0.4% of the national electricity supply. It is BWEA's hope that by 2015 some 8000 turbines will be delivering 15% of power. By the end of 2003 just 640 MW of wind power capacity had been installed, of which less than 50 MW is offshore[22]. If the 2010 target is to be met wind power capacity capable of generating 8GW of electricity will need to be built, of which they suggest half might be onshore and half offshore. This suggests an impossibly large gap to be filled. To meet the target would require installing eight 1MW machines every day until 2010. Merrill Lynch estimate that by 2010 only 3.6 GW of wind power will be installed, of which 1.1 GW will be offshore.[23]

Why has wind fallen so far behind the hopes that have been pinned on it? There are two principal explanations: difficulties in obtaining planning permission and financial uncertainty.

Attempts at establishing onshore wind farms have been frequently held up by the refusal of planning consent, not surprisingly since those locations with best wind resources onshore, viz. tops of hills, are frequently areas of scenic beauty. Recently, the Government has sought to ease the planning blockage by issuing new guidance to local authorities requiring them to set regional targets for renewables.

The cost of capital for wind power developments varies according to the status of the borrower. Circumstances favour large corporations who have access to their own sources of finance. Bankers are sometimes wary of lending money to small developers, although it has been said that those with planning permission and access to sites with wind speeds of 8 m/s or

---

[22] FT 19.12.03

[23] Merrill Lynch (2003). See Data Appendix

more have nothing to fear. What worries lenders most is that the revenue stream of a renewable project is so heavily dependent on political support that could be withdrawn with a change of Government. The replacement of power purchase agreements, like the old NFFOs where prices were guaranteed, with schemes like ROCs means that an assured cash flow no longer exists. The wholesale price of electricity is also perceived to be volatile.

From Onshore to Offshore:

The worries of bankers are further aggravated by the additional risks encountered as the industry moves increasingly offshore. In the unknown territory of offshore wind generation, there are construction, maintenance and operating risks, as well as unresolved engineering questions concerning the scalability of turbines. In an attempt to assuage these doubts, and to lend further support to an activity perceived to be ailing, the Government recently agreed to extend the ROC scheme from 2010 to 2015, signifying that in the latter year suppliers would be obliged to source 15% of their electricity from renewables.

In December 2000, the DTI announced the first round of contracts for offshore development, which resulted in 17 proposals that they said would result in the installation of 500 turbines generating 1.5GW of electricity. The first of these wind farms, North Hoyle, came on stream in November 2003.

On 14 July 2003 the DTI announced Round 2 of the offshore contracts that they said could deliver between 4GW and 6GW to provide between 3.5% and 5.5% of the UK’s electricity requirements for 2010.

The Cost of Supporting Renewables:

A DTI paper[24] in October 2000 estimated that the cost of the RO scheme to the consumer would peak at about £ 600 million in 2010 – roughly an increase of 3.7% increase in 1998 bills. But the February 2003 White Paper estimated that by 2010 the combined effect of the RO and the CCL schemes would amount to an annual subsidy to the renewables industry of around £1 billion, with additional funding from capital grants. For comparison, the annual value of wholesale electricity supplied in the UK at the present time is about £6 billion, while retail sales are about £15 billion. At present, renewables are thought to account for about 2% of household electricity bills.

In addition to these outlays that are devoted to supporting the generation of electricity from renewable sources, most renewables inflict additional costs on the electricity transmission and distribution system. This is because many renewables, including wind, produce an output that is variable and unpredictable, small in scale, scattered in location and, in the case of wind, remote from markets. These additional costs are analysed in more detail in the next section.

---

[24] DTI (2000c)

The Costs of Wind Power

Generating costs and the price of electricity:

The costs of supplying electricity for onward transmission to end users through the national grid can be divided into Generation Costs and Network Costs.

The costs of generating electricity from the wind include the capital costs (site preparation, acquisition and installation of the turbines) and variable costs (operating and maintenance) of generation, as well as the costs of connection to the nearest point of the grid. Costs of generation vary significantly from one site to another, depending on wind availability and speed, and size of turbine. They also vary between offshore and onshore sites: costs of installation, connection and maintenance are typically higher offshore.

Depending on the site, between 75% and 90% of the costs of generating electricity from the wind are capital costs. Within this total, the turbines may count for around 64% of the capital cost, foundations 13%, the electrical infrastructure 8%, and the grid connection 6% The variable costs (10-25)% of generation are largely the costs of maintenance plus rent[25].

The DTI uses a figure of £1 million per MW installed capacity to represent the capital costs of an offshore wind farm[26]. Assuming further a load factor of 40%, a cost of finance of 12% and depreciation charged over 20 years, this leads to a hypothetical generating cost of about £50[27] per MWh.

---

[25] BWEA (2003)

[26] DTI (2000a). Some engineers would put this figure at £1.25 million per MW. (*The Times*, 18.7.03)

[27] DTI (2000a), p.21

Other estimates vary. The Royal Academy of Engineering puts the current average generating cost for offshore wind farms at £55/MWH, although North Hoyle, the only one operating so far, is reportedly coming in at £70/MWh.[28] For onshore wind farms they estimate an average generating cost of approximately £37[29] per MWh. When one realises that the current wholesale price of electricity is only about £22 per MWh, this illustrates the scale of the challenge facing wind power to become a competitive source of electricity.

The Comparative Costs of Generating Electricity:

The Royal Academy of Engineering has recently published a study of the comparative costs of generating electricity from alternative fuel sources and technologies. The study estimated the unit cost of electricity delivered at the boundary of a new-build power station site. The cost therefore includes the capital cost of the generating plant and equipment, the cost of fuel where applicable, and the operating and maintenance costs of the plant. A common financing model with a nominal discount rate of 7.5% was used to derive the estimates that are shown in Table 1.

Table 1: The Unit Costs of Generating Electricity

	£/MWh
Gas-fired CCGT plant	22
Nuclear fission plant	23
Coal-fired CFB steam plant	26
Onshore Wind Farm	37 (54)
Offshore Wind Farm	55 (72)
Wave and Marine Technologies	66

Source: Adapted from RAEng (2004), Tables 1 and 2

---

[28] Private communication

[29] "This cost applies, however, only to the relatively limited areas having the best wind speeds with nominal load factors of 35%" RAEng (2003), p.14.

The figures in brackets represent the unit costs of wind when the additional costs of providing standby generation necessitated by its intermittent supply are taken into account. Otherwise the estimates refer to generating costs only, and exclude the network costs of transmission and distribution (see below). They also exclude the costs of CO_2 and other emissions that are examined in the next section.

Of course, cost comparisons such as those shown in Table 1 which come from engineering and accounting estimates can only be indicative not conclusive. They necessarily leave out of account all of the other major factors which enter into an investment decision in an actual market, including those of risk and uncertainty, financial arrangements, and corporate, regulatory and other considerations, all of which are specific to their context. Only in a business situation are these factors brought together and evaluated.

Nevertheless, the message of the data is clear. At the present time, the financial cost of generating electricity from the wind is roughly twice that of generating electricity from the cheapest alternative conventional sources

How can this gap be closed?

There are two answers to that question. One relates to the short term, the other to the long term. In the short term, as we have seen, the gap is being closed with subsidies. The Renewable Obligation Certificate provided the wind generator in 2003 with £45 for every MWh of electricity supplied. When one adds in the value of the CCL exemption, currently worth about £4.30 per MWh, on top of the wholesale market price of around £22/MWh the gap is closed for most suppliers.

In the longer term, it is widely believed that the costs of generating electricity from the wind will fall to a level that will make it competitive with other technologies. The rest of this section is devoted to examining whether or not this is likely to be true.

The Falling Price of Wind Turbines:

Most projections, official and other, assume that the generating costs of wind power per unit of output will fall over the next twenty years, primarily as a result of economies of scale and specialisation in the supply of wind turbines. These assumptions are often formalised as ‘learning curves’, but nevertheless they remain assumptions. Sceptics may observe that wind power is a mature technology, that the productivity gains observed in the recent past cannot necessarily be projected into the future, and that there will be an offsetting tendency for costs to rise over time as increasingly inferior locations are brought into use.

Nevertheless, the conventional wisdom is that the cost of wind turbines is in continuing decline. Dale quotes “recent studies” as suggesting that costs in 2020 will lie somewhere between 55% and 70% of their present level for onshore installations, while offshore costs are expected to fall more steeply, the range in 2020 being estimated between 40% and 70% of present costs. Merrill Lynch project an annual average decline of 3%-4% in the cost of a wind turbine to 2020.[30] OXERA project onshore generating costs for the year 2020 as lying in the range between £20-£25/MWh, while offshore costs are expected to fall in the range of £21-£29/MWh by 2020. In its ‘Energy Review’, the PIU came up with rather similar estimates for 2020, £15-£25/MWh for onshore wind and £20-£30/MWh for offshore wind.[31]

---

[30] Dale et al (2003), p.4, Merrill Lynch (2003)

[31] OXERA (2003), p.27, PIU (2002)

Network costs:

So far we have been discussing generating costs only. But the total costs of supplying electricity to businesses and households have to take account of network costs as well as the costs of generation. Network costs include the capital and current costs of transmitting electricity through the national grid, and the costs of local distribution. Such costs reflect the need not only for the maintenance and replacement of existing network infrastructure, but also for new investment as the pattern of the production and consumption of electricity changes. This is particularly important in the present context, since the requirement for investment in new transmission capacity is determined by the location of new generation capacity, whether conventional or renewable. And since the best wind resources in the UK are located on the fringes of Northern and Western Scotland, any attempt to capture the benefits of such ‘remote renewables’ for the UK electricity supply is bound to incur significant infrastructure investment requirements as well as the additional costs of transmission from the peripheral areas to the markets in the South.

The Additional Network Costs of Wind:

The addition of wind power to the supply of electricity through the national grid adds extra network costs of four kinds.

There is first of all (i) the additional investment required in *transmission capacity*. A study prepared for the DTI estimated an investment of between £1.7 bn and £3.3 bn, depending on location. The lower value corresponded to a scenario with wind generation dispersed onshore and ‘near-offshore’ around the South of England and Wales, while the higher value corresponded to scenarios with lots of wind capacity being installed in Scotland and the North of England[32].

---

[32] ILEX (2002).

Then there are (ii) the *operating costs of transmission*. If transmission charges were to be fixed to reflect the actual costs of transmission, any generator located in North Western Scotland, where most resources are, would be placed at a competitive disadvantage. Apart from the question of distance, it costs more to transmit electricity throughout the North of Scotland because the cost of transmission per unit falls as the voltage rises, and most lines in the North are only 132kV. On February 12th this year the Government announced that an amendment to subsidise transmission charges for renewable generators in peripheral areas would be introduced as part of the Energy Bill now going through Parliament. The cost of the subsidy was not announced.[33]

There are also (iii) additional investments required in the *distribution network* to accommodate generation from wind and other renewables. These are incurred when the new generation capacity potentially affects the quality of the electricity supply, i.e. voltage management, thermal ratings of equipment and system fault levels. To the extent that a substantial proportion of the new wind capacity comes from large offshore wind farms that can connect to the grid at transmission voltage, total additional distribution costs will be lower.

Finally, there are (iv) *balancing costs*. Since electricity cannot easily be stored, supply must be available at all times to meet variations in demand. In particular, there must be sufficient capacity installed so that the system can meet peak power demands. When wind plays only a small part in a generating portfolio, the additional balancing costs arising from the variability of its output are very small. As the amount of wind power in an electricity supply system increases, however, the unpredictably variable nature of wind power incurs additional

---

[33] This announcement provoked a furious response from Ofgem: “To amend the Energy Bill in this way is unnecessary and misguided….. customers’ bills will rise for no clear benefit” (Ofgem Press Release 13.2.04)

balancing costs over and above those incurred by conventional technologies.

Projections of total costs:

Electricity is typically generated from a mix of fuels whose output is transmitted through a common network. While the generating costs of each fuel technology can be separately identified, the network costs of these technologies are interdependent[34]. This is so for three reasons. First, they are sharing a common transmission and distribution infrastructure. Second, there are the costs that arise from the need to balance supply and demand at the system level in the very short term. Third, there is the desire to diversify a portfolio of generating technologies in order to achieve security of supply in the longer term. In estimating costs of alternative ways of generating electricity it is therefore necessary to compare the costs of alternative portfolios of fuel technologies rather than attempting to compare the costs of the individual technologies themselves.

In the following section of this paper, we shall examine a projection of the total costs of wind power to the year 2020. Lewis Dale and three colleagues compared the total costs of two hypothetical portfolios of technologies[35]. We have chosen this study for a number of reasons. First, because it addresses directly our principal question, namely what are the likely costs of the Government's wind power programme. Secondly, all four of the authors have acted as experts in background studies commissioned by the DTI and available on the DTI website. In the absence of any published official estimates by the DTI itself, we can reasonably assume that the projections in the Dale study are as close to official thinking on these questions as it is possible to get. Thirdly, the result that they come up with is at

---

[34] In other words the total cost of a particular portfolio of technologies is not the sum of the costs of those technologies.

[35] Dale et al. (2003)

the lower end of the range in the prediction in the White Paper that the cost of the renewables programme will add between 5% and 15% in real terms to consumer electricity bills in 2020.

The Dale study developed two scenarios for the year 2020. Scenario (a) is a conventional one in which electricity is predominantly produced by thermal generation (coal and gas). The second scenario (b) has identical electricity output to that assumed in (a), but in this scenario almost 20% of the electricity is produced by wind turbines. Around 26 GW of wind capacity is assumed to be established, with an assumed average 35% load factor. It is further assumed that approximately 60% of this wind capacity will be located offshore and that the majority of this will be directly connected to the transmission system. The results are shown in Table 2.

Table 2 The Costs of 20% Wind in 2020

	(a) Conventional Scenario		(b) Scenario with 20% Wind	
	Unit Costs £/MWh	Total Costs £m/yr	Unit Costs £/MWh	Total Costs £m/yr
Generation Costs	14.1	5627	18.7	7477
Fuel Costs	14.0	5616	11.4	4576
Network Costs	1.8	691	2.9	1158
TOTAL COSTS	29.8	11,933	33.0	13,212

Source: adapted from Dale et. al.(2003), Table 2

Table 2 shows that the total *additional* cost of a 20% wind programme would be just over £3/MWh of electricity sold, or around £16/MWh of wind produced. This represents an increase of just under 5% in the average domestic price, (at the lower end of the range of estimate shown in the Government’s White Paper). In other words, the total cost to consumers in 2020 of achieving the Government’s target for wind may be estimated to be £1.279 billion (in 2002 prices) every year. This extra cost of wind is a real cost to the economy, and is entirely independent of any subsidies which may or may not be in place at the time.

Questioning the assumptions:

These results depend on assumptions which Dale and his colleagues describe as being “representative but cautious”. But how robust are they? Thanks to the gap of seventeen years between the date of the study and the year to which the projections refer, there is inevitably scope for considerable uncertainty. Recognising this, the authors have published a sensitivity analysis of their results. We are able to take advantage of this analysis to explore the consequences of varying their assumptions. We pose the following five questions:

1) What if the assumed wind turbine productivity gains don’t materialise?

2) What if the average load factor for wind generation in the UK is only 20%, not 35%?

3) What if the infrastructure costs of the wind scenario have been underestimated?

4) What about the costs of standby generation?

5) What if fossil fuel prices double?

1) The Future Cost of Wind Turbines

Table 3 shows that the most important uncertainty affecting the estimated difference in costs between the conventional and wind scenarios is the future capital cost of wind turbines. What if these assumed productivity gains don't materialise?

If these costs remain unchanged in real terms from now until 2020, then the estimated *additional* costs of the wind scenario would increase from 0.3 to 0.5 p/kWh. (or £5/MWh). This means total costs would rise to over £2 billion per annum and consumer bills would be about 8% higher than they would have otherwise been.

On the other hand, if the cost of wind turbines continues to fall over the next seventeen years at the rate it has done in the recent past, then the cost disadvantage which wind power continues to suffer against the more conventional technologies would be cut in half.

2) What if the Average Load Factor should be only 20%?

In common with most other official projections, the Dale study uses an average Load Factor of 35%, although the overall load factor for onshore wind generation actually achieved in the UK over the last five years has varied between 26.4% and 30.7%[36], The projected figure is justified by the argument that in future larger wind turbines and access to windier sites in Scotland and offshore England will improve performance. Against this it may be observed that, for variety of reasons, only about 10% of the areas of Scotland with the best wind resources could be planted with wind farms[37]. In England, the Thames Estuary and the Wash where the next round of large offshore wind farms are planned are not notably windy. These sites have probably been

---

[36] DUKES (2003)

[37] RAEng (2003), p.13

chosen for their relatively benign construction conditions, being shallow water in the lee of the prevailing South West winds, and for their proximity to a large market for power.

The load factors actually achieved in West Denmark may be a guide to what can be expected in the UK. West Denmark, (one of two unconnected electricity systems in that country), has already achieved the goal which the UK aspires to in 2020: in 2003 its wind power output accounted for 21% of regional electricity consumption. At Horns Rev, it has the world's largest offshore wind farm, and wind conditions in the region are broadly similar to that in the UK. Yet the average load factor achieved from wind power in West Denmark has only been around 20%. To put the matter another way, the British Government's costings of its wind programme are based on the hope that when that capacity is built it will deliver 75% more energy for each MW of installed capacity that its Danish equivalent[38].

If the average load factor in the UK in 2020 should turn out to be no more than that achieved in West Denmark, then applying Dale's sensitivity test shows that this will almost double the annual cost of the UK wind programme, so that by 2020 it will be costing consumers almost £2.5 billion extra each year.

3) What if Infrastructure Costs have been Underestimated?

Of course, if the load factor is less than 35%, then not only will the number of wind turbines needed to achieve the output target for 2020 have to increase, so will the investment in infrastructure. If the load factor was closer to 20%, then this will require some 75 % more capital expenditure than is currently foreseen. Even if the wind in the UK performs 25% better than its West Denmark equivalent, it will still be necessary to have some 36 GW of installed capacity, which with its associated

---

[38] Incoteco p.1.

additional investments in transmission and distribution capacity would mean an additional outlay of some £15 billion, of which some £5 billion would represent additional infrastructure costs.

In his study Dale took £2.6 billion as his central estimate of capital infrastructure costs. In the ILEX study the range for the comparable estimate was £1.7 to £3.3 billion. However, even if Dale's estimate of these wind-related transmission infrastructure costs is doubled, this only adds a further £0.5/MWh to the price of electricity, on top of the extra £3/MWh due to wind in his base case scenarios. This quite small number can be reconciled with the £ 2.6 billion of extra capital costs by recalling that is conventional to amortise *network capital costs* over 40 years at a discount rate of 6.25%, and that these additional costs are spread over all of the units of electricity produced in 2020, and not just that part which comes from wind power. In contrast, it is conventional to discount the *capital costs of generation* over 20 years using a 10% discount rate.

4) What About the Costs of Standby Generation?

In any electricity supply system, the total generating capacity must exceed the maximum demand anticipated for the system to ensure security of supply in the event of unexpected interruptions. In this respect the intermittency of wind poses a problem. How much of its installed capacity can actual be relied upon? Most studies agree that for a low level of wind penetration the 'firm capacity' value of wind is roughly equal to the value of its load factor, conventionally taken to be 35%. This means that stand-by generating capacity must be available at all times to back up the other 65% of wind capacity which is deemed to be unreliable. The figures in brackets in Table 1 above show the costs of wind generation when the costs of providing this additional stand by capacity are taken into account.

When the proportion of wind in a generating portfolio increases, its notional reliability declines, and in the Dale study the authors have assumed that only 20% of the installed wind capacity can be assumed to be ‘firm’. The corresponding additional standby costs are assumed in the calculations whose results are shown in Table 2. However, one might be even more cautious and, following the argument set out below in the section of this paper on security of supply, assume that none of the wind generating capacity can be regarded as ‘firm’, and it therefore requires 100% back-up.

In that case, we can see from Table 3 that the additional cost of the wind scenario is increased by about one third, by about 0.1p/kWh or £1/MWh.

5) What Happens if Fuel Prices Double?

Given the vast reserves of natural gas resources known to be available in Europe and North Africa, this may seem like an extreme scenario. In their fuel price variation scenario the RAEng study assumes changes of only +/- 20%. Nevertheless, the sensitivity test carried out in Dale’s study allows us to conclude that a doubling of the assumed fuel price of £13/MWh would almost close the gap in costs between the wind scenario and the conventional one by narrowing it from £3.2/MWh to £0.6/MWh.

This result is broadly consistent with that of the recent RAEng study, where it can be seen that a doubling of the fuel price would close the gap between the cost of generation of the Gas-fired CCGT technology and the costs of electricity generated by an onshore wind farm, although it would still leave the cost of the gas technology lower than that of power generated by an offshore wind farm.[39]

---

[39] RAEng (2004) Figure 2

Conclusions on costs:

Our investigations reveal that in 2004 generating electricity from the wind costs roughly *twice as much* as it does from the cheapest conventional sources of power. Even though the costs of wind turbines are expected to continue to fall over the next few years, a comparison of the projected total costs of two portfolios of generating technologies to the year 2020, shows that one which contains 20% wind power (the Government’s aspiration) would then *still* cost more than another with 100% conventional capacity. Under conservative assumptions, the extra cost to consumers would amount to over £1.2 billion *every year*. Under less favourable assumptions, the extra cost could be at least twice that amount.

Environmental Benefits and Costs

The Environmental Benefits of Wind power:

The principal advantage of a generating portfolio with a high wind energy content is a reduction in the emission of carbon and other noxious gases compared to a more conventional portfolio with a higher proportion of thermal generation.[40]

Burning fossil fuels in power stations gives rise to the emission of air pollutants. Concern about these emissions originally centred on their effects on human health, so chimneys tall enough to produce low concentrations of the gases at ground level were thought to be the best method of control. It was later recognised that sulphur dioxide (SO_2) and oxides of Nitrogen (NOx) also contribute to 'acid rain', while carbon dioxide (CO_2) contributes to global climate change. Now concern over these effects has given rise to agreements at national, EU and global levels to control their present and future emissions.

Of course, electricity generation accounts for less than one-third of CO_2 emissions in the economy. Road transport and industry are almost equally large polluters.[41] Nevertheless the specific role which the Government has assigned to renewables in its energy policy is undoubtedly based upon their reputation as an environmentally benign source of electrical power.

There are many ways in which emissions from power stations can be reduced, including reducing consumer demand for

---

[40] When making comparisons between countries or time periods, it is important to bear in mind that a higher proportion of wind in a generating portfolio does not necessarily correspond to an overall reduction in carbon and other emissions. Thus, Denmark has a higher rate of emissions per unit of power than the USA, because the non-wind portion of its generating portfolio relies more heavily on fossil fuels than does that of the USA.

[41] DTI (2000b)

electricity through improved end-use energy efficiency as well as specific measures at power stations. Among the latter are burning cleaner fuels such as gas and low sulphur coals, retiring older coal and oil-fired power stations, and increasing the use of non-fossil systems such as nuclear power and renewables. There are also a number of technical ways of reducing emissions, and cleaner ways to burn coal are being developed.

All fossil fuels contain carbon and hydrogen which on combustion are converted to CO_2 and water. Fuels containing relatively more carbon produce more CO_2: for example coal is more carbon intensive than natural gas. The main approach to controlling CO_2 emissions is by the use of more efficient or less carbon intensive energy conversion systems. More efficient systems include the use of combined cycle gas turbines (CCGTs), while less carbon intensive energy sources include nuclear power and wind power. Natural gas contains virtually no sulphur and very little matter that is incombustible, so virtually no SO_2 or dust is emitted when it is burned. Compared to coal or oil, NOx and CO_2 emissions are considerably reduced, especially when used in high efficiency plant such as CCGT or CHP.

It is of course difficult to disentangle the relationship between government expenditure on wind power expansion and environmental improvement. The reduction of environmental emissions is only one of three justifications commonly offered for supporting wind power, (the others being improving security of supply and promoting technological development and employment in the industry), while the recent UK White Paper cites the expansion of renewables as only one of several elements of its policy directed to the reduction of emissions.

Attempts have been made to carry out a formal cost-benefit analysis of a renewables or wind power programme. In such analyses it is necessary to try to put a value on the emissions saved by the use of wind power in place of fossil fuels, but the uncertainty attached to the valuation of such benefits is quite high. This is so for a number of reasons. First, it depends on the nature of the fuel actually displaced: if wind turbines replace coal, the value of emissions saved is five or six times greater than the value of emissions saved if wind turbines replace gas[42]. Second, views differ on the monetary value of the environmental damage inflicted by a unit of an emitted gas. Third, estimates do not always account for the use of fossil fuels in the manufacture, installation, and dismantling of wind turbines. Finally, emissions from power stations are minimised when demand fluctuations are minimised and base load is at its highest. Unpredictable wind power creates additional demand volatility on power stations, and since neither nuclear power nor CHP gas is technically suited to provide back-up power at short notice, the use of wind turbines tends to restrict the choice of back-up fuel to coal.

Despite these uncertainties, the OECD carried out a cost-benefit analysis of the Danish experience with wind power for each year from 1993 to 1998 and came to the conclusion that:

"The renewables programme, now largely based on wind turbines, seems to have incurred costs much higher than any environmental benefits achieved so far…"[43]

OXERA attempted to quantify and to value the relative changes in emissions between different generation portfolios encapsulated in three scenarios: a base case, a high wind, and a new nuclear build scenario. The results are shown in Table 4:

---

[42] OECD (2000)

[43] OECD (2000) p.107

Table 4: Emissions in 2020

	Base Case	**High Wind**	**New Nuclear**
Carbon emissions mtC	37.9	35.9	30.8
NO_x emissions (kt)	121.6	119.6	98.9
SO_2 emissions (kt)	51.6	52.7	40.2
Total saving (£/MWh)	-	1.1-2.2	3.8-5.6

Source: OXERA (2003)

In Table 4 the first three rows show the quantities of each of three categories of emissions produced by each scenario. In the bottom row, the implied environmental benefit of the wind and of the nuclear scenarios are valued by applying to the reductions in emissions over the base case certain monetary values designed to reflect the damage costs of each emission. The values chosen were £25/tonne of carbon for the cost of carbon damage, £3,484/tonne for NOx, and £2,800/tonne for SO_2. This leads to the conclusion that the value of the emissions saved is considerably greater in the nuclear scenario than in the wind scenario. This result is mainly due to the assumption that wind generation relies more heavily than does nuclear on fossil-fuel generation at peak load periods.

Admirable though such studies are, they can do no more than serve as an indication to policy. Much more effective as a guide to action, as we have argued above in our discussion of energy markets and government policy, is when markets themselves put a price on the environmental damage caused by carbon and other emissions from particular activities. This can be done by using a tax or an emissions trading scheme, such as the one to be introduced in 2005 throughout the European Union.

Hitherto, this has generally not yet been done in the UK. There is instead an extraordinary mix of various kinds of subsidies, obligations and regulations, which often differ from one arbitrarily chosen category of supplier, consumer or activity to another The result is, not surprisingly, a set of policies that, while sometimes using economic instruments, does not really minimise the costs of reaching their targets.

When a market price for carbon emissions is established, this will probably confirm that increasing the output of renewables represents an expensive form of carbon abatement. This is already a practical concern to bankers, who worry that if a convergence of the various “climate change” policy mechanisms occurs too soon then renewables might have difficulty surviving. In other words, if we were to rely on a carbon trading scheme as the only method of emissions abatement, this is unlikely to favour renewables like wind.

As we have mentioned earlier, the Kyoto protocol commits the UK to reducing greenhouse gas emissions by 12.5% below their 1990 level by 2008-12, equivalent to a saving of 20.6 million tonnes of carbon (mtC). From 1990 to 2001 overall CO_2 emissions declined by 10.1mtC, thanks largely to gas displacing coal in power generation, which contributed 10.4mtC. However, the accelerated rundown of nuclear capacity after 2008 threatens to reverse this decline in carbon emissions. The emission- free baseload supply associated with nuclear will be lost, and this can only be replaced by thermal generation, because wind cannot provide a baseload supply. In other words, as The Royal Academy of Engineering has observed: “The retirement of nuclear plant in the period before 2012 and its replacement by fossil-fuelled plant for baseload supply could seriously jeopardise the achievement of the Kyoto target.”[44]

---

[44] RAEng (2003)p.6

Environmental Costs:

Although wind turbines discharge no damaging gases or particles they are often alleged to inflict other costs on the environment. These include the impairment of visual amenity, noise, interference with radar, television and other signals, the destruction of birds and the disturbance of sites of special scientific interest.

Visual Amenity:

Those parts of the country that are most suitable for wind farms are also among the most scenically beautiful. A map of Designated Areas, (National Parks, Areas of Outstanding National Beauty, Sites of Special Scientific Interest etc.) in the UK is almost exactly congruent with a map of high-speed wind sites. This has naturally given rise to public concern, and in some cases to passionate hostility. These feelings have played an important part in England and Wales in moving wind farms offshore, despite the higher cost.

Aesthetic judgments are of course wholly subjective, and there may be as many or more young people who find a wind farm beautiful as there are older people who find it ugly. Objectors say that this is not the point. A wind farm, they say, is a large industrial site, as tall as a 30-storey office block. While an office block might be architecturally beautiful it would be out of place perched on top of a fell in the Lake District. Developers point out that wind turbines will only be in place for 20 years, a shorter life than that of the forests of Sitka spruce, and that they are obliged to pay the costs of decommissioning.

As we have observed above, a large scale wind programme will require the construction of additional overhead transmission lines. Most people agree that pylons and lines are visually unattractive.

Noise:

The noise from a wind turbine comes from both the mechanical gearing and from the aerodynamic properties of the rotating blades. The former can to a degree be controlled and insulated, but the more intrusive noise comes from the effects of the blade moving through the air. The larger the turbine, the greater the air mass moving through the blades and the higher the noise level. Developers point out that the larger, more modern wind turbines are practically noise-free.

Interference:

It is Ministry of Defence (MoD) policy to object to any wind development within 74 km of an air defence radar installation. With 13 such installations throughout the UK, this moratorium covers a significant area of the country[45].The MoD opposed nearly half of all proposals for wind farms submitted in the UK in 2003 because of concerns about their interference with air defence radar, and the consequences for their personnel in low flying aircraft The MoD is also objecting to a wind farm proposed for Minch Moor near Walkerburn in the Borders because it is within a 30-kilometre radius of its seismological station at Eskdalemuir.

The civil aviation authorities have similar concerns about wind farms located near the approaches to airports. For example, the wind farm proposed for Blacklaw near Forth in West Lothian.

Wind turbines are also claimed to have disturbed television signals.[46]

---

[45] The Scotsman 1.3.04

[46] Cambrian News 23.1.97

Birds:

In January 2004, US wildlife experts launched a lawsuit against a San Francisco wind farm known to kill 5,500 birds a year. However, in this country the industry and the Government argue that studies show 'birdstrikes' of less than one per turbine per year. In addition, they maintain, developers consult the RSPB to help them site wind farms away from migratory routes.

So far, 27 major wind farms have been objected to by the RSPB. It has just written to another 30 expressing concerns over the effect on birdlife. Earlier this year, the RSPB, condemned the proposed £600m siting of hundreds of wind turbines on the Isle of Lewis, potentially the largest windfarm in Europe, as illegal because they say that it is the location of an internationally important bird sanctuary.

Wind farms are currently planned for sites near the habitats of some of Britain's rarest birds, including golden eagles, as well as the red kite, of which there are 500 breeding pairs left. The proposals for a huge offshore wind farm at Shell Flats off Lancashire could prove to be a test case. A previously unknown flock of 15,000 common scooter ducks was recently discovered at this site.[47] Two EU Directives, the Habitats Directive and the Birds Directive, apply to proposed developments which are likely to have a significant effect on designated habitat and breeding sites. These Directives have been transposed into UK law by Regulations 48, 49 and 54 of the 1994 Conservation (Natural Habitats etc.) Regulations, which would appear to constrain wind farm developments around such sites.

Taken together, all these areas which are ‘out of bounds’ for one reason or another would appear greatly to curtail the onshore areas in the UK available for wind farm development. And, indeed, objections via the planning process have meant that the

---

[47] The Observer 25-1-04

rate at which planning applications have been converted into consents has been quite slow, although it must be observed that the rate of conversion of consents into actual installations has been equally slow.

Valuation Problems:

This is unlikely to satisfy objectors. The fact is that the present planning system is much too blunt an instrument to deal satisfactorily with the issues of noise, visual intrusion, radar interference and the destruction of wildlife allegedly associated with wind farms. The planning process leaves both developers and residents frustrated, while obloquy is heaped on local politicians and civil servants from both sides.

Some economists have proposed that all such environmental costs should be quantified, valued in monetary terms and aggregated into an overall computation of the costs and benefits of wind power. There are obvious difficulties. Noise and the destruction of wildlife are costs which may perhaps be quantified but are much less easily valued. Loss of visual amenity cannot easily be quantified or valued, but this does not mean that it may not in many circumstances be an important cost, as periodic evidence of popular objections testifies. Responding to the challenge, economists have come up with ingenious attempts at putting money values on the unquantifiable[48]. In such attempts changes in property values can help. But these are attempts at calculations of average accounting prices, whereas actual valuations are highly subjective, varying widely from one person to another, and are context specific.

The way forward in valuation must lie in the direction of replacing or at least supplementing the planning system with markets in property rights.[49] Interestingly, some wind farm

---

[48] e.g. Hanley (1998)
[49] Pennington (2002), Corkindale (2004)

developments proposed in the Western and Northern Isles of Scotland may already be stumbling into such a solution. Potential objections from local residents are being bought off with offers of payment by developers. One of the lessons of other countries is that wind farms are most successfully established where they have the support of local communities. In the Highlands and Islands this may be beginning to happen.[50] If a community is able to capture some of the rents from its local natural resources, this may not only serve allocative efficiency but at the same time perhaps distributive justice.

Such a procedure of course might leave out of account the desires of the great majority of citizens (non-local residents) who may not wish to see the scenery of their country despoiled. One thinks of the coal mines which disfigured much of Lowland Scotland from the mid-19th to the mid- 20th century. John Muir, the founder of the National Parks movement, wrote: “Thousands of tired, nerve-shaken over-civilised people are beginning to find that wilderness is a necessity, and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life”. Some might think it a neglect of our duty to future generations to industrialise even temporarily our last wild places when there are more effective and desirable energy strategies left unused.

---

[50] In Ardnamurchan for example

Security of Supply

Security of energy supplies refers to the possibility of an interruption in the physical supply of an energy product or a sudden price shock, either of which can disrupt the rest of the economy. It has traditionally been a responsibility of government to assure supplies of energy to the economy, and indeed this was one of the principal justifications for the post-war protection of the domestic coal industry. Of course, it was precisely this encouragement of a single source of supply which brought about an actual interruption of power supplies during the coalminers’ strike in the winter of 1974. So it is perhaps not surprising that the White Paper takes a relaxed attitude to the prospect of growing dependence on imported gas supplies over the next two or three decades.

The White Paper says that neither relying on imports nor an increased dependence on gas in themselves pose security of supply problems, pointing out that competitive markets incentivise suppliers to achieve reliability.[51] It is dependence on a particular source or a particular technology not a particular fuel that matters.

On electricity supply, the White Paper goes even further in giving a categorical assurance that the Government will not interfere in the wholesale or retail markets except in such extreme circumstances as to avert, as a last resort, a potentially serious risk to safety. Of course, such an assurance is not intended lightly. It was given because the DTI has recognised that any uncertainty about government intervention affecting future prices could discourage private investment in generating

---

[51] Under NETA, suppliers are responsible for their own balancing costs. Those that cannot meet their contractual commitments might have to pay high prices to buy the electricity to meet those commitments.

or transmission capacity that might otherwise have taken place, thereby jeopardising security of supply.

However the DTI does not seem to recognise that the same uncertainty is being introduced into the electricity markets by its programme to promote renewables.

Whether or not the Government’s targets to 2010 and 2020 are met, as Marshall says, “will have a major and increasing influence on the price of unsupported wholesale electricity and thus on market decisions about plant closures and new investment”[52].

Diversification of Sources of Supply:

There is, however, another dimension to security of supply. In competitive markets the price of a particular commodity being traded reflects in part the reliability of its supply. But markets do not generally take into account the additional security that can be afforded to the economy as a whole by a diversified portfolio of energy commodities, fuel sources or technologies.

While each individual fuel technology can reduce the probability of an interruption of its own supply by incurring specific costs, (e.g. by building new nuclear power stations underground), the security of supply of the power system as whole can also be increased by diversifying the portfolio of technologies. Security of electricity supply therefore depends in part on the profile of the overall generation portfolio.

The problem of the security of supply of electricity can therefore be regarded as one to which a possible solution is some form of insurance, and the form which this insurance takes is that of a diversity of fuel sources or of generating technologies. The premium to be paid for such insurance is the difference in

---

[52] Marshall (2003) p.34

generation costs between the technologies. Fortunately, these are usually quite small, especially when the generation costs represent only about one third of the retail price[53].

Until quite recently, electricity generation in the UK rested on four fuel sources, gas, coal, oil, and nuclear. However, the DTI's official projections show that over the next twenty years, oil coal, and nuclear will all run down, and by 2020 the UK will be dependent on one source, gas, for 70% of its electricity generation, of which some 75% may be imported. Thus the country will move from its present relatively high level of diversification of sources of energy supply to a situation in which we shall become increasingly dependent on a single source, gas, which may vulnerable periodically to abrupt increases in price.

Robinson points out, quite rightly, that the calamitous ventures into nuclear power in the 1960s and 1970s by the Governments of the day[54]can be seen as a failed attempt at portfolio diversification. It is also true that following the privatisation of the electricity industry the number of sources of supply has increased. But this does not mean that such diversification will necessarily occur spontaneously in the future. On the contrary, all the indications are of a growing future dependence on a single fuel source.

No government should regard this prospect with equanimity. After all, dependence on imported food supplies brought this country close to defeat twice in the twentieth century. Prudence therefore suggests that some form of insurance be taken out, either by the formation of a strategic reserve of one or more commodities[55] or by the development of an alternative source of energy. The only principle that needs to be observed is that there

---

[53] RAEng 2001 p. 10

[54] Robinson 2002

[55] It must be said that the US strategic petroleum reserve has not hitherto been a great success.

should be such a degree of transparency and certainty about the arrangement that it should not disturb the market process.

Wind Power and Security of Energy Supply:

Should wind power be that alternative energy source? It seems to be the Government’s position that the expansion of wind power capacity in the UK will contribute to the security of our energy supply, but will it? One of the main drawbacks of wind is that it is intermittent, and randomly so. Because it is unable to supply power on demand its contribution to security of supply is evidently limited. The question has been raised as to whether it can make any contribution at all to energy security in the UK over the next decade or two.

The problem with wind power arises when a large high-pressure weather system moves in over all or most of the country and wind power output drops to near zero. Figure 5 shows on the vertical axis the probability of achieving various power output levels from wind turbines distributed throughout Great Britain, given a theoretical installed capacity of 7300MW, (current actual is about 600MW). Along the horizontal axis is shown the average hourly wind power output across the whole country calculated from Met Office wind data for every hour over the last five years. It can be seen from the diagram that the average hourly power output can vary from 7300MW to almost zero. It shows that an output of, say, around 4000MW would have been obtained during only 1% of the hours recorded over the past five years.[56] For the other 99% of the time it would have either been higher or lower, but mostly lower.

During one year the total amount of electrical energy supplied from this hypothetical capacity of 7300MW would be approximately 20TWh, which is about one half of the electricity required to meet the Government’s target for 2010.

---

[56] Laughton (2002)

Large high-pressure systems with little wind pass over parts of the country throughout the year. Those occurring in the winter are accompanied by low temperatures, frost and fog, the very occasions when heating and lighting loads can be at a maximum. If electrical power has to be available at all times, then wind power capacity has to have back-up by conventional plant. As we saw earlier, moving from 10% to 20% wind penetration can require an additional 80% back-up capacity from conventional sources.

In addition to these cost problems, engineers believe that large-scale penetration of wind would also impose technical problems of control, leading to a loss of supply quality and security. This judgment is supported by the well-documented experience of the transmission system of West Denmark with its high wind content.[57] And this is despite the fact that the Danish system has the advantage of interconnectors with Germany, Sweden and Norway. The Norwegian link is of particular significance because it can supply inexpensive balancing energy from fast-acting hydro stations to counter the natural variations in the output of the Danish wind generators.

From records of wind data covering the whole of mainland UK, there is a significant probability of there being periods of time when there is little or no wind blowing across the country. The results shown in Figure 5 have been confirmed in another study[58] of hourly data of electricity demand and simulated wind generation data covering a period of ten years. This showed that there are significant periods in an average year when demand for electricity is high and wind output is low. For example, there were 1642 hours when wind output was less than 10% of the maximum, including 450 hours when demand was between 70 and 100% of peak demand.

---

[57] A statement attributed to a spokesperson for the West Denmark transmission authority compared the operation of his electricity network on windy winter nights to “driving a giant articulated truck with no steering, brakes or other controls” *The Times* 18.7.03

[58] OXERA (2003)

It has been suggested that the UK can expect to obtain some firm demand from a large wind power system, spread over the length and breadth of the country[59]. Here again the actual experience in West Denmark may be worth noting. In 2002, there were 54 days when wind supplied less than 1% of demand despite accounting for over 20% of capacity. In February 2003, a cold but relatively windless month, a whole week went by when virtually no wind power was generated in West Denmark. Although West Denmark is much smaller than the UK, it covers the latitudes from Sunderland to the Moray Firth. So it is probably unwise to expect that that Great Britain can rely with confidence on any minimum level of wind power, no matter how much capacity it might have. If the wind does not blow, no power can be generated.

The implications for the security of supply of the British power system of an increased reliance on wind generation have been modelled by OXERA[60]. The authors used data drawn from the insurance markets to estimate the probabilities of fuel supply interruption and plant failure for each of the major generation technologies. With an assumed generation portfolio for 2020 they developed a base-case scenario in which there are 10 hours in the year where the demand for electricity can be expected to be greater than the available capacity. They then ran the same simulation with two alternative generation portfolios, one with a higher wind content and one with a new nuclear build programme. In the high-wind scenario the number of hours of potential interruption was reduced to 6, and in the nuclear scenario to 4. Nevertheless, when all factors relating to security were taken into account, and the degree of security of supply was transformed, albeit “crudely”, into monetary values, the computation showed the implied security-of-supply benefit of wind generation was £5.1/MWh, while that of nuclear was only £3.7/MWh. (The authors of the study did not test within their framework other options for improving security of supply such

---

[59] ILEX (2002)

[60] OXERA (2003)

as the provision of additional LNG terminals or increased gas storage capacity which they suggest might have indicated these options would be more cost-effective.) The significance of the numbers just quoted can only be understood in the context of the study itself. The study concluded that the security-of-supply benefits of the wind scenario as compared to the nuclear scenario were outweighed in monetary terms by the extra network infrastructure costs of the wind scenario.

Conclusions on security of supply:

These results, speculative though they must be, lend support to the common sense observation that the baseload capability of nuclear power means that it remains a plausible candidate for strengthening the security of the nation's energy supplies by forming part of its generating portfolio. This includes a recognition that a generic fault in nuclear power generation, while having a low probability of occurrence, might incur heavy costs.

On the other hand, adding wind power to the generating portfolio, whatever else it might achieve, adds little or nothing to the security of the energy supply. An acceptable power supply policy does not necessarily follow from a renewable energy supply policy.

Conclusions and Key Messages

An Assessment of Energy Policy:

The word ‘policy’ suggests a deliberative process in which an analytical choice is made amongst alternative ways of achieving an explicitly formulated objective. In that sense, writes Robinson, Britain has never had an energy policy. What happened between 1945 and 1981 was that policies were:

“...instant responses to apparently pressing problems in the energy field which seemed likely to be of concern to the electorate and which were therefore capable of swaying votes. Typically, the government of the day reacted to each new problem with a short-term political ‘fix’…..Periodically, the set of short-term ‘fixes’ which happened to exist at the time would be gathered together in a White Paper... or a Ministerial speech, described as though it were some analytically sound, coherent whole designed to deal with failures in markets, and dignified by the title of ‘policy’”[61]

Inevitably, there were unintended long-term economic consequences. Those who read Dieter Helm’s comprehensive account[62] of the making of British energy policy since 1997 will discover that, at least so far as the environmental aspect of energy policy is concerned, little has changed.

Between 1981 and 1997 there was a brief period of enlightenment ushered in by Nigel Lawson. The new energy policy was simple: the main objective was economic efficiency, in other words low costs, and the means was the introduction of competition. The subsequent establishment of wholesale and retail markets in energy led to a prolonged fall in the price of

---

[61] Robinson (1993), pp.11-12.

[62] Helm (2003), chaps. 15-22.

electricity to consumers, while at the same time achieving an adequate security of supply.

In 1997 the incoming Labour Government added a third objective to the existing ones of economic efficiency and security of supply, namely the reduction of carbon emissions. If they had wished to achieve consistency with the existing objectives they might have introduced a carbon tax, (fixing a price for carbon), or a carbon emission trading scheme, (fixing the amount of carbon emitted and auctioning licences). Either of these arrangements would have allowed individual households and businesses to decide how to adjust their behaviour. This should have brought about the desired overall reduction in CO_2 emissions at the lowest overall cost. Compared to the outcomes that we are now experiencing, there would probably have been bigger savings in the energy efficiency of households (more home insulation), much greater reductions in emissions by road vehicles and aircraft, less electricity generated by coal and wind, and perhaps a continuing role for nuclear power.

Instead, the Government chose to ignore the lessons so painfully learned in the post-war era by governments and regulators all over the world. This is that governments and centralised planning processes are hopeless at adjudicating between technologies.

The fatal conceit that governments know best is well illustrated by the British post war experience with coal and nuclear power. In the 1960s a (Conservative) Minister of Fuel predicted that nuclear power would be “too cheap to meter”. In 1980, the EU issued a Directive forbidding the use of gas in power generation because of its high value, while the Government announced a plan to build one large nuclear pressurised water reactor (PWR) each year for ten years from 1982. Twenty years later, gas had become the predominant fuel in electricity generation and the PWR programme ceased after the construction of just one plant at Sizewell.

That plant, Sizewell B, was the subject of an official Inquiry costing £25 million that demonstrated just how badly wrong centrally planned judgments could be. The terms of reference limited the choice of technology to that between coal and PWR, completely failing to anticipate the move to gas-fired CCGTs that began two years later. The assumptions about fuel prices were soon outdated. The background for the Inquiry had been the oil shocks of the 1970s; by the time it had finished, the oil price had collapsed. Finally, it turned out not only that Sizewell was uneconomic compared with the alternatives, but also that very little new capacity had been needed at all. As Helm remarks, "Rarely has a decision been taken upon such an erroneous view of the next decade-especially when virtually all the key investment decisions depended upon government and regulatory policy."[63]

Why does central planning nearly always get it wrong? Because "even the most gifted central planners do not and cannot possess the information necessary to bring about the efficient results that competitive markets produce, since the necessary information is only revealed through the market process".[64] Up to two years ago, most people had supposed that nuclear power was a low cost supplier of electricity until the fall of the wholesale price revealed otherwise.

The Government that came to power in 1997 chose to ignore these lessons, and instead adopted the 'predict-and-provide' methods that had failed in the 60s and 70s. A target for a reduced level of CO_2 emissions for the economy as a whole was arbitrarily divided between an 'energy efficiency programme' and electricity generation. Then in a re-run of the 'picking winners' procedure, some generation technologies (most renewables, CHP) were favoured while others (hydro, nuclear) were dismissed. Arbitrary targets ten and twenty years ahead were set for the favoured technologies, while equally arbitrary

---

[63] Helm (2003), pp. 104-105.

[64] Marshall (2003), p.10.

incentive schemes (levies, subsidies and exemptions) were put in place in the hope of achieving these targets. As Helm details, the ends and means chosen for energy policy were not the result of careful forethought, analysis and planning, but rather the result of reactions to unplanned events mediated by the lobbying of vested interests.[65]

The consequences have not been surprising. Because nuclear power stations are not being replaced, CO_2 emissions from generation are likely to rise after 2010 while the overall carbon emission targets are at risk of not being met. The intermediate output targets for renewables including wind are also unlikely to be met, but this is an unintended benefit since they are more costly than the alternatives. Furthermore, uncertainty about the extent to which outputs will fall short of targets will have an increasing influence on the price of unsupported wholesale electricity. This in turn will affect market decisions about plant closures and new investment, and thereby the security of future energy supplies[66]. The real cost of present policies will also be reflected in the less than efficient location of new generating capacity and new transmission networks.

KEY MESSAGES AND RECOMMENDATIONS

1. At the present time the cost of generating electricity from wind power is approximately twice that of the cheapest alternative conventional source. By 2010 the cost of subsidising wind and other renewable forms of energy is officially expected to be about £1 billion every year.

2. The principal instrument of Government policy for promoting wind power is the Renewable Obligations scheme. The cost of the scheme falls on electricity companies who pass it on to consumers in the form of higher bills. At the present time, the

---

[65] Helm (2003), chaps 21 and 22.

[66] Marshall (2003) p.34

extra cost of renewables is thought to be adding about 2% to domestic electricity bills, and it is set to grow. Most consumers are unaware that they are paying this hidden levy, and they do not know what they are getting for it.

3. It is widely believed that wind power will eventually become competitive in price with conventional sources of power. But projections by Government advisers, using relatively optimistic assumptions, show that even by the year 2020 a generation portfolio containing 20% wind power will still be more expensive than a conventionally fuelled alternative.

4. Achieving a target of 20% of electricity generated by wind power in that year would cost consumers at least an extra £1.2 billion each year, and over £2 billion annually on less favourable assumptions, over and above the costs of a conventional generation portfolio.

5. It is most unlikely that realising the official targets for the output of renewables, of which wind power is the principal component, is the lowest cost way of achieving the desired reduction in CO_2 emissions. Achieving greater efficiency savings in transport, households and businesses would be more cost-effective.

6. Between now and 2010 overall CO_2 emissions from the UK are expected to resume an upward path. This reflects strongly increasing emissions from the transport and household sectors, as well as from power generation. Carbon emissions from power generation are expected to rise after 2010 because of the planned rundown of nuclear power stations.

7. Because of the cost of providing additional stand-by generating capacity, it is unlikely that wind power will ever account for more than 20% of electricity generation through the National Grid. That being the case, its development can

make no substantial contribution to an overall reduction in carbon emissions.

8. No matter how large the amount of wind power capacity installed, the unpredictably variable nature of its output means that it can make no significant contribution to the security of energy supplies.

9. A 20% share for Wind and other Renewables in power generation capacity will require a major re-engineering of electricity transmission and distribution networks, costing an extra £2.5 billion to £4.5 billion.

10. Government should take advantage of the renewables review coming up in 2005/6 to reconsider the nuclear option. If they are approved as being safe by the Nuclear Inspectorate, the lives of some existing nuclear plants could be extended.

11. Nuclear power emits no greenhouse gases, avoids extra network costs, and as a baseload generator contributes to security of supply. But if nuclear power is to gain public acceptance Government needs to ensure that solutions are developed within reasonable timescales for the management and disposal of nuclear waste.

12. A serious attempt to address the issue of a reduction in CO_2 emissions in the UK has yet to begin. When it does, it may prove to be costly, raising wholesale electricity prices by perhaps 40 to 60% over a five year period.

13. The Government should move quickly to implement the EU scheme due to phase in from 2000 for the allocation of tradable carbon emission rights, preferably by auction, up to its chosen level of emissions. It could then dispense with most of the other policy measures it has put in place to achieve the environmental objectives of its energy policy.

14. On the basis of past experience, it seems likely that the energy technologies that will play an important part in the economy of 2020 do not feature prominently in current Government policy.

15. In energy policy, as elsewhere, government decisions taken on the basis of short-term political pressures have unforeseen long term economic consequences, usually unfavourable.

16. Since Intermittency is its greatest weakness, wind power will fully come into its own only when a cost-effective method of storing electricity is developed.

17. Meanwhile, when market prices reflect the costs of avoiding environmental damage a small but increasing number of windfarms should become profitable.

18. There are also income benefits to remote communities where wind resources are located. At present these come from subsidies; in future they may come from the attraction of power-using industries.

References:

Baliunas, S. (2002) “The Kyoto Protocol and Global Warming” *Imprimis*, 31, 3

BWEA (2003) *The Economics of Wind Energy*, website at britishwindenergy.co.uk/ref/econ.html

Corkindale, J. (2004) *The Land Use Planning System*, Hobart Paper 148, London; The Institute of Economic Affairs

Dale, L., Milborrow, D., Slark, R. and Strbac, G.(2003) “Total Cost Estimates for Large Scale Wind Scenarios in the UK”, *Power UK*, March

DETR (2000) *Climate Change : UK Programme*, London : The Stationery Office, November

DTI (2000a) *Future Offshore – A Strategic Framework for the Offshore Wind Industry,* London : The Stationery Office

DTI (2000b) *Energy Projections for the UK*, Energy Paper 68, London: The Stationery Office

DTI (2000c) *New and Renewable Energy : Prospects for the Twenty First Century,* London : The Stationery Office

DTI (2003) *Our Energy Future-Creating a Low Carbon Economy* , London, The Stationery Office, February

DUKES (2003), *Digest of UK Energy Statistics 2003*, London: The Stationery Office

Hanley, N. (1998) “Valuing The Countryside: Rural Land Use Policy Evaluation Using Contingent Evaluation in the United Kingdom” in *Heritage, The Environment and The Arts,* Hume

Papers on Public Policy Vol 6 No 3, Edinburgh: The David Hume Institute

Helm, D. (2003) *Energy, The State and the Market*, Oxford; Oxford University Press

ILEX Energy Consulting (2002) *Quantifying the System Costs of Additional Renewables in 2020*, DTI website

Incoteco (Denmark) ApS, *The Practicalities of Developing Renewable Energy in the UK - In the Light of Danish Experience,* www.incoteco.com

Laughton, M.A. (2002) “Renewables and UK Grid Infrastructure”, *Power in Europe*, 383,9, September

Marshall, E. (2003) “Energy Regulation and Competition After the White Paper” Beesley Lecture 11, November

NAO (National Audit Office) (2004) *Risk Management: The Nuclear Liabilities of British Energy plc*, London, February 6

Merrill Lynch (2003) *Wind Power*, London, 24 September

OECD (2000) *Economic Survey of Denmark*, Paris, July

Ofgem (2001) *Energy Efficiency Commitment Administrative Procedures : Working Document*, London, December

OXERA (2003) *The Non-Market Value of Generation Technologies,* Oxford, June

Peacock, A. T. (2003) *The Political Economy of Sustainable Development*, Edinburgh: The David Hume Institute

Pennington, M. (2002) *Liberating the Land*, London : Institute of Economic Affairs

PIU (Cabinet Office, Performance and Innovation Unit) (2002) *The Energy Review*, London : The Stationery Office, February

RCEP (Royal Commission on Environmental Protection) (2000) *Energy: The Changing Climate*, London: The Stationery Office

Rees, M. (2003) *Our Final Century*, London: Heinemann

Robinson, C. (1993) *Energy Policy: Errors, Illusions, and Market Realities*, Occasional Paper 90, London, Institute of Economic Affairs

Robinson, C. (2004) “Gas, Electricity and The Energy Review”, in Robinson, C. (ed) *Successes and Failures in Regulating and Deregulating Utilities*, London : Edward Elgar

RAEng (The Royal Academy of Engineering) (2001) “Energy Policy Review-Project Scope”, *Response to the Cabinet Office Performance and Innovation Unit*, September

RAEng (2003) “Inquiry Into The Practicalities of Developing Renewable Energy”, *Response to The House of Lords Science and Technology Select Committee,* October

RAEng (2004) *The Costs of Generating Electricity, A Commentary*, London: March

Glossary of Terms:

AGR	advanced gas-cooled reactor
BETTA	British energy trading and transmission arrangements
BNFL	British Nuclear Fuels Ltd
BSC	Balancing and Settlement Code
BWEA	British Wind Energy Association
CCGT	combined-cycle gas turbine
CCL	Climate Change Levy
CEGB	Central Electricity Generating Board
CFB	circulating fluidised-bed combustion
CHP	combined heat and power
CO_2	carbon dioxide
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DTI	Department of Trade and Industry
EEC	Energy Efficiency Commitment
FT	Financial Times
GDP	gross domestic product
GW	gigawatt
GWh	gigawatt hour
IEA	Institute of Economic Affairs
IPCC	Intergovernmental Panel on Climate Change
kW	kilowatt
kWh	kilowatt hour
LNG	liquefied natural gas
MW	megawatt
MWh	megawatt hour
NAO	National Audit Office
NETA	new electricity trading arrangements
NFFO	Non Fossil Fuel Obligation/Order
NGC	National Grid Company
NGT	National Grid Transco
NICs	National Insurance Contributions
NORWEB	North Western Electricity Board

NOx	oxides of nitrogen
OECD	Organization for Economic Co-operation and Development
Ofgem	Office of Gas and Electricity Markets
OXERA	Oxford Economic Research Associates
PIU	Performance and Innovation Unit (part of the Cabinet Office)
PPA	power purchase agreement
PWR	pressurized-water reactor
R&D	research and development
RAEng	Royal Academy of Engineering
RCEP	Royal Commission on Environmental Pollution
REC	regional electricity company
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
SO_2	sulphur dioxide
TW	terawatt
TWh	terawatt hour

Data Appendix

Units of Power and Energy:

1kW = 1Kilowatt = 1,000 Watts
1MW = 1Megawatt = 1,000 Kilowatts
1GW = 1Gigawatt = 1,000 Megawatts
1TW = 1Terawatt = 1,000 Gigawatts (1 trillion watts)

It follows from the above that 1p/kWh is equivalent to £10/MWh.

Energy = Power x Time

1MWh = the amount of energy produced when a generator of 1MW installed capacity operates at full capacity for one hour. There are 8760 hours in the year.

Load Factor : is a measure of how much power a generator will actually deliver in relation to its capacity. It is calculated by dividing its actual output (MWh) by the product of its installed capacity (‘nameplate capacity’, ‘rated output’) and 8760. For predictions of wind power by engineers and economists, it is common to assume a load factor of 35%.

Wind Speed: The power generated by a wind turbine is a function of the size of the turbine blade and the cube of the wind speed. Wind turbines start to operate when the wind speed reaches 5 metres per second (m/s), equivalent to a moderate breeze, force 4. They are switched off when the wind reaches about 23 m/s (storm force 10). Average wind speeds in the UK vary between about 5 and 10 m/s according to location and height above sea level. The minimum average wind speed acceptable to bankers is said to be 8 m/s.

Table A1: Installed Wind Capacity, UK (GW)

	2000	2005	2010	2015	2020
Onshore	0.4	0.9	2.5	4.7	6.3
Offshore	0.0	0.2	1.1	3.0	4.9
TOTAL	0.4	1.1	3.6	7.7	11.2

Source: Merrill Lynch (2003) Table 9

Table A2: Carbon Emissions, UK (MtC)

	1990	1995	2000	2005	2010	2015	2020
TOTAL	159.3	149.6	146.7	146.6	148.7	153.6	155.2
Power Stations	54.1	44.1	40.0	38.0	37.6	39.4	37.8

Source: DTI (2000b) Table 7.5

Table A3: Carbon Emissions, UK 2000, by Sector (MtC)

Power Stations	40.0
Households	22.0
Industry	33.7
Road Transport	32.0
Other	19.0
TOTAL	146.7

THE DAVID HUME INSTITUTE

The David Hume Institute

The David Hume Institute was registered in January 1985 as a company limited by guarantee: its registration number in Scotland is 91239. It is recognised as a Charity by the Inland Revenue.

The objects of the Institute are to promote discourse and research on economic and legal aspects of public policy. The Institute has no political affiliations.

The Hume Occasional Paper series presents papers by members of the Institute, by those who have lectured to it and by those who have contributed to "in-house" projects. A selected list of Occasional Papers follows:

56 *Report on the Economic Aspects of Political Independence* David Simpson, Brian G Main, Alan Peacock, and Fabian Zuleeg

57 *Agenda for the Scottish Parliament* Roy Goode, Russel Griggs, Hector MacQueen, Brian G M Main, Hugh Morison, Lindsay Paterson, Jeremy Rowan Robertson

58 *The European Union and the Nation State* (The Hume Lecture 2000) Professor Tommaso Padoa-Schioppa

59 *Are Lawyers Parasites?* (The Hume Lecture 2001) The Rt. Hon. the Lord Mackay of Clashfern KT, PC

60 *Hume on Liberty and the Market - a Twenty-First Century Perspective* (The Hume Lecture 2002) Professor John Gray

61 *Establishing Competitive Economic Advantage in the Scottish Economy* Alf Young

62 *Central Scotland Airport Study*, Brian G M Main, Bill Lever and Jonathan Crook

63 *The Political Economy of Sustainable Development*
Presidential Address by Professor Sir Alan Peacock

64 *The Private Finance Initiative. From the foundations up - a primer*
Professor Peter M Jackson