REF

RENEWABLE ENERGY FOUNDATION

RENEWABLE ENERGY

The Need for Balance and Quality

Manifesto 2005

RENEWABLE ENERGY:
The Need for Balance and Quality

Renewable Energy Foundation

Policy and Research Group

January 2005

About the Authors: The Policy and Research Group, and The Technical Advisory Group

This document has been authored by the Policy and Research Group of the Renewable Energy Foundation with the collaboration of the Foundation's Technical Advisory Group.

The Policy and Research Group is directed by Dr John Constable, Senior Research Fellow of Magdalene College, Cambridge. In this role he is assisted by Dr Mike Hall, BSc. CChem, FRSC, CBiol, FIBiol, and Mr T. J. W. Hale.

In authoring this document the Policy and Research Group has been guided by certain members of REF's Technical Advisory Group who are listed below: Professor John Ffowcs-Williams, recently retired Rank Professor of Engineering at Cambridge University; Sir Martin Holdgate; Professor Michael Laughton, Emeritus Professor of Electrical Engineering at the University of London; Guy de Selliers; Hugh Sharman; Mr Robert Skelton, CEng, FIChemE, MIMechE, FINucE, who is currently a member of the Department of Chemical Engineering at the University of Cambridge; and David White, FIChemE.

Contents

Foreword

The United Kingdom is a round-the-clock economy of nearly 60 million people living in a densely populated island. It has many pressing needs, and one of the most fundamental of these is energy, without which none of its other requirements can be serviced. This energy must be:

- Secure
- Reliable
- Economical
- Clean
- Sustainable

Reconciling these various demands is a complex equation, and it is clear that while a satisfactory trade-off may be possible, it is unlikely that any one of these variables can be *maximised* in a practical policy. In the short and medium term these five features will necessarily be prioritised to ensure public well-being and the stable delivery of the overall energy strategy in the medium and long term. However, an unbalanced dash towards one or two of these five goals will, even if practical, compromise our ability to achieve meaningful results with regard to the others.

We believe that the current policy relating to renewable energy, stemming from the 2002 Ilex Energy Consulting report, *Quantifying the System Costs of Additional Renewables in 2020,*[1] and the *Energy White Paper: Our Energy future: Creating a Low-Carbon Economy* (2003), has resulted in just such an unbalanced and destabilising over-emphasis. In the following document, prepared with the advice of our many academic and industry advisors, the Renewable Energy Foundation presents a constructive critique intended to highlight the problems and point the way towards a resolution.

In summary, we believe that the *White Paper* places a distorting over-emphasis on renewable energy as a pathway to emissions reduction. This is complicated by a further

1 Ilex Energy Consulting, in Association with Professor Goran Strbac (UMIST), *Quantifying the System Costs of Additional Renewables in 2020* (2002). Available from: http://www.dti.gov.uk/energy/developep/080scar_report_v2_0.pdf

and consequent over-emphasis on emissions from electricity generation, which itself is compounded by a lack of balance in the approach taken to renewable electricity generation. **The result of this flawed approach is not only that the original goal of emissions reduction is compromised, but also that it becomes impossible to give reasonable guarantees that the bulk of our energy supply will, in fact, be secure, reliable, economical, and sustainable.**

Renewable energy sources in the broadest definition, encompassing, for example, wave, solar, wind, tidal, tidal flow, biomass, and others, have an important contribution to make in delivery of our overall energy strategy in the longer term. They are potential contributors to the security and diversity of supply, and the reduction of emissions. But asking more of renewables than can reasonably be delivered in the timeframes set will condemn this promising sector to inevitable failure. In turn, this failure could be seriously damaging to the government's primary obligation, namely to develop the shared social objective of a stable infrastructure. Energy, of course, is the lifeblood of such infrastructure, and destabilisation of the sector has high economic and social costs.

Current policy is, we believe, placing renewable energy in a thankless position. The Renewable Energy Foundation is therefore calling for a period of experimentation aimed at achieving a balanced and pragmatic approach which reflects the **quality** variations between the renewable technologies for electricity generation, and puts **more emphasis on renewables in fields other than electricity, for example bio-fuels, local space heating, and water heating**. Only then will each renewable contribute in an appropriate manner and in proportion to its merits, and so enhance rather than jeopardise the UK's energy prospects.

The Renewable Energy Foundation believes that **an energy supply that is harmoniously secure, reliable, economic, and clean will produce a positive feed-back mechanism, and so facilitate the provision of an energy supply that is still more satisfactory.** On the other hand, failure to achieve such a balanced energy provision can only lead to negative feedback, with damaging consequences for the economy and society of the United Kingdom as a whole

Campbell Dunford (CEO)
John Constable (Policy and Research Director)

Executive Summary

The Energy Needs of the UK

The UK needs an energy supply that is *Secure*, *Reliable*, *Economical, Clean*, and *Sustainable.* Reconciling the various demands is a complex matter, and a trade-off is the likeliest practical outcome. Achieving the most satisfactory compromise means correctly prioritising these goals. An unbalanced dash towards any one target will impair our ability to achieve meaningful results with regard to the others. We believe that the Energy White Paper of 2003 has, unfortunately, resulted in a destabilising overemphasis on renewably generated electricity as a means to emissions abatement. The result of this flawed approach is the prospect of unsatisfactory emissions reduction, and an increased likelihood that the UK's electricity supply will be insecure, unreliable, and expensive.

Getting the Priorities Right

REF is calling for a revision of policy that recognises that *security* and *reliability* of supply are fundamental requirements, and thus can lead to an energy supply that is harmoniously secure, reliable, economic and clean. Such a state of affairs will result in positive feedback leading to further improvements. A distorted policy, on the other hand, will lead to negative feedback and subsequent deterioration.

Renewable Energy is a Means to an End

It follows from the positions taken above that renewable energy is valuable in so far as it leads to improvements in the security, reliablity, economic effectiveness, and cleanliness of our power supply. We need, therefore, to be particularly sensitive to issues of quality when devising policy measures to encourage renewables.

Renewable technologies vary in character and are separated by gradients of quality. It is self-evident that they must be evaluated according to their merits, and only deployed accordingly. However, current policy, particularly the Renewables Obligation, rewards all renewable electricity generators regardless of their ability to produce reliable, high value, power (in its technical sense, as distinct from mere energy), and this has led the market to an unreasonable over-investment in lower worth, randomly intermittent, technologies.

The Need to Acknowledge and Respond to European Evidence

A wealth of evidence from Denmark and Germany now shows that randomly intermittent renewables are very difficult, even at lower levels of penetration, and very costly, to integrate into a stable grid.

Furthermore, it is increasingly clear that such “non-firm” renewables do not offer adequate or cost-effective emissions abatement, particularly so since they cause additional stresses to be placed upon the fossil generation required to provide backup and stabilise supplies to society, thus resulting in inefficient plant operation with a deleterious effect on the net reduction in emissions.

Revisions to the Renewables Obligation System

REF is therefore urging a thoroughgoing revision of the Renewable Obligation system to ensure that more is offered to technologies, such as reliable tidal systems, which have themselves more to offer. Randomly intermittent renewables will then find a role appropriate to their merits.

We also note that renewables in areas other than electricity generation, such as biofuels for transport and space heating, and thermal solar renewables for domestic and district water heating, are currently marginalised in spite of the manifest advantages they offer. It is a matter of urgency that policy is revised to improve existing support mechanisms and ensure the institution of fresh initiatives.

Lack of Discrimination Leads to Unreasonable Demands

REF notes that current policy lacks fine-grained discrimination, asks more of renewables than can be reasonably delivered, and is thus condemning the sector to failure. If we desire stable and long-lasting CO_2 abatement, and a realistic contribution to security and reliability of supply at an affordable cost, then we must be practical in our expectations, and selective in our choices. If the finite ability of the nation’s energy system to bear cost is skewed towards renewables, the necessary capital to secure the best technologies for the inevitable fossil component in any realistic mix may not be forthcoming, so that fossil fuels will be burnt dirtily and wastefully in older equipment.

Co-operating with Fossil Fuels: Responsible Renewables

The “Renewables v. Fossil Fuels” conflict which dominates public debate is contrived and deeply misleading. For the foreseeable future all renewables must work in conjunction with firm generation from fossil sources. It is imperative that we take a constructive attitude to this reality, ensuring that the renewables we foster are capable of responsible team-work in the overall generating portfolio. In regard to electricity generation we conclude that policy changes are necessary to ensure that the renewable technologies encouraged:

- Enhance rather than degrade security of supply.
- Are reliable in themselves, and do not degrade the reliability of the existing power generation plant.
- Are economical in themselves, and do not cause the consequential costs to rise beyond reason in the grid and for existing firm plant.
- Are capable of contributing in certainly quantifiable terms towards emissions reduction without causing increased inefficiencies and thus increased emissions elsewhere in the power portfolio. In other words, the net emissions saving should be demonstrable and quantifiable beyond reasonable doubt.
- Are truly sustainable.

In summary, we suggest the simple, all-encompassing, principle that **responsible renewable development will be characterised by the selection of *high quality* renewable technologies**.

RENEWABLE ENERGY:
THE NEED FOR BALANCE AND QUALITY

1. Renewable Energy is a Means to an End

The fundamental goal of a national energy generation policy is the well-being of the public. But the mere provision of sufficient energy is not a guarantee that this ultimate goal has been achieved, for there are issues involving considerations of **quality** as well as **quantity**. The energy provided must demonstrate favourable credentials in a number of areas, and ideally should be:

- Secure
- Reliable
- Economical
- Clean
- Sustainable

However, it should be noted that these are the qualities we wish to be characteristic of the overall energy portfolio. It is not enough that the various component technologies of our portfolio should demonstrate them individually; each technology must manifest these qualities in such a way that

1 the ability of other technologies to deliver their benefits is not impaired, and
2 the value of the energy sector as a whole is not seriously compromised.

Renewable energy technologies, therefore, are like all other energy technologies, **a means by which we reach a desired end**. Consequently, renewables should be judged by the same standards we apply to any other energy technology, and our plans formulated accordingly.

We suggest that the criteria should be arranged in the sequence given above, reflecting their priority and consequence. The logic of this sequence can be explained as follows:

- If security of the primary sources cannot be guaranteed, then reliability at the point of use is questionable.
- If security and reliability of supply are compromised, then our economy will be damaged.

- If our energy supplies are insecure, unreliable, and unaffordable we will be unable to maintain and develop the high technological economy necessary to support our social aims and control the emissions of a large urban and industrial society.
- If the energy system in its total sense is unclean, as is seen in the CIS countries and parts of the developing world, then our social aims will be compromised by ill health in our population, for which there is growing evidence even in the UK (e.g. childhood asthma).
- And finally, if we cannot achieve any of the foregoing aims, our overall energy policy will be unsustainable, and the well-being of the United Kingdom and its people will be poorly served in the short, medium, and longer term.

We emphasise that this sequencing and logic differs radically from that found in the *Energy White Paper*, which we believe is gravely and dangerously flawed.[2] In particular we note that the *White Paper* foregrounds emissions abatement as the principal goal, and allows other goals to settle into subordinate positions in no particular order. In criticising this policy framework, **the Renewable Energy Foundation is not suggesting that emissions abatement is unimportant, but, rather, that placing it centre-stage is likely to compromise the other essential objectives.**

Security of Supply

The maintenance of a secure energy supply is the fundamental priority, without which no other goal is attainable. The *White Paper* itself notes that as supplies of North Sea oil and gas peak the United Kingdom will become a net energy importer.[3] We already import half of our coal supply, and the UK's currently economically mineable coal reserves are believed to have a life of only ten years. The *White Paper* remarks:

> By 2020 we could be dependent on imported energy for three quarters of our total primary energy needs.[4]

2 See, for example, *Energy White Paper: Our Energy future: Creating a Low-Carbon Economy* (Dti: London, 2003), pp. 7ff.

3 *White Paper*, p. 9.

4 *White Paper*, p. 9.

The key point of concern is that in locating sources of energy we should in so far as is possible avoid exposing the UK to interruption of supply arising from resource exhaustion, price escalation, socio-political disturbance, or intense market competition. The latter point is not simply one of market leverage, since, regarding the globe as an entity, there may be economies that can, and *should,* outbid us for energy. It would be absurdly uneconomic, for example, to move and process aluminium or iron ore if the source mine has a cheap source of power nearby and costs could be reduced by processing the ore on site and importing the finished metal to Europe.

We note that the following points should guide us in this regard:

- Ideally, and in so far as is compatible with the following points, energy supplies should be under UK sovereign control.
- Energy supplies should be diverse.
- The selection of an energy source for one reason, say emissions abatement, may have consequential effects on the rest of the energy portfolio, and this may compromise security of supply.

In addition, we should include the requirement that the energy market is maintained in such a condition that it attracts investment in plant and infrastructure appropriate to the long-term interests of the United Kingdom.

Renewable energy sources are generally speaking under sovereign control, and therefore may, naively, be thought to contribute to security of supply in an uncomplicated way. However, it must be borne in mind that due to the nature of these largely intermittent sources, of which wind-power and run-of-river small hydro are the most prominent, various knock-on effects will occur elsewhere in the power portfolio, and these may be inimical to security of supply and to other overall goals.

For example, there is a an over-riding need to provide reliable generation or planned service appropriate to the purpose of providing usable power in the event of a failure of the weather forecast to accurately predict wind strength. This need will inevitably encourage the construction of gas turbines suitable for use as “peaking” generators (i.e. generating for limited periods of high demand and as rapid-response standby). It is likely that these would be Open Cycle Gas Turbines, which are significantly less thermally efficient than Combined Cycle Gas Turbines.

The UK has already seen a remarkable increase in commitment to gas for electricity generation purposes, amounting to 38% of the total generation output in 2003.[5] Happily these were mainly high efficiency units which make good use of finite fossil fuels (unfortunately, peaking machines do not). The *White Paper* is curiously vague with regard to the likely position in 2020, noting only that "Gas will form a large part of the energy mix".[6] However, from the Ilex Energy Consulting report,[7] and the Performance and Innovation Unit's *Energy Review*,[8] we can conclude that the government expects that some 75% of the UK's electricity will be provided by gas-fired turbines in 2020.[9] This over-reliance on one fuel, of which we are already a net importer, gives reason for deep concern. In a paper commissioned for REF Hugh Sharman of the energy consultancy Incoteco has advised us that:

> [...] it is surprising that the White Paper does not acknowledge that during the next ten to fifteen years, as the UK slips from being at the top of an energy supply chain to the bottom, the whole of the world's energy supplies will become severely constrained. For example, it foresees a doubling in the UK's consumption of gas by 2020, although by then almost all gas used in Europe will be sourced from countries far away. China, the USA, and the rapidly growing Indian sub-continent, not to mention the rest of the world, will also compete for the supplies of energy needed in Europe. Even assuming that the UK can obtain the supplies it requires, these will necessarily be at a high price.[10]

In fact, the PIU Report and the White Paper assumed that liberalisation of the European gas market would create competition to keep gas prices low.[11] However, the EU Energy

---

5 Dti, *Digest of United Kingdom Energy Statistics, 2004* (Dti: London, 2004), 118.

6 *White Paper*, p. 18.

7 *Quantifying the System Costs of Additional Renewables in 2020* (2002), pp. 80–83.

8 The Performance and Innovation Unit, *The Energy Review* (Cabinet Office: London, 2002), p. 90, para 5.31.

9 PIU, *Energy Review*, p. 91, para 5.33.

10 Hugh Sharman, (Incoteco Aps), "The UK's Dash for Wind How the UK might adapt its energy planning policies and ambitions in the light of recent and current experiences of West Denmark", forthcoming as a major two-part article in *Civil Engineer*, and soon to be available from http://www.ref.org.uk.

11 Performance and Innovation Unit, *The Energy Review* (Cabinet Office: London, Feb. 2002).

Directorate alerted member states as long ago as 2000 that growth in gas demand throughout Europe would require imports from Russia, the Middle East and North Africa, and that substantial new infrastructure would be needed to transport that gas to market. Consequently, recovery of invested capital would lead to a substantial increase in cost. In addition, as we have seen recently, gas prices have already risen, largely because both the USA and Japan need to import supplies as LNG. Natural gas prices may therefore become linked to an internationally traded commodity not solely to a European market.

For the UK to derive such a large proportion of its electricity from one fuel source, traded in a volatile market, is extremely unwise.

Reliability of Supply

The *White Paper* appears to conflate security of supply with reliability.[12] It should be emphasised that these terms are distinct. A supply can be **secure but unreliable**. In other words, an energy source can be under UK sovereign control, well-capitalised and supported by infrastructure, but **inherently and randomly intermittent**, or prone to substantial and unpredictable fluctuations over time. This would be in itself problematic and may have a destabilising effect on the rest of the energy supply.

Because electricity cannot be stored on an industrial scale it presents the issue of reliability in an acute form. Even apparently minor fluctuations in the supplied voltage from the electricity grid can have significant costs, and complete failures are disastrous. It has been estimated that the two-year power crisis in California, culminating in the rolling blackouts of 2000/2001, cost the state $45 billion in higher electricity costs, lost business, and diminished growth.[13] New York city, alone, is estimated to have lost $800 million in economic activity, and $250 million of perishable goods in the 29 hour interruption in 2003.[14] Merrill Lynch estimated that the power failures in 2003 cost the US between $25 and $30 billion in GDP, and slowed quarterly growth by 1%.[15] While the US blackouts were the most

---

12 *White Paper*, passim, but eg. p. 9, para 1.14.

13 Public Policy Institute of California, quoted in CNN article available at http://www.cnn.com/2003/US/West/01/15/california.energy.ap/

14 http://www.telegraph.co.uk/money/main.jhtml?xml=/money/2003/08/20/cnbkout20.xml

15 http://www.telegraph.co.uk/money/main.jhtml?xml=/money/2003/08/20/cnbkout20.xml

widely publicised, there have been significant interruptions in Italy (28 September 2003), producing a blackout affecting the whole country within 2 to 5 minutes of the first fault occuring,[16] and East Denmark, where on the 23 September 2003 a total interruption of electricity supply lasting several hours has prompted a major reprioritisation of the issue of reliability, and stimulated the Danish Energy Authority to commission a forthcoming report from COWI A/S to assess the cost of such interruptions.[17] Shifting focus from the state to the individual, we need only recall that many humane supports to the vulnerable, kidney dialysis machines in the home for example, depend upon energy and, particularly, *continuous* electricity.

With the management of almost our entire socio-economic fabric now dependent on computer-managed financial, transport, and information networks the impact of power interruptions, even at a local or regional basis, let alone a national level, will be very great.

Thus, even though reliability is a sub-set of security of supply, there can be no justification for compromising the reliability of energy provision.

The task of integrating randomly intermittent sources of energy while maintaining overall system stability is no small challenge both technically and financially. It is particularly so for the United Kingdom, which is geographically and electrically, with the exception of the 2,000 MW connector to France (which represents only about 3.5% of peak UK demand), an island. West Denmark and Germany have both developed substantial wind-power programmes over the past two decades, but both countries are richly interconnected electrically with their neighbours, and are able to use these systems to balance their own grid. Germany has interconnectors totalling 13 GW, in excess of 15% of peak demand.[18] Western Denmark (Jutland) has transmission links to Norway and Sweden just greater than their installed wind capacity of 2,300 MW. Consequently, they

---

16 F. Vandenberghe (Chairman of the UCTE Investigation Committee on the 28/09/2003 Blackout in Italy), "Lessons and Conclusions from the Lessons and Conclusions from the 28 September 2003 28 September 2003 Blackout in Italy Blackout in Italy", presentation to the IEA Workshop, 29 March 2004. Available from http://www.iea.org/dbtw-wpd/textbase/work/2004/transmission/vandenberghe.pdf.

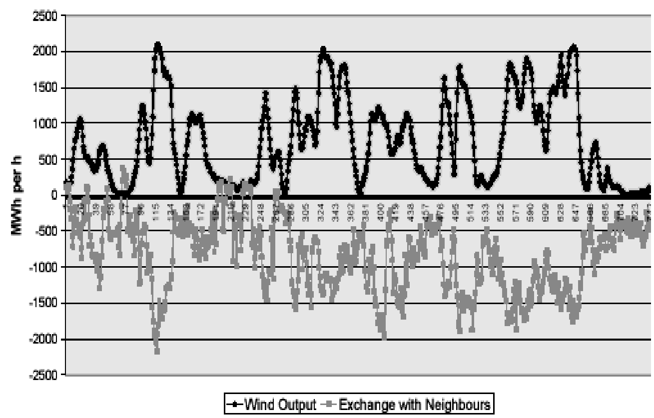
17 http://www.cowi.dk/news/UK/2004/sept2004/forsyningssikkerhed_uk.asp

18 Felix Müsgens, "Market Power in the German Wholesale Electricity Market". EWI Working Paper, Nr 04.03, May 2004, published by the Energiewirtschaftliches Institut an der Universität zu Köln. Available from: http://www.uni-koeln.de/wiso-fak/energie/Veroeffentlichungen/pdf/Ewiwp043.pdf

are in a position to accommodate wind production by trading with their neighbours. However, West Denmark does this at considerable cost (1 billion DKr – approximately £100,000,000 – in 2003 alone)

In the research conducted by Incoteco for the Renewable Energy Foundation, noted above, it is shown that West Denmark's wind-power output coincides closely with its electricity trading.[19] The chart below, based on data publicly available in Denmark, shows wind output for December 2003 in black, and net exchange in grey.

Wind Output and Exchange with Neighbours, December, 2003

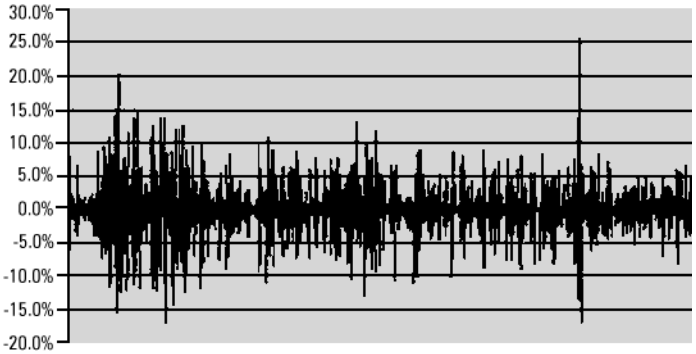


As will be immediately apparent West Denmark makes very full use of its interconnectors. By contrast, the UK's attempts to balance large proportions of unreliable generation will have to take place almost exclusively within the national grid. The extent of the balancing challenge can be seen in the following chart, which shows how the wind carpet output changed from hour to hour during 2002. Changes are expressed as a fraction of the whole carpet which, during 2002, was 2,310 MW. In a conventional grid, thermal units must balance these flows by ramping up and down or by some other means. There is little doubt that this chart will be representative of the manner in which a UK wind carpet will perform.

---

19 Research conducted for the Renewable Energy Foundation, 2004, Hugh Sharman (Incoteco Aps), "The UK's Dash for Wind How the UK might adapt its energy planning policies and ambitions in the light of recent and current experiences of West Denmark". Available from http://www.ref.org.uk.

Wind Output Hourly Ramping as Percentage of Wind Capacity, 2002

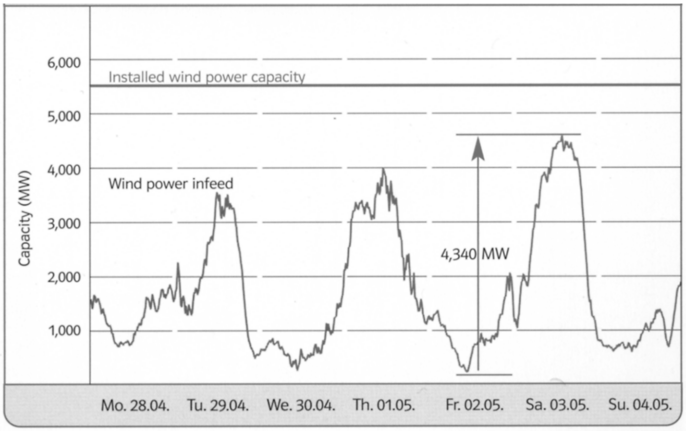


Nor is this unusual. Incoteco points out that in 2003 there were four events when the wind output changed by over 400 MW during a single hour (up to 20% of the wind carpet capacity). In addition there were 56 events when the wind power output changed by between 200 MW and 400 MW in a hour, which is approximately 6–11% of West Denmark's peak winter demand. These are very large generational swings, and present highly significant problems to the grid operating companies charged with maintaining reliable electricity supplies.

Confirmation that these difficulties are not confined to West Denmark can be found in the very recent *Wind Report 2004* of E.ON Netz GmbH, which manages a wind carpet of over 6,000 MW in Germany, making it one of the most experienced companies engaged in managing randomly intermittent renewable energy input.[20] E.ON Netz reports that in the week of 28 April to 4th of May 2003 the wind input to the grid varied significantly:

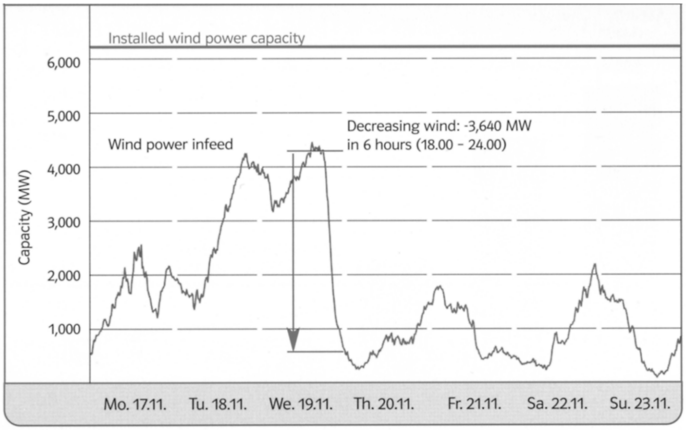
20 E.ON Netz GmbH, *Wind Report 2004* (E.ON Netz: Bayreuth, 2004). Available from http://www.eon-netz.com/.

Strong fluctuations in the wind power infeed (E.ON control area: 28.04 to 04.05.2003) [21]



These fluctuations can occur in very short periods of time. The following chart shows that on the 19th of November 2003 the wind input fell by 3,640 MW in six hours, at an average rate of 10 MW per minute. Putting this in perspective: the total output of the Drax coal-fired power station, the largest thermal generator in Western Europe, is only slightly larger at 3,960 MW.

Rapid fall in the wind power infeed (E.ON control area: 17.11 to 23.11.2003 [22]



---

21 *Wind Report*, fig. 4, p. 6.

22 *Wind Report*. fig. 5, p. 6.

While it is possible that dramatic fluctuations such as this can be handled within an islanded grid system, it is clear that the cost of ensuring that the supply is acceptably reliable would be very large. Indeed, the stresses and costs placed upon even such a robust and well-interconnected system as that of E.ON Netz have proved unacceptable. As E.ON observes:

> Due to the massive and ongoing new expansion of wind power, it has therefore become increasingly difficult to guarantee the stability of the electricity supply – particularly in the event of a power failure.[23]

Consequently, E.ON Netz has revised their grid connection code to place the burden of responsibility on the operators of the wind-farms. In this context it is worth noting that the Irish grid operator, ESB National Grid, has also foreseen instability problems arising from erratic wind-power input and other features of the turbine's performance (notably "fault ride through" and "frequency response"). ESBNG initially instituted a moratorium on new wind-power,[24] and has now revised its grid code to require wind turbine operators to control output in a fashion compatible with the various requirements of grid stability.[25] It remains to be seen whether randomly intermittent generators can meet these challenges and whether the requirement will deter investors.

Economic Considerations

Energy is a significant overall cost factor in any economy. An increased cost in energy provision inevitably has a knock-on effect, and may have very serious consequences for competitiveness and thence for national socio-political standing. This is particularly important in the UK, since we are already less energy effective than many other comparable industrialised countries. The *White Paper* itself publishes a chart, reproduced below, showing energy consumption per unit of national product.

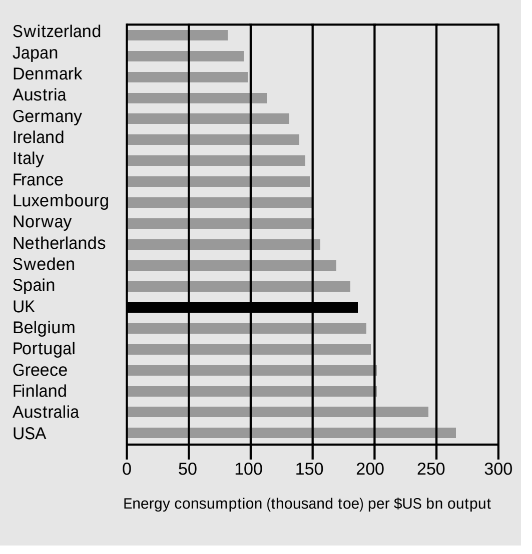
---

23 E.ON Netz, *Wind Report 2004*, 14.

24 Press Release, Thursday 4 December 2003. "ESB National Grid Calls for Wind Energy Moratorium Pending Resolution Of Power System Reliability Issues". Available from http://www.eirgrid.com.

25 For the grid code see: http://www.eirgrid.com/EirGridPortal/DesktopDefault.aspx?tabid=Wind&TreeLinkModID=1445&TreeLinkItemID=42

Energy intensity ration in 'top 20' OECD countries, 2000



Of particular note is the fact that both Germany and Japan are vastly more efficient than the UK, and therefore in one sense proportionately cleaner, **for the cleanest unit of energy is the one that is never produced or applied**.

It is of the greatest importance that steps are taken to improve our energy efficiency and so simultaneously and without conflict meet our energy goals and enhance our international competitiveness. The Renewable Energy Foundation supports the fundamental goals of DEFRA's *Energy Efficiency: The Government's Plan for Action* (Apr. 2004), which estimates that energy use could be reduced by about 30% across the economy as a whole, with carbon-dioxide savings of around 10 million tonnes.[26] However, DEFRA itself notes:

> Although huge opportunities exist to improve energy efficiency in a cost-effective way, they are not being taken up at the rate we need. Individuals and businesses could make financial savings by using energy more efficiently, yet they frequently do not do so despite measures being cost-effective. The key barriers to action are behavioural and organisational, such as lack of senior Board level commitment in large organisations; the landlord/tenant barrier in

26 DEFRA, *Energy Efficiency: The Government's Plan for Action* (Apr. 2004), 3.

> commercial property or the hassle-factor in private homes. Barriers such as lack of awareness of the most cost-effective options, or financial ones, such as the lack of up-front capital, are all aggravated by a relatively weak energy price incentive which, for most consumers, is a small element of overall expenditure. [27]

We find ourselves somewhat uncomfortable with parts of this diagnosis. The UK's businesses, are, arguably, acting rationally within their market context, and simply responding to the fact that they have more effective ways of maximising profit from their limited capital than through energy efficiency. Indeed, we believe that the last point, that there is domestically a "relatively weak energy price incentive", is of particular significance, and highlights the genuine difficulties of improving efficiency industrially. Energy costs are, proportionate to other costs, a small part of overall costs.[28]

However, it would be highly imprudent needlessly to increase our energy costs out of step with our competitors in order to drive down consumption. Maintenance of a high level of wealth in the UK economy is vital if we are to increase the speed at which the country can progress towards the very high technological levels necessary if we are to deliver meaningful progress towards a sustainable energy future. Artificial penalties for energy consumption may not be the best way to encourage efficiency, even assuming that they would have an effect.

While acknowledging the difficulties faced by the government in this regard, the Renewable Energy Foundation must observe that the policies in *Energy Efficiency: The Government's Plan for Action* are only faintly defined, and seem to enjoy weak financial support. Revisions to building regulations, public relations campaigns, and leadership from within the public sector, while entirely worthy, are unlikely to have dramatic consequences unless pursued with rigour. We further note that, in relation to commerce, current policy places a heavy reliance on the effects of the EU Emissions Trading Scheme, the consequences of which are at present unknown.

---

27 DEFRA, *Energy Efficiency: The Government's Plan for Action* (Apr. 2004), 3.

28 Nevertheless, "fuel poverty" is a serious issue. One possible means of meeting rising energy costs is to provide means tested support, not through cash safety nets, but by direct provision of energy. For example, there is a long term social support obligation in tower blocks, and this might encourage Government to put in local CHP where the free market would not venture.

The level of Government support being given to renewable energy has to be recovered within the economy directly or indirectly, and the cost of the Renewables Obligation on suppliers will be passed through to customers. The consumer will also bear the cost of increases passed on by other companies, especially the energy intensive industries such as water and sewerage, with a cumulative effect. In fact, the real cost of renewable electricity supply will be higher than that indicated by its advocates and apparently contemplated by current policy. The Royal Academy of Engineering (RAE) puts the cost of onshore wind at 5.4p/kWh including stand-by generation, and 7.2p/kWh for offshore.[29] These figures are almost certainly conservative, owing to the fact that the annual load factors assumed are themselves very generous (35%), whereas that achieved in 2003 in the UK was only 24.1% onshore.

Results in Germany (under 20%) and Denmark (around 20%) are not encouraging for UK prospects. Both of these countries have mature wind carpets and are therefore exposed to normal rates of mechanical failure and consequent outage, effects which have not yet begun to manifest themselves in the UK. If the full 10% target of electricity consumed is to be generated by renewables by 2010, the cost impact is certain to be very significant. It should also be noted that the RAE's figures do not reflect line loss from the enlarged system, or additional operating and maintenance costs incurred by the demands placed upon the fossil fired capacity used to support intermittent renewables.

A principal plank of current UK policy is the eradication of fuel poverty by 2016–2018.[30] It is not clear that this desirable end can be achieved in tandem with any of the other energy-related policy goals, both proximate and distal, without dedicated governmental intervention to shelter those in the fuel poverty trap. In fact, with an ageing population and a decline in pension funds, increases in electricity prices will inevitably exacerbate the conditions which lead to fuel poverty.

In summary, and putting aside the challenges of improving energy efficiency, straightforward routes to secure, reliable, and cheap energy are very hard to come by. This is particularly true of electricity generation where low variable costs may be married with high capital cost, as in nuclear generation (whose unit capital costs are equal to the best

29 Royal Academy of Engineering, *The Costs of Generating Electricity* (March 2004), p. 6.

30 White Paper, p. 3.

renewable technologies), or where low plant first cost may be conjoined with high running costs, as is the case with peaking gas turbines. **Similarly, distributed generation technologies, particularly of wind generation, require additional grid reinforcement and expansion which bring associated impacts often greater than the devices themselves.** The E.ON Netz *Wind Report 2004* notes that in Schleswig Holstein and Lower Saxony alone E.ON is facing the need for a further 300 km of high and extra-high voltage cabling for the express purpose of accommodating wind powered generators. The cost is estimated at €190 million (£130 million). Germany as a whole is estimated to require some 1,500 km of new cabling for the same purpose.[31]

Even a brief survey of the grid balancing and reinforcing costs reminds us that **in the economics of power it is rarely possible to do just one thing.**

Emissions Abatement

There is widespread public agreement that climate change is in some part anthropogenic and that consequently the UK should take a leading role in reducing the emissions of CO_2 and other greenhouse gases. The Prime Minister has recently endorsed this view in a major Climate Change speech.[32] The Renewable Energy Foundation accepts that it is desirable to reduce emissions of all kinds from the United Kingdom energy generation and utilisation processes.

However, the *White Paper* makes this goal the principal governing aim of the overall energy policy. It is the belief of the Renewable Energy Foundation that by doing so **the policy may in fact drive the UK into a course which is significantly less likely to achieve lasting and stable emissions reductions** than one which prioritises security, reliability, and cost-effectiveness of supply.

From an economic perspective we might note that **if the finite ability of the nation's energy system to bear cost is skewed towards renewables, the necessary capital to secure the best technologies for the inevitable fossil component in any realistic mix will not be forthcoming, so that the fossils will be burnt dirtily and wastefully in older**

31 *Wind Report 2004*, p. 11.

32 14 September 2004: http://www.number-10.gov.uk/output/Page6333.asp

equipment. Indeed, this has actually happened in the last four years, when some of the new Combined Cycle Gas Turbines have been mothballed and older coal stations operated. Still more strikingly peaking gas turbines have been employed in preference to the rapid-response hydro station at Dinorwic.

The fundamental issue here is one already touched upon in our preface, namely energy quality. The principal recommendation for most renewable energy technologies is their potential for providing energy which has a positive emissions balance. While some emissions may be involved in the construction of plant, their overall energy generation displaces vastly more polluting energy elsewhere in the system. **In other words, the value of renewable energy lies in its effect on the rest of the system.**

It is therefore essential that the renewables proposed should have the appropriate qualities to produce this desired and positive effect. However, **a naive quantitative approach to renewables will not necessarily optimise these effects, and may in fact be damaging to the emissions profile of the overall system**.

The central issue to grasp in evaluating renewable technologies in regard to emissions abatement is predictability. While bio-mass and land-fill gas stations can produce power on demand, renewable electricity generation is typically characterised by intermittency, and in some cases, wind for example, by random intermittency. The significance of this is that the addition of such generation to a system does not legitimise a calculation of emissions saving on a simple assumption that a renewable kWh replaces a conventional kWh. In a report commissioned by the Renewable Energy Foundation David White of the Institution of Chemical Engineers summarises this point:

> Policy makers appear to have only a weak grasp of the fact that electricity differs from other forms of energy. It cannot be stored directly, so supply and demand have to be balanced continuously second by second. The accommodation of variable output from wind turbines into the transmission/distribution system is complex and the technical challenges are not fully appreciated outside professional circles. Fossil-fuelled capacity is constantly required to accompany wind generation and stabilise supplies to the consumer. That capacity is placed under particular strains in the backup role, and thus generates more CO_2 than assumed by Government advisors. It is essential to examine the emissions savings from the complete electricity generating system not from theoretical assumptions about kWh replaced. Current

policy is framed as if CO_2 emissions savings are guaranteed by introducing wind and have no concomitant difficulties or costs. This is not the case.[33]

We can see, therefore, that a simple-minded endorsement of renewable technologies because of their prima facie value as low emitting energy generators has a high probability of producing less than satisfactory results in terms of CO_2 abatement. Further, it may well compromise the reliability of the electricity supply and cause needless rises in costs. It is clear that such a scenario will not result in a stable and long term emissions reducing generation portfolio.

Since stable and long term results are the only ones worth having, it is, or should be, obvious that emissions abatement must wait on satisfactory solutions to problems in security of supply, reliability, and economy. This apparent subordination of a major goal may appear paradoxical at first, but on reflection it will be seen to be nothing more than prudent engineering. In building a house the point may be to get a roof over your head, but it is more durable and sustainable to prepare foundations and supporting walls first.

Sustainability

Sustainable development is most widely understood as a development that serves the needs of the present without impairing the ability of future generations to serve their own needs. Whether such a state of affairs is realisable in perfection in the short or medium term we will leave aside, and pragmatically adopt the principle as a relative guide for current action. Developments may do more or less to serve the needs of the present, and do more or less damage to the prospects of future generations. A balance must be struck.

As has been very prominently pointed out by the President of the Institute of Chemical Engineers, climate change policy is a *subset* of sustainability.[34] The Renewable Energy Foundation agrees, and notes that while an energy policy may produce emissions reductions, and therefore mitigate climate change, it may be unsustainable in other ways. Even

---

33 David White, FIChemE., *Reduction in carbon dioxide emissions: Estimating the potential contribution from wind-power*, October 2004. Report for the Renewable Energy Foundation. Available from http://www.ref.org.uk.

34 Dr Robin Batterham, Inaugural Address, IchemE Annual Assembly, 7 May 2004. Report and mpeg video available on http://www.icheme.org.uk.

if a technology brings about emissions reduction, this is not in itself sufficient to qualify the technology as sustainable.

We argue that in order to achieve a balance between serving present needs and protecting future prospects due regard must be had to the sequence of qualities which we have been examining. In consequence, if renewables are to realise their potential as contributors to a sustainable future it is not sufficient merely to point to their emissions abatement benefits. It must also be shown that they have no deleterious effect on security of supply, industrial competitiveness, and capital investment in our energy systems.

For, while secure in themselves, certain renewables may have negative effects on the rest of the energy mix. The technologies must also be shown to be reliable, and to have no negative effects on the reliability of their running mates. Thirdly, they must be shown to be **competitive in regard to alternatives which also offer security and reduced emissions abatement**.

In aggregate these requirements, if met, will lead to a society characterised by stability and prosperity, features which are pre-requisites for the development of the higher technological solutions to our needs, and offer the only practical hope of a genuinely sustainable future in which prosperity and justice advance together.

That is to say, an energy supply that is harmoniously secure, reliable, economic, and clean will produce a positive feed-back mechanism, and so facilitate the provision of an energy supply that is still more satisfactory. On the other hand, failure to achieve such a balanced energy provision can only lead to negative feedback, with damaging consequences for the economy and society of the United Kingdom as a whole.

Ends and Means: Implications for a Strategy for Renewables

We have argued that the correct prioritisation of the features required of an energy system is crucial to the success of the policy designed to deliver this system. A key principle emerges from our reasoning. Namely, that, like all other energy generation methods, **renewables are means to an end**.

Therefore, policy designed to encourage renewable energy should recognise that it is necessary to discriminate between renewable technologies in a sophisticated manner, with due regard to particular strengths and weaknesses. Much therefore depends on the character of the policy instruments employed, and of these the most important is the

Renewables Obligation (RO). As recently as the 14th of September, the Energy Minister, Mr Mike O'Brien MP, has confirmed its overwhelming significance: "The **Renewables** Obligation is the key policy mechanism by which the Government are encouraging the growth necessary to reach the UK's **renewable** energy targets."[35] Bearing this in mind it is regrettable that the RO, in common with the rest of the current energy policy, is not only narrowly focused on electricity generation, but makes no distinctions of quality between technologies beyond those features which are implied in the short term interests of developers, entities which, by definition in the field of long lived infrastructure, will not exist after the first deployment of their devices.

To put this aphoristically, **the Renewables Obligation is a simplistic policy with complex and undesirable consequences.**

The Renewable Energy Foundation has submitted a commentary on the system as part of the DTI's current Renewables Obligation Order 2005 Statutory Consultation, and we will here quote from that text. We note that the RO rewards:

- Any and all qualified MWh irrespective of **when** these are supplied or **whether** they supply any firm capacity.
- Only least cost, nearest market, technical solutions, with the consequence that **only** these have been financed.
- Developers of any qualified renewable energy capacity, irrespective of their overall success in meeting the Government's targets. When a shortfall in the statutory supply takes place the penalty paid by the electricity suppliers is entirely transferred to the energy consumers and remains fixed, so that each qualifying MWh has a higher monetary value, simply as a result of the shortfall in supply.[36]

In summary, the RO is a quantitatively oriented policy instrument operating in an area where only a **quality** oriented policy can produce desirable results. We do not believe that this was the way that the Government intended the legislation to work. In the following section we will comment in further detail on this matter, which is fundamentally one of the

---

35 Mr Mike O'Brien in reply to a question from Mr Austin Mitchell MP, 14.09.04. Available online: http://www.publications.parliament.uk/pa/cm200304/cmhansrd/cm040914/text/40914w10.htm

36 Renewable Energy Foundation and Incoteco, *2005–2006 Review of the Renewables Obligation* (28 Oct. 2004). Submitted to the DTI, and available from http://www.ref.org.uk.

“opportunity cost” of an inappropriate choice of renewable, highlighting the quality disadvantages of the most prominent technology of the day, wind-power, and contrasting it with those of predictably intermittent technology, tidal energy.

Furthermore, we note that **by concentrating on electricity generation current policy may not be playing to the strengths of renewables**, most of which are characterised by qualities unsuited at present to electricity generation.

2. Quality Considerations in Promoting Renewables

There is now a growing body of data available concerning renewably generated electrical power, analysis of which provides a very clear example of the potential and limitations of randomly intermittent generators. **Indeed, the quality issues to which the Renewable Energy Foundation is drawing attention are nowhere clearer than in the case of wind, and the contrasts with predictable though intermittent renewables such as tidal-based generators are extremely sharp.**

In discussing this matter we will concentrate, for convenience, on the two reports to which we have already referred. Namely, the recent E.ON Netz *Wind Report 2004*, and the detailed study of West Denmark's experience in managing a large wind carpet carried out for the Renewable Energy Foundation by the independent consultant Hugh Sharman.

Germany has over 14,000 MW of wind capacity, half of Europe's installed wind-power, and is the world's leading wind-power user. This wind carpet is approximately 11% of the total installed capacity.[37] However, this substantial capacity generates only 18.6 TWh per year, less than 4% of Germany's total consumption.[38]

E.ON Netz GmbH is responsible for the electricity transport grid of the E.ON Group in Germany. It oversees 32,500 kilometres of high-voltage and extra-high voltage lines in Germany, covering approximately one third of the country, and is one of the largest electricity grid operators in Europe. In the UK, E.ON Group owns Powergen.

Within E.ON Netz's control area there is 6,250 MW of wind power, which makes it one of the world's most experienced companies in regard to the difficulties of integrating a randomly intermittent power source, such as wind generated electricity, into a stable grid.[39] The UK government expects three quarters of its 2010 target to be met by wind power, which, according to its own expectation, requires approximately 7,500 MW of

---

37 In 2000 the installed capacity was 116 GW. See Felix Müsgens, "Market Power in the German Wholesale Electricity Market". EWI Working Paper, Nr 04.03, May 2004, published by the Energiewirtschaftliches Institut an der Universität zu Köln. Available from: http://www.uni-koeln.de/wiso-fak/energie/Veroeffentlichungen/pdf/Ewiwp043.pdf. However, substantial additions have been made since then, both in wind power and also in coal generation.

38 *Wind Report*, p. 4.

39 See *Wind Report*, p. 15 for further details.

installed capacity. Thus, E.ON Netz at present administers a “wind carpet” almost as large as that projected for the UK in 2010, and its experience is highly relevant.

Indeed, E.ON Netz knows more than any other institution in the world about the significant operational challenges posed by introducing wind power to the grid, and its report makes the following main points, all of which bear on the quality issues we are here examining:

- The wind is generally too weak to generate much power. The load factor was under 20%.[40] Consequently wind cannot significantly reduce the need for conventional generation.[41] In other words, wind is a supplementary generator.
- Wind power is only as reliable as the weather forecast, and standby generation to the level of over 60% of the installed capacity of the active wind-power is needed to provide instantaneous support when the forecast is in error. This is costly, and itself carries an environmental burden.[42]
- Fluctuations in output are large, even in a large and widely distributed wind carpet. (All of these points confirm data from Denmark, an area roughly the same size as Scotland, where in spite of a large number of distributed turbines the “smoothing effect” is still disappointing, as is shown in the output chart reproduced above. Whether the smoothing effect would be superior in the UK is very much open to question, particularly since the much referred to higher wind speeds of the North West of Scotland may cause difficulties of their own; wind turbines must shut down in wind speeds of over 25 m/s, and such events are likely to be more common than

---

40 *Wind Report*, p. 4, where the total installed capacities and generation figures are given, permitting calculation of rough figures. Load Factor (sometimes called Capacity Factor) is the proportion of theoretical maximum output realisable under normal working conditions. Conventional power stations are limited by scheduled maintenance, and accident. Renewables dependent on natural occurring sources of energy are also limited by the extent of occurrence of those sources. In the case of wind power, simply put, they are limited by the strength and duration at which wind can blow. It is notable that the value of wind-power’s contribution is both capped by being unavailable in very strong winds due to the need for plant survival, and collared by being unavailable during light winds. Strong wind capping (at wind-speeds of over 25 m/s, will unfortunately be correlated with high heating demand due to wind chill and rapid air exchange in the UK’s sub-standard housing stock.

41 *Wind Report*, p. 7.

42 *Wind Report*, p. 8–9.

they have been in Europe, posing interesting questions as to how thermal generating plant will respond to the sudden shortfall.)

- The weather conditions causing peak demand, i.e. very cold and very hot temperature, are strongly associated with stable high pressure systems during which there is little or no wind. [43]
- Wind power requires much more high and extra-high voltage grid network to accommodate wind (1,800 km in Germany as a whole).[44]
- Wind power has previously been allowed to destabilise the grid, but must now become a responsible generator.[45]

The last two of these issues have, for present purposes, been adequately treated above, but the first two require further elaboration, and we will here expand on these topics under the headings of Firm Generation and Reliability.

Firm Generation

"Firm generation" is generation which has a very high degree of predictability, and as such can be relied upon in planning the dependable generation capacity which is to meet the minute by minute demand placed upon a grid.

E.ON reveals that even a very large wind carpet can provide only marginal "firm generation",[46] and states unequivocally:

> The characteristics of wind make it necessary for [...] "shadow power stations" to be available to an extent sufficient to cover over 80% of the installed wind energy capacity. This means that due to their limited availability, wind power plants cannot replace the usual power station capacities to a significant degree, but can basically only save on fuel.[47]

Put another way, wind power requires support from firm sources, and conventional generation cannot be replaced with wind on a MW for MW basis. Indeed, according to

43 *Wind Report*, p. 6.

44 *Wind Report*, p. 11.

45 *Wind Report*, p. 14.

46 *Wind Report*, p. 3.

47 *Wind Report*, p. 7.

E.ON's figures, for every 100 MW of wind it is only possible to reduce conventional generation capacity by less than 20 MW. This is a very poor result, but is entirely in keeping with the predictions of the Royal Academy of Engineering, which has observed that for 22,000 MW of wind there would have to be 16–19,000 MW, i.e. 72%–86%, of thermal plant in reserve for windless days.[48] In fact, since the UK's grid is effectively an island system, whereas the German grid is heavily interconnected, both within its national borders and with its continental neighbours, E.ON's results suggest that the actual requirement in the UK may be towards the upper end of the RAE's predictions.

The relevance for the UK case may be appreciated by bearing in mind the fact that by 2020 70 to 80% of the "firm" generation capacity that provides a high degree of reliability in the UK today will be or should be retired. **Randomly intermittent sources will not be able to fill this gap, because they themselves need support.**

E.ON illustrates the lack of firm contribution from wind turbines by noting that although the wind power infeed varies greatly there is in fact very little wind of great strength. In the E.ON area the wind turbines never achieved more than 80% of their theoretical maximum,[49] and the average power infeed was only approximately 16% of the theoretical maximum. Perhaps most strikingly of all they note that for half of the year the wind power feed-in was less than 11% of its theoretical maximum.[50]

Putting this matter into concrete terms may clarify the matter. Peak demand in the E.ON area is 19,000 MW (winter), and 18,000 MW (summer).[51] The 6,250 MW of wind in the E.ON area is theoretically capable of meeting 33% of demand, but in fact for half of the year it contributed only 3.6%.

The following chart compresses this data into a simple graph. The power for every quarter hour in a year is determined, and then these are arrayed in order of magnitude,

48 "Memorandum by the Royal Academy of Engineering", House of Lords, Science and Technology Committee, 4th Report of Session 2003-04, *Renewable Energy: Practicalities*, Volume II: *Evidence* (London: The Stationery Office Limited, 2004), p. 323.

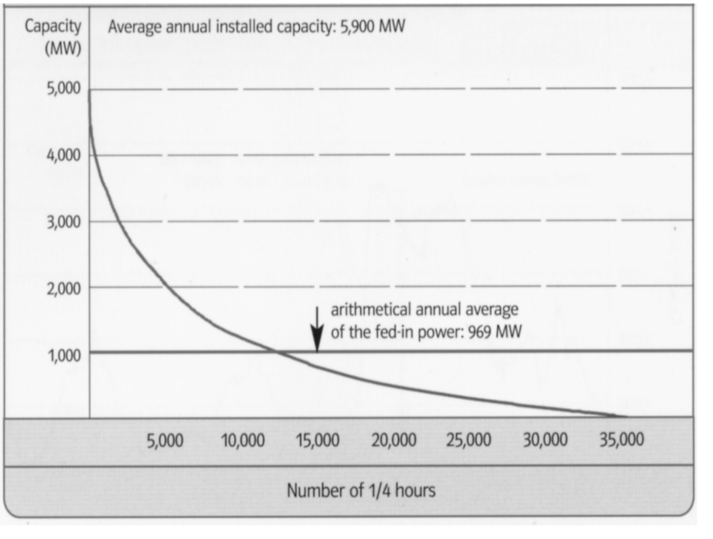
49 *Wind Report*, p. 5.

50 *Wind Report*, p. 5.

51 Information from Dr Thorsten Schneiders, Advisor on Public Affairs, E.ON Energie AG, "Integrating renewables in to the supply system - challenges and limits", presented to the 6th Annual Energy Finance Forum, 2004.

largest first. The *y* axis represents power output in MW, and the *x* axis the number of quarter hours, from 0 to 35,040. Thus, to determine how many hours the wind carpet was producing less than 1,000 MW (approximately 16% of its theoretical maximum) we can see where the chart line crosses the 1,000 MW line, and then read 12,500 quarter hours off the *x* axis. Or to put this the other way round, for the remaining 22,500 quarter hours it was producing less than 16% of its theoretical maximum.

Annual curve wind power infeed 2003 in the E.ON control area [52]

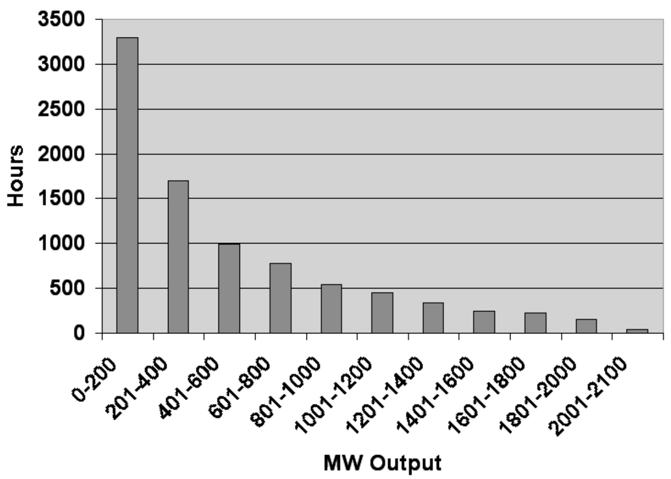


These figures are powerful illustrations of the weakness of wind generation, and the implications for the UK are considerable. The same results have been obtained in Denmark, as can be seen in the following chart, which represents the same class of data in a slightly different and more readily understood way. The horizontal axis indicates ranges of electrical output in MW. The vertical axis represents the number of hours for which the Danish turbines were producing the relevant power output. So, for approximately 3,300 hours of the year's 8760 hours the Danish wind carpet was producing between 0 and 200 MW, or less than 10% of its theoretical maximum. It can be seen from this chart that for

52 *Wind Power,* fig. 3, p. 5.

some 70% of the time the wind carpet produced less than 25% of its theoretical maximum.[53]

West Denmark Wind Carpet Output: 2003 (2,374 MW Installed Capacity)



It has already been noted that we can calculate the achieved Load Factor for the wind turbines in the E.ON Netz region as under 20%. UK policy is based on assumptions of 30% load factor onshore and 35% offshore, which now appear to be highly optimistic. While it is reasonable to think that the UK may have somewhat superior winds, bland assurances that the UK has a large part of the European wind resource are in reality of little comfort, since the fact is that in 2003 the UK's onshore turbines achieved a load factor of only 24.1%, which is unsurprising in the light of Danish and German experiences. It should be remembered that the UK's current turbines are, by and large, located in the most favourable positions available and not yet troubled by issues of wear and tear.

It should also be noted that until very recently the Load Factor data published in the DTI's *Digest of United Kingdom Energy Statistics* was derived from wind operator estimates, but the 2003 data was derived from actual, verified, output,[54] and is therefore a sound predictor of future performance.

53 Danish wind output data is publicly accessible in Denmark from Eltra. The data charted here has been made available to REF by the consultant Hugh Sharman.

54 Information from Ofgem.

In addition to these concerns we must refer back to the earlier sections in which we observed that while wind output is on average very low, it is not consistently low, and this inconsistency in itself presents a serious problem.

Most importantly of all from the point of grid stability, the demand peaks resulting from extreme weather in both winter and summer tend to coincide with periods of low wind:

> Both cold wintry periods and periods of summer heat are attributable to stable high-pressure weather systems. Low levels are meteorologically symptomatic of such high-pressure weather systems. This means that in these periods, the contribution made by wind energy plants to covering electricity consumption is correspondingly low.[55]

In other words, when E.ON Netz's customers really needed power, for example during the heat-wave of July/Aug. 2003, wind-power could not supply it. This confirms remarks made by other analysts, particularly the observations of Professor M. A. Laughton in a *Platts Power* article in 2002.[56] That they apply with force to the UK cannot be doubted. As Laughton remarks in another statement:

> Large weather systems, particularly high-pressure windless systems, can cover most of the country, as seen during the January 2003 cold spell for several days and again during the subsequent July heat wave. At such times the contributions from any wind and wave generation are severely curtailed.[57]

Predictability

E.ON has invested heavily in weather forecasting, but significant errors are still common. In 2003 the error range was +/–2,900 MW, just under half the capacity of the installed wind power.[58] As a consequence, E.ON has found it necessary to have 50–60% of the installed

55 *Wind Report*, p. 6.

56 M. A. Laughton, "Renewables and the UK Electricity Grid supply infrastructure", *Platts Power in Europe*, No. 383 (9 September 2002), pp 9–11.

57 M. A. Laughton, *Power To The People Future-proofing the security of UK power supplies* (Adam Smith Institute: London, 2003), p. 25. Available from http://www.adamsmith.org/policy/publications/pdf-files/powerpeople.pdf.

58 *Wind Report*, p. 9.

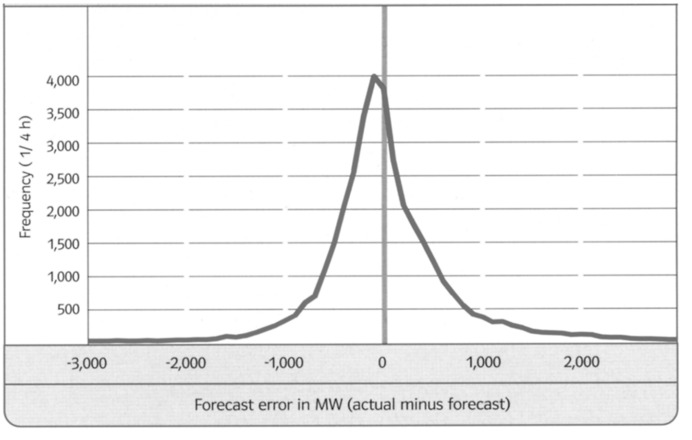
wind capacity on permanently available standby to cover sudden shortfalls.[59] Such standby generation is, in E.ON's words:

> power station capacities that can be brought onto or taken off load at short notice and which are reserved with the power station operators by the transmission system operators, for a fee, to be used for balancing out deviations between the actual and forecast wind power infeeds.[60]

In fact, managing these "uncontrollable fluctuations" in generation has required the commitment of considerable resources, "thereby increasing the demands placed on control and bringing rising grid costs".[61]

Weather forecasting is, unfortunately, not enough, and though E.ON has invested heavily in improved technologies, error is persistent and serious, as the following chart shows:

Frequency distribution of the forecast error for wind power infeed 2003 in the E.ON control area, 2003 [62]



The maximum forecast error (+/–2,900 MW) is, as E.ON emphasises, of "crucial importance", since the grid operator must be ready to deal with such errors, however

59 *Wind Report*, p. 3.

60 *Wind Report*, p. 9.

61 *Wind Report*, p. 8.

62 *Wind Report*, fig. 9, p. 9.

uncommon, to maintain a steady supply. In fact, E.ON not only notes in non-numerical terms the cost of maintaining 60% reserve standby generation, but also remarks that in the E.ON area alone new reserve capacity has had to be built *specifically* to provide standby generation for wind, at a cost of €100 million (£68.54 million).[63]

The unavoidable conclusion of these observations on firm generation and predictability is that **wind power is low value supplementary generation.** Very large, and very costly, installed capacities of such supplementary generators produce costly and unpredictable streams of power. While some fuel saving may be possible, substantial costs are entailed in providing conventional firm generation which can act in a support capacity for wind-power.

These findings are by no means unusual, but **we emphasise that they do not justify the total rejection of wind.** They mean, rather, that **we must be realistic as to the burden we place on such a generator.**

Denmark has often been cited as a leading light for the UK by industry interests suggesting heavy deployment of wind. However, as the trading chart reproduced above indicates, it has not been an outstanding success, and public enthusiasm for onshore wind has now waned. In a recent article in the *Jyllands Posten*, Denmark's largest daily newspaper, Bendt Bendtsen (Economy and Trade Minister) and Connie Hedegaard (Environment Minister) wrote encouragingly about future developments of offshore wind, but reassured readers that they recognised that wind turbines had an environmental impact and that even offshore there would be no unmeasured hurry.[64] The paper's editorial applauded the ministers' direction, adding that the "existing nightmare of obsolete land-based wind parks are ready for replacement" before closing with the words "Out with the turbines, out to sea, where they can be useful without doing harm."[65]

In the light of these European lessons it is quite unreasonable for the UK's policy to ask a low quality renewable such as wind power to make up the lion's share of the renewable target for 2010, some 7,500 MW. To create a market situation in which it will inevitably be

63 *Wind Report*, p. 9.

64 Bendt Bendtsen and Connie Hedegaard, "Vindmøller i vælten" (Wind turbines in fashion), *Jyllands Posten*, 21 September 2004.

65 Editorial, "Ud med møllerne" (Out with the turbines), *Jyllands Posten*, 22 Sept. 2004.

the lead technology up to 2020, resulting in one of the largest wind carpets ever built, 15.20 GW in size, in an island grid is, we believe, extremely unwise.

Indeed, one possible conclusion is that at present, with the exception of firm generating capacity such as biomass, land-fill gas, waste to power, and co-firing power stations aside, **the subsidisation of renewable electricity generation is premature.** Instead of forcing the pace of implementation of expensive monotechnologies at a rate which has more political than ecological logic, we might be better advised to develop choices which would be market-ready when the fuel shortage causes the fossil price to make renewables naturally competitive without subsidy.

That is to say, our future-oriented policy should be driven by the investigation of *high value* renewable electricity generation. In the short term we should be looking to other fields of renewable energy, for example bio-fuels for vehicles, and thermal solar for domestic and small-scale commercial use.

In fact, we may not have to wait long for predictably intermittent renewable energy systems capable of producing high value power. The example we will bring forward here is tidal generation, both in tidal stream and tidal barrage or lagoon forms. We will focus on the latter, because we believe it to be an extremely promising technology, richly suitable for the United Kingdom, but we do not intend to suggest that it is the only predictably intermittent renewable electricity generator suitable for consideration, or the only marine renewable. Tidal lagoons have obvious merits, but may shortly be in good company, particularly from sub-sea turbines operating in tidal streams. We describe it here as an illustration of the best kind of renewable for the UK.

The movement of water in tides is one of the most thoroughly understood of natural phenomena. Its force and timing can be predicted with remarkable accuracy far into the future. Consequently, as an energy source, it has very high value. Whether it is economically attractive requires complex analysis, but we can see immediately that it is manifestly secure, reliable, and clean.

On further consideration, because of its reliable nature, we can confirm that its security does not compromise any other aspect of the power system. Similarly, it is thoroughly reliable and therefore its emissions saving potential is high, owing to the fact that it is firm generation and can be planned into the diurnal schedule, even though its generation peaks vary and will not be perfectly timed to meet peak demand. Predictability, in this case, goes some way to compensate for the technology's limited capacity for following load. It is also intrinsic in what is essentially a hydro system that an element of pumped storage can be included so that excess energy from non-firm sources can be absorbed and released controllably in time of need thus reducing the plant and fuel use of fossil fuelled peaking plants.[66]

The relative merits of various tidal technologies are at present being investigated by various companies, and it would be improper to single out any particular method at this stage, but overall it is reasonable to note that **tidal-based renewables, lagoons and sub-sea turbines for example, give all the appearances of being *firm* renewables.**

Discriminating between Firm and Non-firm Renewables

The Renewable Energy Foundation believes that the greatest single flaw in current renewable energy policy is the failure to offer any degree of favourably differential reward to firm renewable generators.

Consequently, the long-term trend encouraged by present policy is towards destabilisation of the overall electricity system, higher costs, and higher prices. This is needless and in our consultation submission to the DTI we have suggested that the Renewables Obligation should be enhanced to encourage firm generation.[67] Our proposals include the following:

i. Limit the number of ROCS available for randomly intermittent capacity

To avoid needlessly running into the problems documented by *EON Netz*, research must be commissioned on the ability of the UK system to absorb randomly intermittent power, without excessively wasteful and expensive balancing operations by fossil plant. Beyond this calculated limit, no stochastically intermittent generating capacity should be accredited for the issue of ROCs. This limit would only be lifted if the generator can ensure,

66 For a helpful overview of the subject see the New and Renewable Energy Centre website. http://www.narec.co.uk/technologies-wave-tidal.php.

67 For the full statement see, Renewable Energy Foundation and Incoteco, *2005–2006 Review of the Renewables Obligation* (28 Oct. 2004). Submitted to the DTI, and available from http://www.ref.org.uk.

through energy storage or by some other technical solution, that the power can be delivered according to demand, in a market-friendly and predictable manner.

ii. Introduce two new classes of "firm" ROC

We propose that all renewable generation systems that are able to provide firm capacity, should be rewarded by a "firm" ROC (fROC).

Of even greater value would be renewable capacity that is not intermittent at all. Hydro-power falls into this category, when rainfall and sound management allow, and we recommend that it should be included in the RO system both for its own sake and also to establish a benchmark of quality.

Such power has a comparable "quality" to that from fossil plant. In its nature, it is likely to be more expensive than either intermittent power sources, and it is right that the ROCs needed to finance such capacity should reflect this premium aspect.

We propose to dub this type of ROC the Premium ROC, or pROC, and recommend its consideration and early adoption.

The value of both of these "quality" ROCs can be enhanced either by a separate component for fRocs and pROCs, with a higher buy-out price, *or* by requiring that a percentage of the RO be met by any combination of fROCs, pROCs, where 1 ROC = an appropriate fraction of an fROC and a smaller fraction of a pROC.

3. Renewable Energy: A Balanced Approach

We have so far argued that in designing a renewable energy policy the goals should be sequentially addressed and should **play to the strengths of currently available renewables,** and **avoid forcing over-development in the field of electricity generation.** Current policy is unsatisfactory in both regards, with the result that the broad-scale development of low quality electricity generating renewables has been encouraged to a degree that is greatly out of proportion to their merits and to any contribution they can make. Policy must recognise qualitative differentials between technologies, and the degree to which low quality renewables indirectly compromise security of supply, and have direct negative consequences for reliability and on the economy.

We will now expand on the fact that over-emphasis of randomly intermittent renewables for electricity generation narrows the scope for emissions saving. We believe that **current policy passes over issues of power quality and encourages the over-investment of national resources in emissions abatement strategies that are significantly less effective than the alternatives.**

Emissions Reduction: The Need for Broad Scope

Since the emissions abatement effect of renewable energy generation lies at the heart of the White Paper's argument, it is surprising that there is in fact so much uncertainty about the extent of this saving in relation to wind turbine power stations. While it is true that developers will make claims of the order of "up to 72,322 tonnes of CO_2" per year, implying a saving of 0.86 tonnes per MWh, or a similarly high figure, this is very far from being based in any wide consensus.[68] 0.86 tonnes per MWh is, indeed, an emissions factor cited by the British Wind Energy Association,[69] and grounded in the assumption that the conventional generation displaced by the UK's turbines is high-emitting coal generation. However, other figures are provided by authoritative governmental organisations, and reasoned analysis leads to still other assessments.

68 This quotation is taken from actual prospectus (reference withheld, but available on request), and the emissions factor calculated from other data in the publication.

69 http://www.bwea.com/edu/calcs.html

In point of fact, it is notoriously uncertain as to what generation would be displaced by wind turbines or any randomly intermittent generator. The DTI's *Wind Energy Fact Sheet 14: Energy and Performance* (DTI: Aug. 2001), p. 4, states, very wisely:

> […] the emissions avoided when a wind farm operates depend on what type of power plant wind displaces and the operating emissions of that power plant. Reductions in emissions will be greatest if wind displaces coal, significantly less if it displaces gas or nuclear. The UK electricity market is extremely complex, particularly under the New Electricity Trading Arrangements (introduced March 2001), and it is not possible to make categorical statements on how wind changes the generation mix.[70]

This is incontrovertible, and, consequently, it would be much more reliable when discussing annual CO_2 emission savings from randomly intermittent generation to use a grid average emissions figure, rather than one typical for coal.

Such an up-to-date average can be found in DEFRA's recent *Guidelines for the Measurement and Reporting of Emissions by Direct Participants in the UK Emissions Trading Scheme* (June 2003), Protocol A1 of which gives (p. 20) a figure of 0.43kg CO_2 per kWh, i.e. 0.43 tonnes per MWh. We also note that the use of a grid average is the method recommended by the Carbon Trust website in a worked example showing how to calculate the emissions saved by a renewable energy project. Further confirmation, if it is required, can be found in the fact that Ofgem recommend the use of a grid average figure of 0.43kg per kWh (i.e. 0.43 tonnes per MWh) when converting Renewable Obligation Certificates to Emissions Trading Scheme credits.[71]

In fact, because of the need for fossil reserve capacity to cover for unexpected shortfalls in wind generation, there are further doubts over even the 0.43 emissions factor recommended by DEFRA, DTI, Carbon Trust and Ofgem, and these arguments are ongoing in technical engineering circles.

Optimistic misrepresentation of the likely CO_2 abatement effect consequent on randomly intermittent generation is so pervasive in industry literature that the Renewable Energy Foundation believes that current government policy may be based on a serious

70 http://www.dti.gov.uk/energy/renewables/publications/pdfs/windfs14.pdf

71 See Ofgem, *ROC Register End user guide* (July 2003 Version 2.0), p. 7.

misapprehension as to the complexity of the emissions abatement effect of a randomly intermittent renewable. Consequently, the Foundation has commissioned research from David White of the Institution of Chemical Engineers to review the state of global engineering opinion with regard to this matter.[72] His conclusions are summarised here:

- The accommodation of variable, wind generated, power into the transmission/distribution system is complex and the technical difficulties are not well understood, even within technical circles.
- Current policy is framed as if CO_2 emissions savings are guaranteed by the introduction of wind and have no concomitant difficulties or costs. This is not the case.
- Fossil-fuelled capacity is constantly required to accompany wind generation and stabilise supplies to the consumer. Because that plant is called upon unpredictably it operates inefficiently, and so generates more CO_2 than is assumed by Government advisors. It is essential to examine the emissions savings from the complete electricity generating system, rather than basing these calculations on narrow and theoretical assumptions about kWh replaced.
- Forecast CO_2 savings from the DTI, DEFRA and other bodies differ considerably. DEFRA's fixed figure cannot be reconciled with the DTI's recognition that fuel type and generating technology play a key role in the level of emissions.
- No single "emissions factor" figure can represent the dynamics of back-up supplies to yield the CO_2 saving. Variation in achieved saving will vary considerably from situation to situation.
- In practice, the introduction of wind-generated power creates a variable inefficiency in the conventional plant that must be operated in parallel. Hence, even the DTI figures overstate the savings because of the frequency of start-up and shut-down of conventional plant in absorbing the wind production while matching demand.
- The statements made about wind being a CO_2 free replacement for 100% of fossil fuels are not correct. Evidence from the UK, Ireland, Germany, Denmark and the USA proves the point.

72 David White, FIChemE, *Reduction in carbon dioxide emissions: Estimating the potential contribution from wind-power*, (Dec. 2004), a report for the Renewable Energy Foundation. Copies of the report are available from the Renewable Energy Foundation, and may be downloaded from http://www.ref.org.uk.

- There are cheaper and more certain methods of reducing CO_2 emissions and it is almost certainly wiser to place more reliance upon those, and less upon wind. A greater reduction in CO_2 could be achieved by building CCGT at much lower cost. As natural gas prices rise, coal could be converted into gas with CO_2 capture at a competitive cost. Combined Heat and Power, and other energy efficiency measures, offer yet other options for economical emissions abatement.
- The encouragement of renewable energy enjoys general public support, and the New and Renewable Energy Centre was established to evaluate a range of options. However, before NaREC has had an opportunity to begin its work or provide feedback, the Government has launched into a massive wind programme. However, low annual load factor and high capital cost makes it an expensive way to generate power and reduce CO_2 emissions.

The Renewable Energy Foundation notes with considerable concern that a major programme of low quality renewable energy generation should have been allowed to emerge in response to policy without any clear understanding of the likely emissions abatement effect, or of whether this effect or greater savings could be achieved via more economical routes.

We are particularly concerned that:

- High value, firm, electricity generating renewables have been marginalised.
- Opportunities for increases in efficiency, via Combined Heat and Power, and other techniques, have been neglected, even though they are highly attractive as carbon-dioxide abatement techniques.
- Carbon abatement via other non-electricity generating renewables such as bio-fuels for transport, have been regarded as of interest only in the medium term, when in fact rational consideration shows them to be potentially of current significance. Germany currently produces 2.8% of its diesel from biomass sources, and this figure is growing.[73]

---

73 Reported in a meeting with Barbel Hohn, Environment Minister of North Rhine Westphalia, hosted by the Corporation of London, 19th October 2004.

- Carbon dioxide capture and sequestration, particularly for Enhanced Oil Recovery, has been treated as a futuristic option, when in fact it is currently viable.[74]

In summary, we find ourselves in agreement with the ESB, the Irish grid operator, whose recent report concludes with the following sentences:

> It can be estimated that, in the long term, using WPG [wind power generation] to comply with the EU target will increase electricity generation costs by 15% (€196m as a percentage of €1.28bn). This translates to a CO_2 abatement cost in excess of €120/tonne. The cost of CO_2 abatement arising from using large levels of wind energy penetration appears high relative to other alternatives.[75]

We note also that even this may be an optimistic scenario. In a recent technical article in *UK Power*, Bass and Wilmot examined the macro-level knock-on effect of large-scale use of wind as a means of emissions abatement, though without noting any of the reductions in efficiency touched upon by David White. Even with these somewhat favourable premises, Bass and Wilmot concluded that far from reducing emissions "the current 'Dash For Wind' could actually make the situation worse".[76]

While the Renewable Energy Foundation recognises, and hopes, that the configuration of circumstances that Bass and Wilmot present in their nightmare scenario is unlikely, we recognise that their findings are indicative of the instability of the CO_2 abatement achievable through a non-firm renewable electricity generator, a basic conclusion which is forcefully presented in David White's report. In fact there is now a growing consensus of doubt as to the merit and cost-effectiveness of randomly intermittent generation as a means to emissions abatement, and we note as being particularly revealing the authoritative

---

74 For further details see REF's response to the DTI's Carbon Abatement Technologies consultation: Renewable Energy Foundation, (28 Oct. 2004), submitted to the DTI, and available from http://www.ref.org.uk/images/pdfs/REF_Carbon_Abatement.pdf.

75 ESB National Grid, *Impact of Wind Power Generation in Ireland on the Operation of Conventional Plant and the Economic Implications* (ESB National Grid, Feb. 2004). Available from: http://www.eirgrid.com/EirGridPortal/DesktopDefault.aspx?tabid=Wind&TreeLinkModID=1445&TreeLinkItemID=42

76 Robert J Bass and Dr Peter Wilmot, "Wind Power may not be the answer", *UK Power*, 2 (2004).

remarks of the Council of European Energy Regulators in their recent analysis of renewable energy support schemes.[77]

Co-operating with Fossil-fuels

In the light of the remarks of White, Bass and Wilmot, CEER, ESB and many others, we conclude that the contrived conflict between renewables and fossil generators must be abandoned. **Even high quality renewables must, at least for the foreseeable future, work in conjunction with firm generation from fossil fuels.** It is therefore imperative that we take a constructive attitude to this reality.

The general public and many decision makers have been misled into believing that renewable sources, particularly wind, can displace conventional generation on the grand scale and in the short and medium term.

The reality is that low quality renewable technologies cannot provide any substantial replacement of conventional generation, and without careful control and management may have a detrimental effect on the efficiency of fossil plant, with ecological and economic consequences. High quality renewables, tidal for example, have more to offer, and make acceptable running-mates for the fossil generators of the short and medium term.

77 Council Of European Energy Regulators (CEER), *Current Experience With Renewable Support Schemes In Europe* (2004), pp. 57, 59.

4. Responsible Renewables

In many of the comments above we have found it necessary to speak with some severity about the over-marketing of randomly intermittent renewable generation. However, we wish at this concluding stage to emphasise that wind, and other non-firm electricity generating renewables, will have a role. The point we have tried to make is that the **current policy is over-focused on electricity generation, and fails to provide proper guidance for evaluating each renewable energy technology in proportion to its merits**, with the result that **low-value renewables are being encouraged where only high value renewables can succeed**. A more appropriate balance of technologies must be found.

We conclude that a review of the current policy is necessary, to ensure that future renewable development is diverse and not over-committed to one energy use, or to one technology.

In regard to electricity generation we conclude that policy changes are necessary to ensure that the renewable technologies encouraged:

- Enhance rather than degrade security of supply
- Are reliable in themselves, and do not degrade the reliability of the existing power generation plant
- Are economical in themselves, and do not cause the consequential costs to rise beyond reason in the grid and for existing firm plant
- Are capable of contributing in certainly quantifiable terms towards emissions reduction without causing increased inefficiencies and thus increased emissions elsewhere in the power portfolio. In other words, the net emissions saving should be demonstrable and quantifiable beyond reasonable doubt
- Are truly sustainable

In summary, we suggest the simple, all-encompassing, principle that **responsible renewable development will be characterised by the encouragement of *high quality* renewable technologies**.

Renewable Energy Foundation, Beaumont House, Kensington Village, Avonmore Road, London W14 8TS
Telephone: 020 7605 1100 Fax: 020 7605 1101 Web: www.ref.org.uk