PIU Energy Review

RENEWABLE ENERGY - FURTHER NOTE

Reference: Renewable Energy - Further Note
Date: August 2001

1. PURPOSE OF THIS NOTE AND WAY FORWARD

1.1 This note sets out work in progress on the prospects and potential for the development of renewable energy in the short (2010), medium (2020) and very long term (2050). Key issues and uncertainties for future development are explored, particularly with regard to cost trends and technical challenges.

1.2 The PIU Resource Productivity and Renewable Energy Team have been working on issues connected to renewable energy since January 2001 and this note reflects work that has been progressed by this team. This work has now been merged into the Energy Review Team.

Readers should not assume that the PIU has in any respect closed its mind. Questions are put in order to draw responses.

1.3 We have already conducted a number of bilateral meetings and workshops with key stakeholders on the subject of renewable energy. We will continue to take forward discussion of the questions and propositions raised in this note over the next two months.

1.4 The PIU has already invited all interested parties to put submissions to it by 10th September on all aspects of the PIU Energy Review. Interested parties are invited to respond in their submissions to the questions and propositions raised in this note.

1.5 We would also be grateful if interested parties could let us know as soon as possible if they consider this note overlooks key questions, if any of the questions posed, or propositions put, are fundamentally misconceived, or if the note contains any factual errors.

2. WORK TO DATE

2.1 This note builds upon, and summarises, work already undertaken for the PIU study on Resource Productivity and Renewable Energy which has now been integrated into the PIU Energy Review.

2.2 Work to date has focussed upon three key areas:

- Assessment of current policy, and modelling of likely developments in the renewables sector in the UK to 2010 and 2020 under current policies;
- Assessment of cost trends and technology development potential to 2020;
- Scenario analysis of potential developments to 2050.

3. BACKGROUND

3.1 Renewable energy is the harnessing of natural flows of energy – wind and wave, solar radiation, plant growth, tides and currents – to produce electricity, heat and fuels for human purposes. The technologies for doing this are many and varied and outlined below. With the exception of large hydro-electric schemes, which have been operating in many countries since the first half of the 20th century, renewable technologies are in an early stage of development relative to more established options for the production of electricity and fuels. Most are more expensive as a result and in almost all UK applications renewables are not commercially viable without policy support. Renewables currently make a very small contribution to UK energy supply, but the potential resource of some of the leading options is very large. Assessment of the potential development of renewable technologies in terms of both technical challenges and cost reductions has been a key task of PIU work to date.

3.2 Energy that is derived from, or energy demand which is reduced as a result of, appropriate management of, the bi-products of life will be analysed in a separate strand of work within the Energy Review. It will build on work already undertaken in the Resource Productivity project.

3.3 Renewables generally have much lower environmental impacts than ‘conventional’ alternatives, and in particular have the potential to provide energy with very low emissions of CO2 and with no radioactive wastes. Largely because of this, policy support for renewables has been expanded considerably in many countries, including the UK, in the last 10 to 15 years. Many countries, including the UK, have policies and targets intended to significantly expand the contribution of renewables.

3.4 Renewables currently contribute around 2.8% of electricity and 0.9% of all primary energy. Of this, a large proportion, almost 50% is supplied by large hydro, with the remainder supplied by the ‘new’ renewables such as wind power and biomass.

4. TECHNICAL POTENTIAL

4.1 The technologies with the largest potential in the UK are on- and offshore wind, wave and tidal stream, solar photovoltaics and biomass (energy crops and agriculture and forest materials), and large hydro - though most large hydro potential has already been harnessed. Smaller contributions are possible from a range of other technologies, such as small hydro and solar water heaters. A significant contribution could also come from large estuarine tidal barrages, most notably the Severn barrage[1].

4.2 Overall, despite the current small contribution of renewables in the UK, their potential contribution is large (see Table 1). Taken together, the main options outlined could easily exceed UK electricity demand of some 350 TWh/year at present. UK policy sets a target of 10% of electricity from renewable by 2010. Modelling work by the PIU suggests that a further target of 20% by 2020 is feasible, and preliminary analysis of the implications of a more ambitious target of 30% is underway.

4.3 It is possible to envisage an energy system based primarily upon renewables, and it is certainly possible for intermittent renewables (such as wind or solar) to supply 50% or more of electricity needs. However this would be likely to require the development of a range of associated technologies – such as the means to effectively store electricity and changes to the way local electricity distribution networks are managed. Reinforcement of the national electricity transmission grid and interconnection with the rest of Europe may also be required. Evaluation of such changes, their timeframes and their costs, will be an important part of the PIU's work on the potential evolution of energy systems in the long term.

Proposition: The UK could meet a significant proportion of electricity needs from renewable sources in the medium term – 20-30% by 2020 may be feasible. In the longer term, much larger proportions, 50% or more, appear possible

Table 1: Resource and cost in 2025 (derived from DTI 1998[2])

Technology	Cost* p/kWh	Economic potential at this cost* TWh/yr	Technical potential TWh/yr	Practicable potential TWh/yr

[1] Because it would involve a very large single infrastructure project – of similar scale to the channel tunnel - the Severn Barrage presents very different issues to the other renewables. The DTI are funding a scoping study for re-evaluation of the Barrage, the findings of this study will inform the Energy Review

[2] Supporting analysis for the Renewables Consultation: New and Renewable Energy: Prospects in the UK for the 21st Century, Supporting Analysis, DTI 1998

Building integrated photovoltaics (BIPV)	7.0	0.5 **	266	37**
Offshore wind	2.5 - 3.0	100	~3500	100
Onshore wind	<3.5	58****	317	8*****
Biomass (energy crops)	4.0	33	'large'	33
Wave	4.0	33	600 +	50

This table is an interpretation and simplification of the DTI analysis, therefore some caution is needed in interpreting these figures:
* DTI derive 'resource cost' curves for all technologies, essentially supply curves, that increase with cost, in most cases up to a maximum level at which practicable constraints cut in. The costs quoted are those at which this maximum level of deployment would be achieved. The exception to this is PV, where cost, rather than practical constraints, is the limiting factor, and larger resources would be available at higher costs.
** BIPV- practicable potential limited by assumptions about penetration rate into new buildings, economic potential to even lower penetration of those new buildings with potential for offset building costs
**** Assumes minimal constraints due to planning, network and build rate
***** Assumes severely constrained build rate and no network reinforcement – hence the rather perverse result that economic potential higher than practicable potential!
All figures quoted are based upon 8% discount rate.

5. COST TRENDS AND DEVELOPMENT POTENTIAL

5.1 None of the emerging renewable energy technologies are currently able to supply energy at costs competitive with the least cost alternative – currently a new gas-fired combined cycle generation stations at around 2-2.5p/kWh. As a result they are dependent upon policy support. The current costs of the leading options are as follows:

Onshore wind	~ 3.0 - 4.0 p/kWh
PV (building integrated, excludes offset costs)	~ 70 p/kWh
Energy crops	~ 8.0 p/kWh
Offshore wind (first UK projects, projected)	~ 5.0 – 6.0 p/kWh
Wave/tidal plants (estimate of early offshore devices)	~ 4.0 – 8.0 p/kWh

5.2 Significant and sustained cost reductions have already been secured by those renewables, such as wind and PV, which have a track record of market development. The costs of PV have declined 50 fold since the mid 1970s, and costs of wind energy fell fourfold in the 1980s, and halved again in the 1990s. These cost reductions have been driven, in part, by rapid market growth – around 20% per year for both technologies. The extent to which such cost reduction trends are set to continue, what drives them, and the potential for the other key options for the UK, is clearly of great importance in assessing the future for renewable energy. Cost reduction potentials have been analysed in detail by the PIU. Key conclusions from this analysis are summarised below.

5.3 The PIU's analysis of cost reduction potential used two complementary approaches to cost reduction assessment – engineering cost assessment and so called 'learning' or 'experience' curves:

- The former is based upon a detailed assessment of production processes, materials and sub-components. It allows the analyst to undertake an *a priori* assessment of the potential for cost reductions through technical improvement and economies of scale, as technologies move from early prototype to commercial scale production. This is particularly useful for those technologies at a very early stage of development, for which market data is currently limited, but can also provide a 'reality check' on extrapolation using learning curves.

- The latter is based upon empirical evidence of the relationship between cumulative production and cost, which allows the *learning rate* (percentage cost reduction observed for each doubling of cumulative production) to be determined. This relationship between market size and costs has been documented for a wide range of industrial products. Expected market growth rates enable future costs to be projected.

Question: Is the methodology utilised by the PIU for assessing cost reduction potentials appropriate and acceptable? Are there other factors that we have failed to take into account?

5.4 Preliminary findings for renewables are as follows:

- There is good evidence to support the contention that onshore wind is likely to become amongst the cheapest of *all* generating technologies within 10 - 15 years, in the average sites **– less than 2 p/kWh.**

- There is also good evidence that PV is likely to continue to experience sustained and substantial cost reductions over the next 20 years. However, though PV will become cost competitive in many applications in sunnier climes, it will still **be some way from cost competitiveness in the UK – around 10 p/kWh**.

- Offshore wind costs, where world experience is limited, is less certain. On the one hand, offshore wind might be expected to gain from onshore wind learning benefits so that costs become similar. On the other hand, engineering assessment of offshore technology issues suggests that offshore wind is likely to become broadly **competitive with the current costs of conventional fossil stations by 2020 – 2 to 3 p/kWh**.

- Advanced combustion technologies for energy crops also have considerable potential for cost reduction, with capital costs projected to fall by around 50% as the technology moves from the current demonstration phase to commercial deployment. Reductions in crop production and processing will also be required if energy crops are to become cost competitive. This makes **cost reductions in biomass more difficult to assess. Best estimates lie in the range 2.5 – 4 p/kWh.** Energy crop plants have the very important benefit that they may be switched on at will and hence may be able to compete for higher priced 'peak' electricity.

- More uncertainty surrounds wave and tidal technologies, with many competing devices currently at an early stage of development. As yet it is not clear which technologies will 'win', and all face technical hurdles. Parametric estimates of potential costs suggest that costs will be of the order of **4 to 8 p/kWh** for early devices, but it is not yet clear when this might be achieved. The UK is currently at the forefront of wave and tidal power and continued development could be secured at modest short-term cost.

> ***Proposition: The cheapest options for exploiting renewable energy sources will become broadly cost competitive with 'conventional alternatives' within 20 years.***

6. BUILD RATES AND POTENTIAL TARGETS FOR 2020

6.1 Cost reductions of the order described above are predicated upon continued strong growth of world markets for renewable energy. How rapidly the UK market for renewables could expand is an important area for further study. The PIU modelling of the Renewables Obligation indicated that a target of 20% of electricity from renewables for 2020 appears feasible and could be met without needing to raise the Obligation's price 'cap' on the premium paid to renewables.

6.2 Further work will explore the possibility of a 30% target for 2020. A 30% target would make a major contribution to continued CO_2 emission reductions post 2010, with the potential to ensure that the projected upturn in emissions from the power sector between 2010 and 2020 does not occur. It would also help to promote diversity. Key issues include technical constraints upon build rate and total burden upon consumers – which will depend heavily upon cost reductions.

> ***Question: What role, if any, should expanded and longer term targets play for the development of renewables? Should such targets be regulatory or aspirational?***

7. INFRASTRUCTURE ISSUES

7.1 Most analysts suggest that the current UK grid system could accommodate around 20% of electricity from intermittent sources, such as wind and wave energy, before technical and managerial changes are required. The intermittency of a diverse and geographically dispersed input from such renewables would not impose any statistically significant burdens on the system as the level of fluctuation would be no greater than the normal variations in demand. However, the economics of such supply sources under current electricity trading arrangements for England and Wales are more complex (see Paragraph 11.4 below). It is also possible that localised network constraints could become significant in some areas – at both the level of local distribution networks and the transmission grid, for example the development of northern Scotland's wind resources may be constrained by both the limited capacity of the local network and of the interconnector with England.

7.2 With a view to the longer term the implications, both technical and economic, of a much larger contribution from renewables requires further analysis. Preliminary work on the options for accommodating high levels of intermittency has been started. This suggests that the development of energy storage technologies and of systems for the active management of local networks could be important for the cost effective management of large penetrations of renewables. This is an important area for future analysis.

Proposition: Network and 'intermittency' constraints will not have a major impact on the development of renewables for the foreseeable future. However, additional development of key technologies for dealing with intermittency should be prioritised in order to hold open the option of much larger contributions in the longer term.

8. ENVIRONMENTAL IMPACTS AND PUBLIC PERCEPTIONS

Impacts

8.1 The environmental impacts of renewable energy technologies are generally very low compared to fossil fuel alternatives. Atmospheric emissions of most technologies are effectively zero at point of use, with the exception of biomass technologies. All technologies have very low lifecycle emissions of CO_2, with most lifecycle emissions arising from manufacture and installation of plant (biomass technologies produce CO_2, but low or zero net emissions are possible as CO_2 is absorbed in growth by plant-based fuel). Renewable energies produce very low levels of toxic solid wastes (heavy metals are associated with the production of some types of PV cell) and no radioactive wastes.

8.2 Renewables can have significant local environmental impacts. These include:

- wildlife and habitat changes;
- visual (landscape and architectural) intrusion;
- noise.

Wildlife and habitats can be altered by many technologies and it is important to note that impacts can be both positive and negative. For example: wind turbines can have some impact on bird populations (though in almost all studies this has been demonstrated to be low); wave energy technologies and offshore wind platforms create new sub-sea structures, which may create new habitats, but installation may cause some habitat disturbance; and biomass plantations change habitats (with the potential for both negative and positive implications) and may have implications for water abstraction.

Visual intrusion is primarily an issue for onshore (and possibly offshore) wind. The problem of noise from wind turbines has been very significantly ameliorated through improved technology and better siting. Both visual intrusion and noise from wind installations are intimately linked with issues of perception and acceptability. They have had a major impact on the development of renewables in the UK and are explored in more depth below.

Proposition: The environmental impacts of renewables are generally low.

8.3 Perceptions

There is a substantive body of literature on the perceived visual impact of renewable energy technologies, in particular of wind power, which has been the subject of considerable controversy in the UK. It is notable that attitudes to wind power differ markedly between countries, with opposition hindering development in the UK and the Netherlands, but with much more limited opposition in other countries, for example Denmark and Germany. In part this reflects the nature of different planning systems, but clear differences in public perception between countries are manifest in studies of opinion polls. Opposition to wind power is often characterised as 'NIMBYism' (not in my back yard). However, the evidence suggests that this is overly simplistic. Some studies suggest that acceptance increases with proximity to wind farms (i.e. those closest to them object to them least), that acceptance increases *after* wind farms are built, and there is also a strong link between the institutional and ownership arrangements (local ownership/financial benefits) and levels of opposition. It is also possible that the nature of UK financial support mechanisms may have driven UK developers toward more visually sensitive sites than has been the case in countries that have experienced more limited levels of public opposition. This is an important area for further analysis.

9 SECURITY

9.1 Renewable energy is able to provide security to the energy system. This is because UK produced renewable energy reduces the need for physical import of energy. Moreover, small generators aggregated together are more reliable than a single unit of equivalent size. Together, this means that renewable energy should increase system security. An Embedded Generation Working

Group (EGWG) was established to address a range of issues associated with small-scale generation and reported in March 2001. As the Report pointed out, because of the current design and operation of the distribution network, electricity system security benefits provided by multiple generation points are undervalued or ignored and even, in some situations, negated.

Proposition: Renewable energy is an important tool in increasing the security of the energy system

10 RENEWABLE ENERGY POLICY

Overview of past and current policy

10.1 The UK Government has been supporting the development of new and renewable sources of energy since the mid-1970's[3]. Most notably, renewables were included in the Non-Fossil Fuel Obligation (NFFO) in 1990. Under NFFO, electricity from renewables was provided with a guaranteed market at premium prices, subsidised by a levy on electricity consumers.

10.2 A supporting programme ran alongside the NFFO, aimed at stimulating the development of a range of new and renewable technologies:

- a range of biofuels (used either as static energy sources or as (partial) alternatives to petrol and diesel);
- wind;
- fuel cells;
- solar (both PV and solar water heaters);
- small-scale hydro (on rivers); and
- wave and tidal power.

10.3 Most of the projects in receipt of the grants from this programme were relatively small (< £100,000) and many of the grants were for monitoring and evaluation, with much of the capital raised separately.

10.4 The Utilities Act 2000 removed the legislative basis for further contracts under the NFFO, though existing contracts remain in place.

10.5 A New Strategy for Renewable Energy

The Government has set itself a target of securing 10% of electricity from renewable sources by 2010. There are four elements to this new strategy in support of renewable energy:

- The Renewables Obligation

[3] Support to date has primarily been focused on encouraging electricity generation from renewable sources, however renewable energy has a large potential for generation of heat and to make a contribution towards transport fuels.

- Climate Change Levy (CCL) Exemption
- Capital Grants (& Planting Grants for Energy Crops)
- Research & Development Funds

10.6 The Renewables Obligation

Electricity Suppliers in Great Britain will be required to purchase a certain proportion of renewable electricity from a range of eligible technologies. The Government has already undertaken a preliminary consultation on the proposed obligation and the statutory consultation is currently underway with a view to laying the Order before the House in October and bringing the Obligation into effect on 1 January 2002.

Under the Obligation energy suppliers can fulfil the obligation in three ways:

- buying Renewable Obligation Certificates (ROCs) from an accredited renewable generator; or
- buying ROCs from other suppliers / traders who have bought more than they need (through the trading of ROCs); or
- paying Ofgem the "buy-out price" of (currently) 3p/kWh for each unit the supplier is under obligation

The proportion of electricity that energy suppliers would be required to source from renewables is expected to increase over the period of the obligation. It is proposed that the obligation would account for around 3% by 2002, rising to about 10% by 2010/11. To provide long term security for investors, the Obligation will continue until 2027.

10.7 Recycling of the buy-out

The buy-out payments will be recycled to suppliers according to compliance. It is unclear what value this will give to the supplier and how much of this will be shared with the generator. However, what is clear is that the more that actual renewables generation falls short of our targets, the higher this value will be.

10.8 Climate Change Levy Exemption

From 1st April 2001, a climate change levy has been payable on the use of energy by all non-domestic (industrial, commercial and public sector) customers throughout the UK. The rate for electricity is 0.43p/kWh[4]. Renewable generation (excluding hydro over 10MW) is exempt from the CCL. This means that suppliers who sell renewable electricity to non-domestic customers are able to obtain a refund. Some of this will be shared with generators.

10.9 Capital Grants

[4] The value of this exemption drops to 0.086 p/kWh for those energy intensive companies entering into Climate Change Agreements and only paying 20% of the full rate.

The level of payment to renewable generators accruing from ROCs and the CCL exemption will not be enough to support all renewable energy technologies. One means of providing additional support is through capital grants. In this situation, a generator is able to bid for a capital grant, which could bring down their costs of generation (p/kWh) to within the expected price cap.

10.10 Research and Development

DTI's budget for R& D into renewable technologies is £18m per annum for the 3 years from 2001/2. This covers a wide range of renewable energy technologies – wind energy, hydro, solar, biofuels and fuel cells. Further funding of £3.5m per annum to support R&D activities is also available from the Engineering and Physical Sciences Research Council (EPSRC). Existing research projects totalling £11m are under way.

10.11 £100M Additional Support

The Prime Minister announced £100M additional support for renewable energy earlier this year to *"help us to promote solar PV, give a boost to offshore wind, kick start energy crops, and bring on stream other new generation technologies"*. The PIU has been leading a piece of inter-departmental work on analysis and recommendations for use of the additional funding and final decisions on how this funding will be allocated will be published this Autumn.

11 INSTITUTIONAL BARRIERS TO RENEWABLE ENERGY

11.1 The PIU study has concluded so far that it is likely that 10% target can be met with the above package of support measures but only if institutional barriers are removed or overcome. In particular related to:

- The difficulties in obtaining planning permission;
- Constraints imposed by the regulation of networks, infrastructure and connections;
- The effect of the New Electricity Trading Arrangements (NETA).

11.2 Obtaining Planning Permission

Difficulty in obtaining planning permission is still perceived as a barrier to the development of renewable energy projects in the UK. Success in gaining planning permission varies greatly across the different technologies and onshore wind projects in particular have encountered severe problems in gaining planning permission.

To a significant extent, the difficulties and costs experienced by many developers in gaining planning permission simply reflect attitudes on the ground, and the fact that – although in favour of renewable energy in principle – the public has many concerns about the local impact of specific renewable energy projects (as discussed in Paragraph 8.3 on public perception). But the energy review will also look at the planning system itself, and how it deals with renewable energy.

11.3 Regulation of Networks

Although it is not the case for all renewable sources of energy, many will be optimally linked to regional or local distribution networks rather than to the national transmission network. The current regulatory regime and commercial arrangements do not provide a level playing field for these renewable sources. The Embedded Generation Working Group was established specifically to address these issues. It is clearly important for renewable energy development that these recommendations are now taken forward quickly.

11.4 The New Electricity Trading Arrangements (NETA) commenced in March 2001. They encompass the basic principle that those wishing to buy and sell electricity should be able to enter into freely negotiated contracts to do so. Because NETA is still only a few months old, there is little empirical evidence to demonstrate how it is impacting on renewable generation (and also small-scale CHP, which shares some characteristics). There is likely to be a settling down period while actors become more familiar with its workings. It is thus hard to reach a firm conclusion about the long term, real effect of NETA on the scale of the impact on smaller, or intermittent, generators. Nevertheless, from the evidence available so far, it does appear to be possible that NETA is creating difficulties for small scale renewable and CHP generators.

OFGEM and DTI are currently undertaking an early review to look at whether NETA is having a disportionate impact on small generators. Following this review the case for transitional arrangements will be considered. The subject of how electricity should be traded in the longer term will be considered within the energy review.

11.5 At the moment, electricity trading and network access arrangements are intended to be technology blind. The extent to which the existing arrangements genuinely treat different types of generation fairly is an important area for analysis. Moreover, a further consideration is whether these arrangements should contain elements which are designed to give special treatment to different technologies. This leads to the broader and more fundamental question of the respective roles of Government Guidance to OFGEM and OFGEMs own role in deciding these issues.

Comments are invited on current institutional barriers to renewables, their current impacts and how they should be overcome.