House of Commons

Science and Technology Committee

TOWARDS A NON-CARBON FUEL ECONOMY: RESEARCH, DEVELOPMENT AND DEMONSTRATION

Fourth Report of Session 2002–03

Volume I

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Volume I:
Report and Proceedings of the Committee

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SUMMARY

This inquiry sought to establish the role of research, development and demonstration (RD&D) in moving the UK towards a non-carbon fuel future. We assessed the expenditure by public funding bodies (the Research Councils, Government Departments and the Carbon Trust) and found that the sums invested in public RD&D lack focus and are wholly insufficient in helping the UK meet its renewables targets, in absolute terms and in comparison with the UK's competitors. There is a superabundance of funding bodies, resulting in fragmentation of effort and confusion in academia and industry. Where UK technologies are developed, we found the private sector unwilling to develop these technologies while the Government is failing to step in to take them forward or provide the necessary incentives to encourage private companies.

We conclude that the Government's structures for energy are inadequate and that a new Renewable Energy Authority with strong ministerial direction is needed to provide the drive to make the Government's energy targets achievable; currently they are not. The Authority would be charged with identifying Britain's strengths—its natural resources and skills—and capitalising on them in partnership with academia and business. We believe that the focus should be on offshore technologies—wind, wave and tidal—and nuclear fission and fusion.

Not only is the technology push feeble but the market pull is inadequate. The Renewables Obligation creates incentives only for technologies close to market, the Climate Change Levy is a blunt instrument and the Government's confidence in the European emissions trading scheme is misplaced. While we were pleased to see the Energy White Paper announce that new housing regulations would be forthcoming, powerful incentives to bring forward new energy technologies are lacking. We propose a radical taxation system which distinguishes between fossil fuel sources and carbon-free or carbon neutral sources at different stages of development. We believe that nuclear fission should enjoy the full status of a carbon-free technology. Renewable sources of power are not coming on stream fast enough and nuclear power must fill the gap. The Government's decision to delay a decision on nuclear leaves the UK with an energy shortfall which will only be made up with fossil fuels.

FOURTH REPORT

The Science and Technology Committee has agreed to the following Report:

TOWARDS A NON-CARBON FUEL ECONOMY: RESEARCH, DEVELOPMENT AND DEMONSTRATION

INTRODUCTION

1. We decided to conduct an inquiry to establish what the UK is investing in research, development and demonstration (RD&D) in the fields of low and non-carbon forms of energy and how it is directed. The inquiry was announced on 16 May 2002 with the following terms of reference:

- To evaluate the level of expenditure on RD&D on non-carbon energy technologies, by the UK Government, the Research Councils, the Carbon Trust and industry, and where it is being directed;
- To identify which technologies are, or should be, receiving support, and how much investment is directed at research, development and demonstration respectively;
- To assess the skills base and the state of RD&D for different technologies;
- To establish how government policy on energy RD&D is formulated, implemented and evaluated, and the nature of coordination between department, external agencies and industry;
- To establish the level of and rationale for international collaboration in energy RD&D and how priorities are determined;
- To examine the effect on energy RD&D of privatisation, liberalisation, regulation and changes in ownership in the sector; and
- To make comparisons with overseas competitors.

2. The purpose of inquiry is to highlight RD&D issues during the preparation of the Energy White Paper and to influence its implementation following its publication on 24 February 2003. Our predecessor Committee conducted a short inquiry at the end of the last Parliament on Wave and Tidal Energy.[1] We take forward some of the issues raised in that inquiry. Some aspects of energy policy are devolved and the energy markets in Scotland and Northern Ireland are distinct from that in England and Wales, although the DTI's support for research and innovation is nationwide. Our recommendations apply principally to the UK Government.

3. The importance of climate change and the economic importance of the energy markets has rightly been reflected by considerable Parliamentary activity. As well as our predecessor Committee's Wave and Tidal Energy inquiry, notable reports have been published by the Trade and Industry Committee on security of supply and the Environmental Audit Committee on renewable energy.[2] The Government's Foresight programme has made a valuable contribution in recent years through its Energy and Natural Environment Panel. Our aim is not to duplicate the work undertaken by these committees but to emphasise the importance of innovation in meeting our future energy needs and to identify how the process can be strengthened.

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[1] Seventh Report of the Science and Technology Committee, session 2000–2001, *Wave and Tidal Energy*, HC 291

[2] Fifth Report of the Environmental Audit Committee, *A Sustainable Energy Strategy? Renewables and the PIU Report*, session 2001–02, HC 582-I; Second Report of the Trade and Industry Committee, *Security of Energy Supply*, session 2001–02, HC 364

4. We have used the term non-carbon fuel in the title of this report. This is to be interpreted broadly to include low-carbon and carbon-reducing technologies, reflecting the short-term imperative to reduce carbon emissions. Thus the technologies considered include:

- clean(er) fossil fuel power generation;
- renewable and carbon-neutral sources of power generation;
- nuclear power (fission and fusion);
- carbon sequestration;
- energy efficiency; and
- cross-cutting technologies, including those concerned with electricity supply and transmission, and enabling technologies such as fuel cells and hydrogen.

5. Our inquiry has not considered transport fuels in any detail. Although they are responsible for 40% of carbon dioxide (CO_2) emissions by the UK, we have found it necessary to restrict the scope of an inquiry into a very broad subject. We note that even if electricity generation emitted no CO_2, the UK would not achieve the desired 60% reduction in CO_2 levels by 2050 recommended by the Royal Commission on Environmental Pollution (RCEP) in its 2000 report *Energy—the Changing Climate* without measures in the transport field.[3] Our discussions on fuel cells and the hydrogen economy are of course relevant to transport, and electrical power generated from renewable sources can be used for transport uses.

6. The use of the term "research, development and demonstration" recognises that attention should be given to all stages of the innovation process. We accept that this is not a simple linear process with discrete stages but breaking it down is necessary to identify the problems and obstacles in the innovation process. We will also consider barriers to commercialisation and features of the industry and the market that clearly act as barriers or disincentives to scientific and technological innovation.

7. We started our inquiry with a private seminar on 10 July 2002 and heard presentations from Professor John Chesshire; Dr Tariq Ali, Imperial College; Professor Dennis Anderson, Imperial College; Dr John Hassard, Imperial College; Mr Nick Otter, Alstom Power; and Professor Dave Elliott, the Open University.

8. We have received 55 written submissions. We held six oral evidence sessions between October 2002 and March 2003 from 14 sets of witnesses, representing the Research Councils, academic energy researchers, energy SMEs, the nuclear industry, NGOs, electricity transmission and distribution companies, building researchers and companies, oil and gas companies, and the Government. We made two visits relating to the inquiry: to Japan on 14–21 September 2002 and to the UK Atomic Energy Authority's fusion research facilities at Culham, Oxfordshire on 11 November 2002.

9. We are grateful to all those who have assisted with the inquiry, and in particular to our Specialist Advisers: Professor Dennis Anderson of Imperial College, London; Mr Nick Otter of Alstom Power, and Professor Michael Elves, former Director of the Office of Scientific and Educational Affairs, Glaxo Wellcome plc.

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[3] Royal Commission on Environmental Pollution, *Energy—The Changing Climate*, June 2000, Cm 4794; Performance and Innovation Unit, *The Energy Review*, February 2002, p 8

BACKGROUND

10. The scientific case for global warming has been made, principally by the Intergovernmental Panel on Climate Change. In response to these concerns, the United Nations Framework Convention on Climate Change was agreed at the Earth Summit in Rio de Janeiro in 1992 and adopted in 1994. Under the Convention, all developed countries agreed to aim to return their greenhouse gas emissions to 1990 levels by 2000. The Kyoto Protocol, agreed in December 1997, recognised that the Convention commitments could only be a first step in the international response to climate change. Developed countries agreed to targets that will reduce their overall emissions of a basket of six greenhouse gases (including CO_2) by 5.2% below 1990 levels over the period 2008–12. These targets will be legally binding, and differentiated between Parties to the Convention. The European Union Member States agreed to a reduction of 8%, which will be distributed between Member States to reflect their national circumstances. The UK's target will be a 12.5% reduction. This forms part of the DTI's PSA target 4, which directs the Department to "improve the environment and the sustainable use of natural resources, including through the use of energy saving technologies, to help to reduce greenhouse gas emissions by 12.5% from 1990 levels and moving towards a 20% reduction in carbon dioxide emissions by 2010".

11. The RCEP has argued that to make a significant impression on climate change "the Government should now adopt a strategy which puts the UK on a path to reducing carbon dioxide emissions by some 60% from current levels by about 2050".[4] This figure was accepted by the Prime Minister in his appearance before the Liaison Committee in January 2003.[5] The Energy White Paper, *Our energy future—creating a low carbon future*, affirms the Government's intention of meeting this target.[6] The RCEP concluded that such a reduction was possible using current technologies. Subsequently its members have acknowledged that they understated their case and that technological developments would improve the chances of reaching that target.

12. The effects of the Kyoto Protocol and increases in atmospheric CO_2 have been studied by the UK Climate Impacts Programme, which is funded by the Department for Environment Food and Rural Affairs (DEFRA). The programme has produced climate change scenarios, which suggest that to stabilise CO_2 levels the UK would need to decrease emissions to 60–70% of their 1990 levels and that this would still result in a 2–3 degree increase in global temperature.[7] In this inquiry we have sought to establish how to enhance the role that scientific and technological innovation has in achieving decreasing the emissions through energy production and use, and the extent to which the policies pursued by the Government and the private sector on RD&D are facilitating the transition to a low carbon economy. In response to the RCEP report, the Government asked the Performance and Innovation Unit (PIU, now re-named the Strategy Unit) to conduct an energy review, which was published in February 2002. The Government responded with a consultation document published in May 2002. A White Paper originally scheduled for the end of 2002 was finally published on 24 February 2003.

The UK's energy mix and renewables

13. During the 1990s the UK replaced coal with gas as its principal source of electricity generation. Since gas generation results in less CO_2 for a given power output, the UK is in a much stronger position than many other nations to achieve its Kyoto targets. It should

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[4] Royal Commission on Environmental Pollution, *Energy—The Changing Climate*, June 2000, Cm 4794, para 10.10
[5] Liaison Committee, Oral evidence from the Prime Minister, 21 January 2003, Q 42
[6] Department of Trade and Industry, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 1.10
[7] Hulme M et al (2002) *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*, Tyndall Centre for Climate Change Research, University of East Anglia, chapter 8

be noted that the UK's CO_2 emissions have been declining steadily over the past 30 years and thus any future reductions will be harder to achieve.

14. Reflecting an awareness that the source of electricity generation must change, the Government set a target of 10% of electricity generation by renewable technologies by 2010. Renewables are defined by the Department of Trade and Industry (DTI) as " those continuously available sources which do not rely on exhaustible fossil fuels". In 2000 they were responsible for 2.8% of electricity generation, comprising 1.4% hydroelectric, 0.2% onshore wind and 1.2% from other sources such as landfill gas, municipal waste combustion, sewage sludge digestion and energy crops.[8] The scope for increased hydroelectric generation is considered minimal due to limitations in suitable sites and environmental concerns.[9] Nuclear power generation was responsible for around 23% of electricity generation in 2001 but this will decline to 17–18% by 2010 and to 7–8% by 2020 unless new nuclear power stations are constructed.[10] The PIU report recommended that the Government's 10% renewables target for 2010 should be supplemented by a 20% target for 2020. In the White Paper, this has been become an "aspiration".[11] The Minister for Energy and Construction, Brian Wilson, told us that the 2020 aspiration would be easier to achieve than the 2010 target.[12]

15. We agree with the value of a target for renewable electricity generation but we must not lose sight of the principal objective, which is to introduce non-polluting, sustainable forms of energy on a large scale. It is important that Government thinking and policies are not hampered by arguments over what does or does not constitute renewable energy or loses sight of other means by which carbon emissions may be reduced.

16. The energy industry was privatised in the late 1980s and early 1990s. This, and the liberalisation of the energy market, had a profound effect on the energy mix. Gas replaced coal as the primary source of energy and this contributed to the lack of nuclear build.

The Energy Research Review Group

17. To inform the PIU's energy policy review, the Secretary of State for Trade and Industry commissioned the Chief Scientific Adviser, Sir David King, to conduct a review of Government support for RD&D activities. The Energy Research Review Group (ERRG) considered whether the overall level of expenditure on RD&D was sufficient, whether it was being targeted at the right areas and who should in future maintain an overview of expenditure.[13] The ERRG report was published in February 2002 as an annex of the PIU review. It recommended that research should focus on the following technologies:

- CO_2 sequestration;
- energy efficiency;
- hydrogen production and storage;
- nuclear power (nuclear waste);
- solar PV; and
- wave and tidal power.

18. The ERRG picked up the suggestion made by the Energy Foresight panel in its *Power without Pollution* report published in March 2002, that there should be a national energy

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[8] www.dti.gov.uk/energy
[9] www.dti.gov.uk/renewable
[10] DTI, *2002 Digest of UK Energy Statistics*, Table 5.6; Second Report of the Trade and Industry Committee, Session 2001–02, *Security of Energy Supply*, HC364, para 20
[11] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.11
[12] Q 592
[13] Office of Science and Technology, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002

research centre, based on a spoke and hub model. This has subsequently been incorporated into a successful bid to the 2002 Spending Review by the Research Councils, which we will consider further in paragraphs 33–37 below.[14]

19. The Energy White Paper accepts the recommendations of Sir David King's ERRG report, in terms of the priority research areas and the need to invest more in public RD&D.[15] No additional RD&D funding was made available beyond that announced in the Spending Review.

PUBLIC FUNDING OF ENERGY RD&D

20. Public funding for energy RD&D comes directly from Government Departments, from the Research Councils and from Government-funded bodies such as the Carbon Trust. This is summarised in Table 1.

[14] Ev 136–138
[15] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.15

Table 1: UK Government funding of energy RD&D (£million)

	Historical expenditure			Forecast expenditure			
	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06
DTI							
Biomass	2.2	1.2	2.8	4	4.2	3	0.3
Waste	0.02	0.6		0.04	0	0	0
Embedded Generation				2	0.8	1.02	3
Fuel Cells	1.5	1.4	2.2	2	1	0.4	0.02
Solar	1.73	1.4	2.7	5	4.2	1.4	0.5
Wind	1.2	1.1	2.2	2	0.9	0.3	0.01
Hydro	0.3			0.2	0.1	0	1
Wave	0.01	0.4	0.3	1.6	2	0.55	0
Tidal	0			1.2	0.4	0.53	4
Technology Transfer and Export Promotion	0.9	3.6	3.4	0.3	0	0	0
Nuclear fusion	14.4	14.3	14.3	14.3	14.3	14.2	14.3
Research Councils[16]	7.2	8.2	10.8	11.0	7	12.6	13.4
DEFRA							
Bio Energy					0.5	1	2
Community Energy				20	30		
Carbon Trust R&D aspect of the LCIP				4.2	8	5.6	
Energy Saving Trust Energy Efficiency and FP Research		0.24	0.45	0.07	0.02	0.02	

[16] The forecasting figures only include funding for the Research Councils Sustainable Energy Programmes and EPSRC's SUPERGEN initiative (assuming £5 million a year). A breakdown of allocated Research Council expenditure can be found on Ev 76–77

Public funding bodies

Research Councils

21. The seven Research Councils are NDPBs under the auspices of the Office of Science and Technology (OST), within the DTI. These fund research and researchers in universities and within their own research institutes. Five of the Research Councils have interests in energy research: the Biotechnology and Biological Sciences Research Council (BBSRC), the Council for the Central Laboratory of the Research Councils (CCLRC), the Economic and Social Research Council (ESRC), the Engineering and Physical Sciences Research Council (EPSRC) and the Natural Environment Research Council (NERC). Between them, in 2002–03, they will spend an estimated £11 million on low and non-carbon energy technology.[17]

Engineering and Physical Sciences Research Council

22. The largest contribution comes from EPSRC, which expects to spend £9 million on low carbon energy technologies in the year 2002–03. The Council's total budget for 2002-–03 is £460 million; generally energy research represents around 2% of its expenditure. The expenditure on non-carbon energy related research has increased in recent years (see Table 2), reflecting the budgetary increases to the EPSRC, and indeed all the Research Councils. The EPSRC also quotes its expenditure on energy in terms of its "portfolio", which Dr Peter Hedges, Manager of the EPSRC's Energy and Environment programme, told us meant the "current value of grants at that particular time. It is confusing because we will quote figures in different ways".[18] Dr Hedges is absolutely right, it is confusing and there seems little obvious purpose of talking about "portfolios", unless from a desire to make small figures look bigger. **The EPSRC has a large area of science to fund but it is hard to accept that energy research, given its economic and environmental importance to the UK, should receive such a small slice of the cake.**

[17] Ev 74, 76–77
[18] Q 24

Table 2: EPSRC grant expenditure on non-carbon energy related research (£k)[19]

Technology area	1998–99	1999–00	2000–01	2001–02	2002–03	2002–03 percent
Biofuel	0	0	22	52	142	1.5%
Biomass	359	357	289	477	515	5.5%
Combined heat and power	36	63	77	267	372	4.0%
CO_2 sequestration	0	0	23	42	67	0.7%
Fuel cells	1,016	703	899	1,145	1,487	15.9%
Geothermal	0	0	0	7	4	0.1
Hydrogen	136	59	83	319	536	5.7%
Photovoltaic	3,002	2,760	2,992	3,536	2,685	28.7%
Nuclear	81	62	128	325	293	3.1%
Wave and tidal	0	0	185	491	452	4.8%
Wind	216	167	261	330	481	5.1%
Waste	10	40	40	96	125	1.3%
Conventional	1,317	1,260	1,428	2,058	2,211	23.6%
Total	**6,173**	**5,471**	**6,427**	**9,145**	**9,370**	**100%**

23. The EPSRC's energy research funding comes predominantly through managed mode (see paragraph 25). This enables it to direct its funding to priority areas rather than to respond to the interests of researchers. Looking at Table 2, it is not clear how it arrived at its priorities. There is a bias towards photovoltaics, fuel cells and "conventional technologies" (which we understand relates to research into improvements in conventional generation, such as clean coal, and electricity transmission[20]). We appreciate that the EPSRC must be sensitive to the needs of its user industries but spending such a high proportion of its research funding on "conventional technologies" where there is an established industry seems curious, especially when nuclear fission research funding is negligible and none of this is targeted at new reactor technologies. The EPSRC decides its research priorities with inputs from a Technical Opportunities Panel, comprised largely of academic researchers, and a User Panel with industrial representatives. There is a danger with the latter that it steers the EPSRC's research priorities towards areas with which it is familiar. **Half the membership of the EPSRC's council is from industry and we fear that this may lead to conservatism. We regret that technologies with the potential of wave and tidal or hydrogen are given so little funding. The EPSRC should be given a stronger lead by Government to ensure that investment is consistent with wider energy policy.**

[19] Predicted spend for 2002–03.
[20] Qq 9–11

24. EPSRC said that the figures provided for the inquiry were based on projects directly related to energy. Dr Peter Hedges told us that if they included blue skies research that might have applications to energy the figure would be several times higher (see Table 3).[21]

Table 3: Estimate of blue skies research with possible energy applications and the resulting expenditure in 2002–03

Basis of estimate	Grant expenditure in 2002–03
Directly relevant research topics	£12.4 million
Directly and indirectly relevant research topics	£68.2 million

25. The EPSRC, in common with other Research Councils, allocates its research funds in either managed or response mode. In the former, the Council invites applications in a specified field of study, while in the latter researchers will submit grant proposals for research they wish to pursue and it is funded on merit. The ratio of managed to response mode funding for the EPSRC is around 1:2, but in energy it is 2:1.[22] We are aware that the EPSRC, in common with other Research Councils, has been receiving an increasing number of applications and that this is having an effect on the success rate of applications. We were told that until recently the success rate for grant applications for the EPSRC as a whole was around 34%.[23] Professor John O'Reilly, Chief Executive of the EPSRC, told us that "My own view is that if the success rate of highly regarded proposals is between one in two to one in three then the system itself is a workable and sustainable one. When success rates get to be very low then I think it is not". EPSRC has presented data to us, showing that energy projects perform quite well, with a 56% success rate in response mode and 45% in managed mode.[24] Professor Dennis Anderson from Imperial College is concerned that because of the low success rate for Research Council grant applications "many researchers do not submit applications given such a high probability of rejection and the time and effort entailed, and many projects that are financed are under funded".[25]

26. We have also heard concerns that EPSRC's funding is too risk-averse, concerned more with the researcher's track record than the quality of the proposal. Professor Michael Graham of Imperial College told us that "EPSRC always asks now for adventure in research and ticking those boxes is requested if you are refereeing these applications, but it is just one of the items being assessed and probably the most important are the track record and the scientific quality of what is being looked at".[26] We believe that good research needs to take chances and pursue novel lines of enquiry. **We appreciate that striking the right balance between funding applied and blue-skies research is difficult but we urge EPSRC to ensure that researchers with innovative, if risky, projects get the funding they need.**

27. The EPSRC has recently established a major research programme on Sustainable Power Generation and Supply (SUPERGEN). This programme will invest £25 million over five years to establish research into the sustainability of the power supply industry. EPSRC is expanding its SUPERGEN programme into the social, environmental and life sciences to address these challenges with input from BBSRC, ESRC and NERC. EPSRC is also

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[21] Q 3
[22] Ev 157
[23] Q 28
[24] Ev 158
[25] Ev 162
[26] Q 156

planning to work in partnership with the Carbon Trust on a major joint RD&D venture called the Low Carbon Innovation Programme.[27]

28. The DTI's budget for nuclear fusion research has recently been transferred to the EPSRC, following a DTI review. This has some advantages, notably that the EPSRC is well placed to build links between the fusion research conducted at the UK Atomic Energy Authority's (UKAEA's) facilities at Culham in Oxfordshire and universities. We do have concerns, however, that the EPSRC has little experience of funding a large project of this type. Indeed, we understand that there was a suggestion that UKAEA would have to apply for funding through the usual peer-review process. This would have been completely inappropriate. A project of this nature could not have continued with the likely fluctuations in funding that would have inevitably resulted. We were reassured to hear Professor O'Reilly say that "The fusion activity at Culham is certainly ... rated very highly amongst fusion research in the world. I think we do have something that we should be willing to make a commitment to".[28] We consider the future of fusion in greater detail later in paragraphs 181–191. **We agree with the Government that there are merits in placing fusion research under the auspices of the EPSRC but we have reservations about its commitment to the technology. To maintain the UK's position in this field, we believe it should remain a special case for funding with a ring-fenced budget. We will be watching the operation of the new funding arrangement for nuclear fusion research at Culham with great interest.**

Other Research Councils

29. The energy-related expenditure of the other Research Councils is relatively modest; nevertheless many of them have an active interest in the field and we welcome their positive input to this inquiry. We are not qualified to comment on the merits of individual funding decisions; that is rightly left to those with a specialist knowledge. What is important is that they work together on areas of mutual interest. Energy research is multi-faceted and the research funded by the Research Councils needs to be well coordinated. **It is pleasing to see that the Research Councils are beginning to improve the way they are working together and in particular that they put in a successful joint bid to the Spending Review on sustainable energy.**

30. We are particularly pleased to see the ESRC playing an active role in energy research. Issues of acceptability and adoption of new technologies are causes for concern: it is vital that social research is undertaken in tandem with the technological development. On 22 January 2003 we invited Professor Ian Diamond, the new Chief Executive of the ESRC, to take part in an introductory hearing before the Committee. We were pleased to hear of his track record in conducting multidisciplinary research and hope that this experience can be applied to the Research Councils' programme on sustainable energy.[29]

The Tyndall Centre

31. The Tyndall Centre is a national centre for research on climate change, launched in November 2000. Its headquarters are in the School of Environmental Sciences at the University of East Anglia but eight other UK research institutions are partners. The core funding of the Tyndall Centre (£10 million over 5 years) is composed of contributions of £5 million from NERC, £1.25 million from ESRC and £3.75 million from EPSRC. The DTI provides additional support to fund a Business Liaison Officer.[30] The Centre expects to have

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[27] Ev 70–71
[28] Q 53
[29] Evidence presented by Professor Ian Diamond, Chief Executive, Economic and Social Research Council, on 22 January 2003, HC 277-i
[30] Ev 165

spent £2 million on research of direct relevance to low or zero-carbon energy research between 2000 and 2003.[31] Examples of projects funded by the Tyndall Centre are shown in Table 4.

Table 4: Examples of Tyndall Centre funded projects on zero and low-carbon energy technologies

Description	Expenditure 2002–2003 (£k)
Technology and the economy—energy system in an integrated assessment of climate change	107
Technology policy and technical change, a dynamic global and UK approach	326
The transition to a decarbonised UK: research with a direct relevance to low or zero-carbon energy research	100
Behavioural response and lifestyle change in moving to low carbon transport futures	97
Carbon sequestration: a pilot stage multi-criteria evaluation of biological and physiochemical approaches	30
The hydrogen energy economy: its long-term role in greenhouse gas reduction	156
Integrating renewables and CHP into the UK electricity system	157
Micro-grids—distributed on-site generation	104
Fuel cells: Providing heat and power in the urban environment	100
Research on energy efficient and low-emission housing	240

32. The Centre is clearly conducting useful multidisciplinary work on climate change and energy, and is reaching out to the UK research community, as was planned, strengthening the UK's reputation in this field. We are concerned that the research is not adequately driven by the Research Council's energy research programme. We were pleased to see, however, that the Tyndall Centre was identified as a playing an important role in the formation of the recently announced National Energy Research Network and indeed serves as a model for the Network's structure and management. The Tyndall Centre's funding has been confirmed until 2005 but a decision about future funding is not planned until the end of 2004.[32] **We urge the Research Councils to make an early decision on the continuation of funding of the Tyndall Centre to avoid any interruptions in the Centre's research programme, and to increase its resources.**

[31] Ev 75
[32] Ev 164; DTI, *Science Budget 2003–04 to 2005–06*, December 2002, pp 25–26

Spending Review 2002 and the UK Energy Research Centre

33. Of the six grant-awarding Research Councils, three—EPSRC, ESRC and NERC—made a successful joint bid to the 2002 Spending Review for a Cross-cutting programme on sustainable energy. The programme aims to:

- create an international lead in basic and strategic research on sustainable energy and its impacts;
- support the development of economically viable and publicly acceptable renewable energy sources and technologies to enable the UK to achieve 10% of electricity generation from renewable sources by 2010;
- identify and support the development of new products and processes; and to
- enhance our understanding of the implications of the liberalisation and globalisation of energy markets, technological developments, new energy sources and policy and regulatory frameworks.

34. An extra £26 million will be made available over two years (2004–05 and 2005–06).[33] This sum is tiny given the scale of the problem, but we accept the argument that research capacity cannot be built overnight and look forward to further increases in funding for sustainable energy research in the 2004 Spending Review. In 1998 our public expenditure per capita on energy RD&D had fallen to one tenth of the OECD average, and one eighth of that of the USA.[34] The challenge of creating a low carbon energy future has been with us for nearly 50 years, going back to the 1950s; the emergence of the climate change issue has only added to the importance of this; it remains the biggest technological challenge the energy industry has ever faced, and will not be solved without a significant RD&D effort. **We welcome the cross-Council programme on sustainable energy. The Research Councils' expenditure on energy research has been pitiful and this investment is a step in the right direction. But it only remains a step, which we hope will be followed up vigorously in the future. If UK technologies are to succeed the scale of investment must increase rapidly.**

35. A key part of the Councils' Spending Review proposal was for a dedicated UK Energy Research Centre (UKERC) and a National Energy Research Network (NERN).[35] We understand that this will begin work in April 2004. UKERC's principal functions will be to:

- promote interdisciplinary, integrated whole systems approaches to UK energy research;
- provide greater coherence, coordination and connectivity for all government-funded energy research activities primarily via establishment and operation of a NERN;
- provide a focal point for data and information on UK energy research funding;
- provide a capability for effective knowledge transfer of research outcomes to both business and policy makers; and to
- provide views and advice on future research needs.

The Research Councils are consulting on a more detailed specification. It is not clear to us what research budget it will have of its own, although we understand the cost of setting up the Centre will be in the region on £8–12 million.[36] Unless it its research budget is substantial it will lack the credibility to make a real difference. **We will await the development of a UK Energy Research Centre and a National Energy Research**

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[33] BBSRC, CCLRC. EPSRC, Medical Research Council and NERC. £6 million had already been allocated to the Research Councils following a speech by the Prime Minister on 6 March 2001, along with £2 million for the 2003–04 budget.
[34] Ev 162
[35] Ev 136
[36] Ev 166

Network with great interest but we are concerned that its remit is too narrow and aims to modest to turn energy RD&D into deployed technologies.

36. Concern has been expressed to us about the proliferation of public funding bodies. Indeed, Research Councils UK refers to the "complex research landscape" in the energy field. We gather that the Research Councils are "giving consideration as to how best to engage and involve other major players" such as the Carbon Trust and DTI in the UK Energy Research Centre, yet surely these "major players" should have been an integral part of the Centre's strategy from the beginning.[37] **We understand that UKERC will provide "a focal point for data and information on UK energy research funding".[38] If this means that the Centre will provide a one-stop shop for those seeking energy-related RD&D funding then it is a proposal that we warmly welcome.**

37. **We have no doubt that the Research Councils are funding world-class research into low carbon energy, but is our impression that instead of driving these exciting new technologies forward they have a passive, unadventurous approach. There will be few sleepless nights in our competitor countries.** The Research Councils might argue that this is not their role, and we would agree but at present no public body exists that will take this on if they do not.

The Carbon Trust

38. The Carbon Trust came into being on 29 March 2001 as an independent company limited by guarantee, set up by Government in partnership with business to invest in the development and deployment of low carbon technologies.[39] Its funding, approximately £50 million a year, comes from grants from DEFRA, the Scottish Executive, the National Assembly for Wales and the Northern Ireland Assembly, and in part from Climate Change Levy receipts. It has two principal programmes: Action Energy, designed to accelerate the deployment of existing energy efficiency and low carbon technologies; and the Low Carbon Innovation Programme (LCIP) to support the development and commercialisation of new and emerging low carbon technologies. One of the four elements of LCIP is support for RD&D (£18 million over three years). A second element funds demonstration projects (£20 million over three years).[40] Part of the LCIP, a £14 million partnership with EPSRC called Carbon Vision, was launched in November 2002. Under the scheme, identified demands from business for low carbon technologies and solutions will be matched against university R&D departments. Investments will be in the region of £1–2 million.[41] Projects funded through this initiative were announced on 24 February 2003. These are shown in Table 5.

39. The Carbon Trust published its Low Carbon Technology Assessment for 2002 in January 2003, using as its starting point the ERRG report.[42] It reviewed 49 technologies and aimed to identify those technologies which have emerged as having the greatest impact on carbon reduction and where Carbon Trust levels of investment can have a significant impact. These are:

- biomass (for local heat generation);
- building (fabric, heating, ventilation, cooling, integrated design);
- combined heat and power (CHP) (domestic micro);
- CHP (advanced);

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[37] Ev 166
[38] Ev 136
[39] The Carbon Trust is funded by the Department for Environment, Food and Rural Affairs, The Scottish Executive, Invest Northern Ireland and the National Assembly for Wales, partly via funds voted by Parliament and partly from climate change levy receipts.
[40] Ev 62
[41] Press release from the Carbon Trust "New business/academic partnership delivers £14 million for low carbon innovation", 11 November 2002.
[42] The Carbon Trust, *Low Carbon Technology Assessment 2002—Making Our Investment Count*, January 2003

- fuel cells (domestic CHP, industrial and commercial);
- hydrogen infrastructure (including transport, production, storage and distribution); and
- industry (combustion technologies, materials, process control, process intensification, separation technologies).

Table 5. Examples of projects funded by the Carbon Trust

Type	Project	Value (£k)
RD&D	Carbon Vision, an R&D fund (jointly with the EPSRC) for universities. Projects will include low carbon buildings, industrial processes and fuel cells	14,000
	Portico Software, a Welsh project on energy analysis and monitoring tools to provide more effective energy management for process industries such as steel and glass.	340
	Participation in the Orkney-based European Marine Energy Centre to support companies involved in the development of future wave and tidal power technologies.	6,700
	Usher, a demonstration project that links photovoltaic generation to hydrogen production, storage and utilisation to power fuel cells.	4,500
	University of Glamorgan research project for producing hydrogen from starch to use in electricity production via fuel cells.	76
Commercialisation	Minority participation in a £16 million equity investment to support the development of a Southampton-based Bowman Power which produces advanced gas turbine CHP systems.	–
	Funding for B9 Energy Biomass, a Northern Ireland-based company developing a biomass CHP plant.	600
Dissemination of new technology	Project run by IT Power that will implement a UK-wide roll-out of an accredited programme for photovoltaic installation training.	160

40. The Action Energy programme has an annual budget of around £20 million and promotes deployment of efficient and renewable technologies. Alongside the services it provides to businesses and public sector organisations, are two financial support initiatives:

- the enhanced capital allowances scheme, in which companies can set the whole of their expenditure on designated energy efficiency equipment against taxable profits; and

- the Carbon Trust's interest free loan scheme. The scheme helps SMEs invest in energy efficient plant or processes through loans of £5,000–50,000 repayable over four years. Total funding for the loan scheme is £10 million over three years.[43]

41. We asked several of our witnesses their views of the Trust but few were very forthcoming. Most felt that it was a good idea and that its strategy was sensible. None of the researchers who gave evidence to us had had much contact with it. It was the impression of Professor Mike Hulme from the Tyndall Centre that "It seems to have been rather slow to actually get off the ground".[44] We have greater concerns over the level of funding, which appears to be too low to make much of an impression. A second worry is that its formation introduces yet another funding body into energy research. We are pleased to see evidence of collaboration with other bodies but this will be little consolation for researchers or energy technology companies. We asked Brian Wilson what distinguished funding provided by the Carbon Trust from that from the DTI or the Research Councils. Very little, seems to be the answer. He said that it was independent and provided flexibility.[45] Independence is little use, however, if it means that its funding does not complement that of other public funding policy. It is not clear to us why the DTI cannot be similarly flexible if this is such a virtue. Mr Wilson insisted that the Trust's work was complementary to the DTI and the Research Councils. This misses the point. The issue is whether there was any good reason to set up the Carbon Trust in the first place if existing Government structures could have fulfilled its function. **We do not understand why the functions of the Carbon Trust could not have been taken on by existing Government bodies. We suspect that its formation was primarily a political gesture to bolster the Government's green credentials.**

42. We have heard from researchers frustrated with the work required to attract public funding, sometimes for very small amounts of money.[46] In the Energy White Paper, the Government said, in response to the PIU's recommendation of a review of low-carbon support schemes, that the programmes of the Carbon Trust were too new to be reviewed but that this would take place by the end of 2004.[47] **It is too soon to judge the effectiveness of the Carbon Trust but we detect a lack of urgency. It must be an active partner of the UK Energy Research Centre in its provision of advice and information on funding.**

Energy Saving Trust

43. The Energy Saving Trust (EST) was set up by the UK Government after the 1992 Rio Earth Summit as a non-profit company. In 2002–03, the EST's budget is £90 million, comprising mostly funding from the UK Government and the devolved administrations. The EST runs two schemes aimed at stimulating the market: the Community Energy programme, funded by DEFRA and managed jointly with the Carbon Trust, and the Photovoltaic Demonstration programme, funded by the DTI. Support through the Community Energy programme includes 50% of the cost of development studies, and up to 40% of capital cost of implementing a scheme. £20 million is available in 2002–03, and £30 million in 2003–04 for the implementation of community heating CHP schemes. The Photovoltaic Demonstration programme provides 50% of the cost of installation for small-scale applications (0.5kWp-5kWp) and between 40–65% of the cost of installation for larger scale applications (5kWp-100kWp). £20 million is available over three years. The EST also runs

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[43] Ev 62
[44] Q 119
[45] Q 575
[46] Q 157
[47] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 7.16

an innovation programme, providing up to £10,000 for feasibility studies and up to £90,000 for implementation of schemes that reduce CO_2 emissions in housing.[48]

44. It has been suggested that the EST and the Carbon Trust should merge to reduce the number of funding bodies. Tom Delay told us that the organisations focused on different markets and where there was overlap they worked closely together. There are so many funding bodies that we feel that every effort should be made to reduce them. We commented in paragraph 41 that it was unclear what the Carbon Trust could achieve that central government could not. The same is true of the EST. We present proposals to simplify the public support system for new technologies in paragraph 68.

Government Departments

45. The DTI is the principal funder of energy-related RD&D, even excluding the investment by the OST through the Research Councils. The Department for Transport, the Department of Environment, Food and Rural Affairs and the Forestry Commission also fund energy RD&D.[49]

Department of Trade and Industry

46. The Energy Group, one of the five DTI Directorates, takes responsibility in Government for pursuing its objectives of energy diversity, sustainability and competitive prices.[50] It funds support programmes in new and sustainable energy, cleaner coal and oil and gas extraction. It will spend around £55 million on sustainable energy-related RD&D in 2002–03 (including capital grants), which is part of £260 million in support for renewable energy over the next three years (£10 million of which will go to the Research Councils).[51] The RD&D programme supports the early demonstration of prototype technologies (see Table 6).

[48] Unpublished memorandum from Energy Savings Trust
[49] Ev 101
[50] Ev 101
[51] Ev 118

Table 6: Examples of DTI-funded RD&D projects

Project	Technology
Funded under the DTI's Renewable Energy Programme, a Northumberland based company, The Engineering Business have successfully developed their ideas for Stingray from concept through to demonstration stage. In September 2002 a full-scale prototype weighing 180 tonnes was successfully operated on the seabed in Yell Sound, Shetland.	Tidal stream
The Beddington Zero Emissions Development in South London is a zero carbon development of 82 units, offering affordable, high quality housing incorporating photovoltaics. The DTI's contribution to the project was 25% with another 35% coming from the EU.	Solar
Funded under the DTI's Renewable Energy Programme, Cornish company Seacore has developed and built a special purpose rig, which will be used to help build the UK's first large scale commercial offshore wind farm at North Hoyle, Wales.	Offshore wind
DTI have provided grant assistance of £1.6 million under the Renewable Energy Programme to Pembrokeshire-based company Tidal Hydraulic Generators Ltd to further develop their novel tidal stream device from concept stage through to prototype testing. The device will extract useful energy from marine currents by developing and utilising water turbines mounted on the seabed to generate electricity. The planned prototype device will operate underwater for at least one year and is expected to generate an average of 200 kW.	Tidal stream
The DTI has provided grant support of £1.6 million to Ocean Power Delivery Ltd to further develops their offshore wave energy concept known as Pelamis. The aim is to build the first full-scale prototype later this year and test it at the proposed European Marine Energy Test Centre in Orkney.	Offshore wave
The DTI are providing grant support of £2.1 million for Wavegen Ltd to further develop its oscillating water column technology. This has already been successfully demonstrated as a shoreline device in Islay in Scotland. The successful development of this concept will result in a modular device which could be produced in quantity in existing manufacturing facilities and provide an additional option for exploiting wave energy.	Offshore wave

47. The DTI's rationale for supporting RD&D is that the social rates of return on RD&D energy technologies that can help to address to environmental problems are higher than private rates of return and involve lengthy development timescales, making private investment unlikely. The DTI applies seven criteria is deciding what projects to fund:[52]

- RD&D funding should be consistent with the delivery of stated DTI's Energy Group or Government policy aims and objectives, or inform the policy-making process.
- Evidence of one or more relevant market failures should be demonstrable.

[52] Ev 104

- Funding should be related to themes or opportunities identified by Foresight and contribute to wealth creation, jobs and the knowledge base.
- The principle of "additionality" should apply; i.e. the DTI's Energy Group should avoid funding activities that would otherwise be funded by industry.
- Funding should not duplicate RD&D and related activities being undertaken overseas unless there is a clear rationale for doing so—international collaboration should be used to maximum advantage and strengthen not weaken UK competitiveness.
- Funded projects and programmes should incorporate a technology transfer/deployment plan; have reasonable prospects of being developed to commercial success and/or the results can be utilised by the Government and its agents to enable it to meet its regulatory functions.
- RD&D support should have a clear industry focus; e.g. the work should be relevant to industry's needs and include their input on defining the RD&D and its evaluation.

The most contentious of these is evidence of one or more market failures. According to the Tyndall Centre, this approach assumes that the creation of new scientific and technical knowledge is the main benefit of public research, whereas in practice, there are other important benefits, such as skills training, stimulating co-operation and collaboration and the creation of new firms and industries.[53] In short, this betrays a simplistic view of the innovation process. Moreover, in waiting for proof of market failure, opportunities can be missed. The Energy White Paper recognises the interrelationship between skills, research and innovation but provides no information as to how this insight would be reflected in DTI funding policy.[54] **The DTI seems to be looking for reasons not to invest in RD&D. The Government must be doing more than filling in the gaps left by the private sector and drive forward important technologies.**

48. We are aware of criticisms that the DTI has not taken forward small projects to demonstration. Dr Nigel Brandon from Ceres Power said that "The DTI have struggled to help those few companies that are involved in [the fuel cell sector].... there is a small, focused programme that has run for a number of years for the fuel cell sector specifically and that has been useful at getting a number of UK companies involved in that sector, but time has moved on. It is about how that area can be taken beyond a few small research programmes into more of the demonstration stage. That is an area that at the moment there has not been any funding made available for".[55] Phillip Wolfe from the Intersolar Group agreed: "Quite often, there is RD&D thrust at the beginning to get a technology up and started and all of a sudden the effort comes to a grinding halt somewhere short of commercialisation. You get to the stage where you need further support to take something through to commercialisation and the response comes back, 'That is too near term in terms of the market. Industry should be paying for that'".[56] Brian Wilson denied that this was his approach and was critical of some renewable energy companies: "they have to get out of this perpetual R&D mode and into things that work and are making a contribution to the energy needs of the country".[57] TXU told us that it had funding from the DTI for its fuel cell programme but that "the procedure for obtaining support was disproportionately laborious".[58] We have had positive comments on the DTI's activities. Dr Garry Jenkins of Gazelle Wind Turbines described the SMART Award scheme (not confined to energy) as "an exemplar", although he did feel that the UK tended to focus too far ahead and leave all the development to industry.[59] **The Government has expressed its concern that the UK**

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[53] Ev 42
[54] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 7.21
[55] Qq 263–264
[56] Q 267
[57] Q 597
[58] Ev 30
[59] Ev 8

does not derive sufficient commercial benefit from the excellence of its science base. The DTI's inability to fund properly energy RD&D projects is a clear case of its policies betraying the fine words of its Ministers.

Department of Environment, Food and Rural Affairs

49. In addition to the funds channelled through DEFRA to the Carbon Trust (£4.2 million and £8 million in 2002–03 and 2003–04 respectively), the Department funds a Community Energy Scheme amounting to £20 million in 2002–03 and £30 million in 2003–04. Strictly, this does not fund RD&D but aims to install and refurbish community heating schemes, primarily using CHP. DEFRA invests £700,000 on programmes looking at the safe handling and storage of radioactive wastes.[60]

Forestry Commission

50. The Forestry Commission has an interest in energy crops, to which it contributes around £300,000 annually.

Government capital grants

51. The Government, in its consultation for the Renewables Obligation, proposed that "a small number of early commercial demonstration projects should be given additional funding in the form of grants towards the capital cost of plant construction".[61] Capital grants enable energy companies make the step from RD&D project to commercialisation. As such, their availability is an important stimulus in the development of new technologies. The distribution of DTI funding is less widely distributed between technologies than its support for RD&D, probably reflecting the maturity of the technologies (photovoltaic and wind technology; see Table 7).

Table 7: DTI expenditure on capital grants for low carbon energy technologies (£million)

	Historical expenditure			Forecast expenditure			
	1999–00	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06
Photovoltaic				2	4	7.5	6.5
Offshore wind				13	13	18.5	18.7
Community and household						4	6
Bioenergy					2		27.2
Planning facilitation						1	1.5
Clean coal	4.6	4.9	4.3	3.6	2.4	0.9	0.02
Other	0.5	0.5	0.2	4	4.17	4.12	4.1

[60] Ev 112

[61] DTI, *New & Renewable Energy: Prospects for the 21st Century—The Renewables Obligation, Preliminary Consultation*, October 2000, annex C

Other capital grants are available from the New Opportunities Fund and DEFRA (planting grants for energy crops). The Energy White Paper announced a further £60 million for the next Spending Review period (2003–04 to 2005–06).[62] In March 2003, Brian Wilson announced that £40 million would go to offshore wind projects.[63]

New Opportunities Fund

52. The New Opportunities Fund is a Lottery Distributor created to award grants to education, health and environment projects throughout the UK. The Fund runs a renewable energy programme worth £50 million over five years from 2003–04.[64] The programme has three priorities: projects generating electricity from energy crops (at least £33 million), offshore wind projects (at least £10 million) and small-scale biomass heating schemes (at least £3 million).[65]

European Commission

53. The European Commission's research funding is allocated through a series of "Framework Programmes". Energy RD&D has formed a significant part of all previous European Framework Programmes. In the Fifth Framework Programme (FP5), which ended in 2002, non-nuclear energy RD&D was supported by the a sub-programme called ENERGIE, with a budget of €1042 million over four years. Nuclear RD&D is funded through the EURATOM programme, which is part of the Framework Programme, but has a different Treaty base, meaning that it is negotiated separately from the main programme. Within EURATOM there are two programmes, nuclear fission (waste management and safety) and fusion. The budget in FP5 was €1260 million, of which fission accounted for €142 million, fusion €788 million and nuclear research at the Commission's Joint Research Centre €330 million.

54. FP6 runs from 2002–2006. It will continue to support energy RD&D through its theme on "Sustainable development, global change and ecosystems", which has a budget of around €800 million. The EURATOM programme budget will be €1230 million, with €140 million for fission and €750 million for fusion. A further €290 million will fund nuclear research at the Joint Research Centre. Although the energy RD&D budget for FP6 is smaller than FP5, the DTI believes that this is at the expense of fossil fuel research and that support for renewable energy has been maintained.[66] We will return to EURATOM funding for nuclear fusion and fission later in the report (see paragraphs 163–191)

55. There are large amounts of money potentially available to UK researchers from the Framework Programmes and tremendous opportunities. This prompted us to conduct an inquiry into"UK Science and Europe: Value for Money?", which we announced on 21 November 2002. We will reserve our conclusions and recommendations on this issue for this report but we have some observations based on the evidence we have received during this inquiry:

- the application process seems to be extremely bureaucratic and time-consuming;[67]
- the low overhead costs paid by EU grants presents problems of UK institutions;[68] and
- the emphasis on collaboration between large research teams may place the UK at a disadvantage.[69]

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[62] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.13
[63] Speech to British Wind Energy Association's Offshore Wind 2003 conference, 26 March 2003.
[64] Ev 118
[65] www.nof.org.uk
[66] Ev 105–106
[67] Q 157
[68] Q 161
[69] Q 165

56. The European Commission's Directorate-General for Energy managed a programme called ALTENER II from January 1998 until December 2002. It aimed to stimulate the development of renewable energy sources. It also encouraged both private and public investment in the production and use of renewable energy.[70]

International comparisons

57. The Chief Scientific Adviser's ERRG report attempted to make international comparisons of the UK's expenditure on energy RD&D, using data collected by British Embassies around the world to complement those produced by the International Energy Agency.[71] Although there are many gaps and estimates in the figures, UK spending on energy RD&D clearly suffers by comparison with its international competitors (see Table 8). For example, in the years 1998 and 1999, the USA spent around $2 billion, France around $600 million, Germany $300 million and the UK around $80 million.[72] The ERRG report recommends that "Spending, over time, should be brought more in line with that of our nearest industrial competitors in Europe".[73] Even if this were to occur, UK spending would compare poorly with Japan's investment, which we heard about during our visit (see Box 1). **The UK is spending much less than its competitors on energy RD&D. The PIU money and the Research Councils' new Sustainable Energy Programme provide a welcome and long-overdue boost to energy RD&D in the UK. We are pleased to see the Chief Scientific Adviser recommending further increases in the future and strongly urge the Government to make a commitment to this end over a defined period.**

[70] europa.eu.int/comm/energy
[71] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002
[72] As above, para 23
[73] As above, para 29

Table 8: Selected government R&D budgets ($million)[74]

	Conservation	Fossil fuels	Renewables	Fission/ fusion	Other	Total
Denmark (1999)	6.49	1.71	10.99	3.11	7.27	29.57
Finland (1999)	24.87	3.88	13.45	7.07	12.8	62.07
France (1999)	8.16	20.29	8.78	396.47	0.0	433.71
Germany (2001)	19.32	n/a	32.82	74.36	19.32	n/a
Italy (2000)	21.1	0	20.4	97.9	100.9	240.3
Japan (2000)	563	104.6	148.2	2531.9	232.8	3580.5
Netherlands (1999)	39.11	0.23	17.51	15.77	34.63	107.25
Norway (1999)	0.97	11.61	4.58	5.20	3.96	26.32
Portugal (1999)	0.12	0.23	0.89	0.0	0.15	1.39
Spain (1999)	8.73	0.56	13.22	13.39	0.55	36.45
Switzerland (2000)	19.9	0.72	35.5	27.1	29.28	112.5
UK (2000)	7.19	5.80	11.18	16.75	23.16	64.08
USA (2000)	550	96.2	113.77	157.92	n/a	n/a

[74] Source: International Energy Agency Energy Technology R&D Statistics Service; OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, page 37. n/a = data not available

Box 1: Japanese investment in energy RD&D

Japan's energy RD&D and deployment is overseen by the Government's Ministry of Economy, Trade and Industry, which sets out the basic policy and its budget. The policies are implemented principally by two agencies: the New Energy and Industrial Technology Development Organisation (NEDO) and the New Energy Foundation (NEF). Both were set up in 1980 as a response to the second oil crisis. NEDO is a semi-governmental body that funds the technological development of new energy technologies and their deployment in the industrial and public sectors. Its renewable energy budget in 2001 was ¥172 billion (around £900 million), of which ¥76 billion is spent on introduction and dissemination. On the RD&D side, ¥7.1 billion was spent on wind and solar, ¥12 billion on fuel cells and ¥5 billion on geothermal. Fuel cells are a major concern and NEDO's programme has defined development targets for different fuel cell technologies, including those using hydrogen fuel. Much of the funding goes to subsidise research being undertaken in industry, which we witnessed at Sanyo and Osaka Gas. NEF is a non-profit organisation which promotes deployment of renewable technologies and has an important role in maintaining an overall view of the development and deployment of technologies. It also administers the Government's residential photovoltaic subsidy scheme. In 2001 this subsidy amounted to ¥23.5 billion.

Nuclear fission and fusion research is undertaken by the Japan Atomic Energy Research Institute (JAERI). Its budget was ¥121 billion in 2001–02 (around £640 million, which is invested in nuclear safety, new reactor technologies and materials, and fusion. Japan is one of the countries bidding to host ITER (see paragraphs 184-–191).

Collaboration and cohesion

58. There is concern that the large number of public funding bodies results in a lack of cohesion between the different initiatives and policies. The evidence we have received from these bodies shows them to be at great pains to explain how closely they work together. We were told of the Inter Departmental Group on Energy Crops, led by DEFRA.[75] The Research Councils seem to run a large number of joint schemes both between themselves and in collaboration with other bodies such as the Carbon Trust. These are worthy ventures and while they may make perfect sense to civil servants in Swindon and Whitehall, we doubt that this view would be shared by the RD&D community in either the public or private sectors. Professor Acres told us "There are too many Government agencies involved in this area and the picture is confusing".[76] Professor Ian Fells, Chairman of the New and Renewable Energy Centre in Northumberland, wonders how Government Departments can develop a coherent strategy: "I see no sign of any coordination in their disparate approaches, nor does there seem to be any coordination with Ofgem".[77] This view is shared by TXU which believes that "it would be very helpful to make granting and support mechanisms for RD&D in low carbon technology simpler and clearer. Currently there appear to be a wide variety of granting initiatives underway from a multiplicity of agencies and government departments. It is often difficult to identify what is available and where to find out about it".[78]

59. The DTI has also been criticised for viewing projects seeking funding as either too close to market or too speculative. Dr Andrew Garrad, a wind energy consultant, told us "if you try to gain money from the DTI for RD&D in wind, it is either too commercial or

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[75] Ev 105
[76] Q 157
[77] Ev 6
[78] Ev 28

not commercial enough. We find it virtually impossible to find a meaningful route through the present DTI projects".[79] The EPSRC clearly has its own view of where its remit ends and the DTI's begins.[80] We note Peter Hedges' comment that "We are conscious that in the past our programmes have not been as well integrated with the DTI's programmes as they could have been". The EPSRC seems confident that the UK Energy Research Centre will result in "greater co-ordination between the different funding agencies with different responsibilities".[81]

60. The Government set up in 2002 (meeting first in October), a group headed by Sir David King with high-level representatives from public energy funding bodies including Departments, Research Councils, the Carbon Trust and the Energy Savings Trust. It aims to improve the coordination of research and ensure that research that is funded is in accordance with the recommendations of the ERRG report.[82] We welcome this new initiative to improve the coordination of energy research funding but we are concerned about its reliance on the ERRG report for its guidance. The group admits that its review "had raised many relevant issues which it had not had time to explore fully in the short time available for its work" and that their "recommendations, if accepted, will need to be filled out by further detailed work, which is beyond the scope or our immediate remit".[83] It would be unwise for the Government to base its energy RD&D strategy on a short study based on three meetings. In relation to fuel cells, the Carbon Trust told us it was considering, with the Department for Transport and the DTI, setting up an "entry portal" to simplify the process whereby prospective applicants for RD&D support apply for Government funding.[84] Fuel Cells UK, announced in the Energy White Paper, does not seem to embrace this function. **We support the idea of a single entry portal for those seeking support for RD&D in fuel cells, but believe there is merit in extending the concept to embrace all new energy technologies.**

61. Sir David King seems to have high hopes for the UK Energy Research Centre, providing linkages between different research activities, not least with economists and social sciences.[85] **The coordination of public funding bodies and research policy in the field of energy RD&D has been poor. We shall be monitoring the progress of Government and the Research Councils in improving coordination with great interest. The establishment of a UK Energy Research Centre is a step forward but we have little confidence that it has the remit to solve the problem.**

Prioritisation

62. There is a tension in energy RD&D funding between providing broad support for a range of technologies and funding certain promising technologies selectively. It is unfortunate that the latter option has been branded as "picking winners" as this obscures the debate about how much support individual technologies justify. It is our view that Government does have a role in giving priority to those energy technologies where the UK has strengths, in terms of resource, skills and knowledge, and which have a chance of delivering real benefits, avoiding the danger of spreading modest resources too thinly. We were pleased to see the ERRG report identify six priority areas for research, which Sir David King terms his "broad menu approach",[86] even if we do not necessarily agree with them. Of course, the Government does prioritise. Looking at its planned energy RD&D

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[79] Q 265
[80] Qq 33–37
[81] Q 37
[82] Ev 102
[83] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, p 2
[84] Ev 63
[85] Q 574
[86] Q 568

expenditure for the next few years (see Table 1), it clear that the Government thinks that solar and biomass are high priorities.

63. In its review of UK energy policy, the International Energy Agency describes the UK's RD&D policy as "mature and circumspect" but suggests that "the priority and focus among the Government's various RD&D objectives and programmes could benefit from further clarification of the respective roles of government and industry to efficiently facilitate the deployment of new technologies". It also argues that the UK should clarify the priority of different technology areas.[87]

64. Not only is Japanese expenditure far higher than the UK's ($3580 million in 2000): it is also more targeted.[88] It supports a handful of technologies—nuclear fission and fusion, photovoltaics, fuel cells and energy efficiency—but gives less attention to wind, and very little to offshore technologies (see Box 1). As a result, in some of these technologies Japan is a world leader and has the largest amount of installed photovoltaics in the world.[89] We appreciate the pitfalls, however. We were impressed by the scale of Japan's fuel cell programme but we were interested in Dr Nigel Brandon's view in this context that "There are a number of technology programmes around the world, a number of them in large corporations, where the approach taken will never result in a cost effective product in today's climate".[90]

65. We appreciate the Government's nervousness about saddling the wrong horse. It would be roundly condemned if it were to put millions into a technology which the market would not support. One need look no further than the nuclear industry for instances where this has occurred. Nevertheless, **it is reasonable to ask how the Government can have an energy RD&D policy that does not embrace a vision of which technologies should be backed.** If the Government is worried about getting its fingers burnt, the Danish experience with wind technologies is one that it would do well to study (see Box 2). One cannot find a 'winner' without picking some losers: finding solutions to problems requires the research community to explore all reasonable paths in often unknown and risky territories, and inevitably some will be dead ends or 'dry holes'. Thus risks have to be taken; the right strategy is to pull out once an option has been explored and is a proven 'loser'. **The Government has the option of creating a framework of incentives, such as tax credits for RD&D, which will devolve the responsibility for picking winners (and inevitably some losers) to industry; but it also has to make choices and take risks too, especially in its support for RD&D, where it cannot avoid setting some priorities. The Government has an important role in identifying those of Britain's strengths that are consistent with the industrial environment and the market. It should provide a clear and unambiguous focus.**

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[87] International Energy Agency, *Energy Policies of IEA Countries: The United Kingdom 2002 Review*, pp 42–143
[88] Ev 120
[89] Data presented to us by the New Energy Foundation during our visit to Japan in September 2002.
[90] Q 293

Box 2: The Danish experience
Denmark currently generates 18% of its electricity from wind and is responsible for over 10% of the EU's wind generation.[91] It is the largest manufacturer of wind turbines, responsible for around 60% of global sales. Demark has achieved this by introducing a number of Government incentives, which have been introduced through a series of energy strategies dating back to the oil crisis of 1973–74. The current scheme, Energy 21, was launched in 1996 and lays down the policy agenda until 2030. Danish schemes both stimulate demand and technological development.[92]

Windmill Law
This law requires electric utilities to purchase output from private wind turbine owners at 85% of the consumer price of electricity plus ecotax relief or about Krone 0.62 per kWh. Electric utilities receive Krone 0.10 per kWh production subsidy for power generated by wind.

Export Assistance
The Danish International Development Agency provides both direct grants and project development loans to qualified importing countries such as India.

Grass-roots development
Individual farmers or cooperatives have been given incentives to develop small wind clusters and utilities have been required to connect any new wind generation to the distribution grid. The cost of grid connection is split between the wind turbine owners and the electric utilities.

Research, Development and Demonstration
The Danish Government has long supported development of technology for its manufacturing industry. Between 1976 and 1996 period, total RD&D funding was about Krone 350 million (around £30 million). Demonstration projects received about Krone 170 million (around £15 million) over the same time period.

66. EPSRC also seemed shy on the subject of prioritisation. Looking at its expenditure, it is clear that of the low carbon technologies, photovoltaics and fuel cells are getting significantly more funding that some other technologies such as wind or even wave and tidal, which exploit the UK's natural resources.[93] EPSRC should be more forthright about why it has decided to support some technologies and not others.

67. **The Government seems nervous of being accused of picking winners. As a result tough decisions have been avoided. We should be selecting all of those research projects for funding which we have the capacity to execute and which have a reasonable chance of delivering solutions and significant benefit for UK society.**

68. In the course of this inquiry we have encountered a large number of Government bodies with interests in energy. We asked Brian Wilson whether he had considered re-forming a Department of Energy. He said that it had been abolished "for ideological reasons" but that "energy is dispersed among various Departments ... there will a lot of virtue in bringing it together". He went on "everything I do suggests to me there are too many organisations with functions which are not all that dissimilar and which is a maze for people to find their way through, and they are organisations with big budgets". It is therefore extremely surprising that a Department of Energy was "not really considered at

[91] European Wind Energy Association briefing, November 2002, www.ewea.org
[92] International Energy Agency, *Wind Energy Annual 2000*, pp 67–82
[93] Ev 76

any length".[94] We are disappointed that this idea did not warrant more serious consideration, particularly given this Government's enthusiasm for shifting departmental boundaries. **Britain's energy structures are too complicated. As a result, efforts to stimulate RD&D are fragmented and directionless. No public body or Minister is taking responsibility for driving forward technological innovation and deployment. Much bolder action is needed to make non-carbon technologies play a significant contribution to the UK's energy mix. For this reason, we recommend the creation of a Renewable Energy Authority. It should emulate the function of UKAEA in driving the nuclear industry after the World War II. The Authority would subsume the UKERC and the Carbon Trust, the DTI's energy programme and the energy policy unit. It would:**

- **conduct applied research and development in selected technologies;**
- **conduct demonstration programmes, usually but not exclusively in collaboration with industry;**
- **provide a fast-track planning service to non-carbon energy applications; and**
- **supervise infrastructural modifications to the grid and distribution netwoks to facilitate the connection of distributed generation.**

PRIVATE SECTOR RD&D

69. Our report makes recommendations to the Government and our inquiry's focus has been on its policies and expenditure. The inquiry would not be complete, however, without an assessment of the low and non-carbon energy RD&D being undertaken by the private sector. It is not appropriate to generalise too much about different types of energy company and the conclusions we have drawn are based on those companies who submitted evidence.

70. Before privatisation in the early 1990s British Gas and the Central Electricity Generating Board had corporate RD&D facilities that conducted a large amount of energy RD&D. This has declined dramatically. According to the Tyndall Centre, in the 1970s and 1980s, public expenditure of RD&D was typically several hundred million pounds, and much of this would have been conducted in these laboratories. For example, British Gas typically spent around £70 million before privatisation. Lattice, which took over most of British Gas's research functions spent £14 million in the 15 months to March 2002.[95] In 2000 nine companies invested a total of just over £130 million in RD&D. The 'nuclear' companies, BNFL and British Energy, contributed just under half of the total expenditure in the sector. The ERRG suggested that privatisation and a more market-oriented business strategy has resulted in less of energy RD&D conducted by UK industry.[96] This view is supported by several witnesses. The Advanced Power Generation Technology Forum, a Foresight Associate Programme, comments that privatisation has had a "negative effect" on RD&D, claiming that the generation companies "are increasingly risk averse".[97] Professor Ian Fells from the New and Renewable Energy Centre in Newcastle argues that the liberalisation of the energy market has "wholly malign" effect on RD&D.[98] The Institution of Electrical Engineers agrees, stating that with exception of some RD&D to meet the Renewables Obligation, there is no incentive.[99] The evidence from the Building Research Establishment (BRE) in relation to energy efficiency is similarly forthright:[100]

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[94] Q 578
[95] Ev 40–41
[96] Ev 107
[97] Ev 18
[98] Ev 6
[99] Ev 23
[100] Ev 136

> "Privatisation of the gas and electricity utilities has resulted in a catastrophic loss of a number of major centres of expertise in the UK associated with energy utilisation research. Energy price reductions, although advantageous to the economy, have had the effect of reducing interest in developing new energy sources and improving energy efficiency".

71. The Government disagrees, attributing this decline in expenditure to the maturation of a range of important technologies and a shift to energy providers in the North Sea and the renewables sector.[101] In this case the reduction in expenditure might have been expected, yet a discussion paper produced for the Government's PIU noted in 2001 that "It was ... anticipated that a liberalised market might be more open to innovation in meeting customer needs than a monopoly". However, it said that "Liberalisation introduced commercial competition to the R&D process and with it, improved efficiency in the allocation of resources. However, there were costs associated with this and R&D budgets have seen substantial reductions. Moreover, there is some evidence that increased competition has shortened the time horizons for R&D expenditure creating a focus on short-term commercial goals rather than long-term investment.".[102] **We are puzzled by the Government's assertion that privatisation and liberalisation has not led directly to a decline in energy RD&D—it has led to a dramatic decline, by far the largest decline in all OECD countries. The forces that drove innovation in the past are at least as strong as they ever were and it seems hard to believe that the Chief Scientific Adviser's energy group and several of our witnesses are so ill-informed. We are concerned that the Government is poorly placed to stimulate energy RD&D investment in industry if it is in a state of denial over its causes.**

72. More efficiently run private enterprises may have streamlined their RD&D effort and improved its focus. Brian Count of Innogy told us that research conducted by the CEGB (Central Electricity Generating Board) was muddled and that it "developed many ranges of steam technology and ... almost nothing of that is world competitive".[103] The PIU concluded in 2001 that "The CEGB's system of innovation was inefficient with significant levels of research funding being wasted through lack of proper controls and monitoring and inadequate financial commitments by manufacturers".[104] **The fall in private sector RD&D expenditure has been higher than would have been expected from simply improving its focus. We conclude that there has been a real and damaging reduction in the amount of private energy RD&D spend since privatisation and liberalisation of the market.**

Generators

73. We took oral evidence from Innogy, Powergen, British Energy and BNFL and received written evidence from TXU, before its UK operation was purchased by Powergen. Of these, only BNFL is investing significant sums in new generation technologies (see paragraphs 163–180 below). It is our impression that generating companies are doing very little beyond improving efficiency of existing power plants or positioning themselves as informed purchasers of technology. The RD&D facility at Powergen is interesting, as it is a self-contained business unit, Power Technology, within the company. We do not doubt that this provides a valuable service to its customers, but hardly demonstrates an attempt to provide Powergen with the technologies it will need in the future. Indeed, Power Technology's Director, Dr Derrick Farthing, reckoned that only £3 million was spent on

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[101] Ev 107
[102] PIU, *Discussion Paper: Electricity Market Liberalisation and Innovation in a Carbon-Constrained World*, November 2001, paras 9, 37
[103] Q 190
[104] PIU, *Resource productivity: making more with less. Annex J: Electricity market liberalisation and innovation in a carbon-constrained world*, The Cabinet Office, November 2001, p 107

pure RD&D.[105] Innogy's electricity storage technology Regenesis is more interesting but it is revealing that Chief Executive Brian Count says that "I do not believe that electricity companies are set up to be developers of technologies or manufacturers of technologies".[106]

74. We note that all the companies from whom we received evidence from had interests in wind power, but as purchasers not as developers of the technology. This interest, as Dr Christopher Anastasi of British Energy made clear, is driven by the Renewables Obligation (see paragraph 207–208): "We have to have 10% of [our supply] by 2010 in renewables or pay the penalty. The quickest way to do that is to build wind and that is what most people are tending to follow".[107]

Electricity transmission and distribution companies

75. The electricity transmission system in the UK is comprised of four high voltage grids (400kV and 275kV): one in England and Wales (the National Grid Company), two in Scotland and one in Northern Ireland. A number of Distribution Network Operators (DNOs) link the grids to consumers using lower voltage connections (132kV and lower).[108] They have no direct role in the generation of non-carbon sources of energy but there are a number of physical features of the electricity transmission system that impede the greater use of low and non-carbon sources of energy. Many of these are not constrained by technology. For example, the transmission system evolved to transmit electricity large generators to consumers, in one direction. Many non-carbon sources of energy are diffuse and situated a long way from major urban areas.[109] As a result, modifications to the system are necessary: this requires massive capital investment but there are no technical barriers. Also, there are features of the market and its regulation at least as important in bringing power generated by renewables onto the system. These are dealt with in paragraphs 198-–214.

National Grid

76. Conventional power stations hold stocks of fuel and can generate at will to meet demand almost instantaneously. Some renewable sources of energy, notably wind and solar, suffer from intermittency, which provides challenges for the grid companies, as discussed in detail by the Trade and Industry Committee's report on Security of Energy Supply.[110] The National Grid has the responsibility of balancing supply and demand but it has stated that no major changes to the grid would be required if 10% of electricity were generated from renewable sources, and that there is no technical ceiling to the use of renewables.[111] Nevertheless, we do have concerns about the level of RD&D being undertaken by National Grid. At £5 million it represents 0.5% of the company's turnover. We accept that it is a capital intensive company and that it purchases new technologies from suppliers. Its RD&D spend is still very low, however. Dr Lewis Dale, the company's Regulatory Strategy Manager, admits that the grid is ageing, with some components 50 years old.[112] He said that much of the RD&D looked at how the grid aged. We feel that some of this money would be better directed at finding innovative and efficient means of controlling the network and transmitting electricity, and researching techniques to minimise losses (currently 1.5% of generated electricity[113]). In its evidence to us, National Grid outlined their funding of

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[105] Q 187
[106] Q 190
[107] Q 319
[108] Ev 124
[109] Q 444
[110] Second Report of the Trade and Industry Committee, Session 2001–2002, *Security of Energy Supply*, HC 364, para 33–43
[111] Q 444
[112] Q 448–449
[113] DTI, *Transmission Losses in a GB Electricity Market*, a consultation paper, January 2003

EPSRC's SUPERGEN initiative (see paragraph 27 above) and in establishing the National High Voltage Research Centre at UMIST.[114] Its investment in these research programmes is admirable but the amounts involved (£800,000) are modest.

Distribution network operators

77. Renewable sources of energy are typically diffuse with many generation facilities producing much lower outputs. It is more appropriate for such facilities to connect to the lower voltage networks. This "embedded generation" raises technical issues (and indeed financial ones). Embedded generators provide electricity into the system where it was not originally expected. This poses particular problems with intermittent sources such as wind energy as the power flow will depend on whether the wind is blowing or not.[115]

78. A promising strategy for delivering reductions in CO_2 emissions is for domestic users or communities to generate their own electricity, using technologies such as CHP, photovoltaics, wind or energy from waste. A key part of such a strategy is making it financially viable for the user to sell surplus power back to the area's supplier. This raises technical problems. Domestic users need to run appliances from a stable and standard voltage and unreliable inputs to the network would disturb this stability. Furthermore, metering systems would be required to establish the net usage or supply of power. According to United Utilities, these present more fundamental problems than strengthening the networks to allow new generation to connect.[116] We were pleased to learn from the Energy White Paper that the Government is "exploring the scope for developing simpler metering arrangements to help micro generators (including solar PV) obtain a fair value for the surplus electricity they export to the grid".[117]

79. Despite the fact that many of the technical solutions to the connection of distributed sources of energy are known, it is less clear how these solutions will be applied in practice. United Utilities has called for a programme of demonstration projects, saying that they "are not alone in being confused as to how to seek assistance in developing these solutions into practical workaday applications".[118] This seems a practical way forward. **We recommend that the Government establish demonstration projects to establish how distributed sources of electricity generation can be incorporated into local networks, in particular the development of metering systems to allow domestic generation to export power to the network.**

80. United Utilities rightly recognises the value of non-technical research into commercial and regulatory initiatives for distribution networks. We recommend that the Economic and Social Research Council make provision for such studies.

Engineering and technology companies

81. In the 1980s energy innovation was focused within the nationalised industries rather than UK equipment manufacturers. When the market was liberalised, the burden of innovation shifted towards engineering and technology companies. There were few UK companies to take things forward, and these were slow to adapt to the new environment. Foreign-owned companies such as GE, Siemens, Alstom and ABB, who at the time had firm bases in unliberalised markets, were able to take advantage.[119]

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[114] Ev 125

[115] Second Report of the Trade and Industry Committee, session 2001–2002, *Security of Energy Supply*, HC 364, para 38

[116] Ev 140

[117] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.56

[118] Ev 140

[119] PIU, *Discussion Paper: Electricity Market Liberalisation and Innovation in a Carbon-Constrained World*, November 2001, para 15

82. A discussion paper produced for the PIU argued in 2001 that "While electricity companies cannot be expected to carry out technology RD&D alone, as the franchise holders for the monopoly networks, they need to provide a framework that enables innovative technology".[120] It is our view that energy RD&D burden has fallen too heavily on engineering and technology companies. **We appreciate the commercial constraints on companies and recommend that the Government and the regulator work to create a better environment for RD&D.**

Fuel companies

83. We received evidence from Shell and BP. They come first and second in the Government's RD&D Scoreboard for RD&D expenditure in their sector, investing £267 million and £266 million in 2001, although not necessarily invested in the UK.[121]

84. BP's RD&D spending on non-carbon energy is directed at three main areas: carbon capture and storage, hydrogen and solar. It is developing a small number of wind projects in addition.[122] BP makes clear that while it collaborates with a number of academic research groups, its own RD&D is market-led. Basic research, it stresses, is matter of public investment and should be conducted as an end in itself. Shell has a similar focus. According to its evidence, it has interests in carbon sequestration, hydrogen and fuel cells, and biofuels.[123] A look at its website also indicates an interest in solar and wind.[124]

85. A surprising omission from both companies is any activity in marine renewable technologies such as offshore wind, wave and tidal. Our predecessor Committee found that one of the UK's great strengths to be in marine engineering stemming from the North Sea oil and gas industry.[125] We asked Shell and BP what plans they had to apply their experience in offshore technologies to marine energy technologies. Mr John Mumford of BP said "We would certainly consider it" and "It is an area that we have some expertise in, clearly, but at the moment we are not doing anything in BP of a demonstration nature in that area".[126] Dr Bernard Bulkin, Chief Scientist at BP, went on: "If a company like BP or Shell proposed to build such a structure in the sea for any part of our business we would be roundly castigated in the press for disturbing the sub-sea environment". This is a pity. Undoubtedly, environmental groups would have concerns but they should have more confidence in the public's ability to weigh up the merits of the case. Brian Wilson, in giving evidence to us, said that we thought synergies would develop between companies active in the North Sea and those developing marine energy technologies: "There are some interesting projects coming forward".[127] He did not, however, reveal any incentives that would help the process. **It is disappointing that the UK's experience in the North Sea oil and gas industry is not being employed to develop new marine energy technologies. Clearly the incentives for oil and gas companies are insufficient, a situation which the Government should remedy.**

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[120] PIU, *Discussion Paper: Electricity Market Liberalisation and Innovation in a Carbon-Constrained World*, November 2001, para 12
[121] RD&D Scoreboard, www.innovation.gov.uk
[122] Ev 96
[123] Ev 97–100
[124] www.shell.com/renewables
[125] Seventh Report of the Science and Technology Committee, session 2000–2001, *Wave and Tidal Energy*, HC 291, paras 40–41
[126] Qq 541–542
[127] Q 583

Renewables SMEs

86. Renewable technologies can be at very different stages of development. The RD&D contribution to research will be considered in discussions on each technology in paragraphs 115–162.

Government incentives

87. Between 1981 and 1998 total UK private sector spend on RD&D fell from 1.5% to 1.2% of GDP, and a large proportion of the total (37%) is undertaken by the pharmaceutical sector. Total UK RD&D expenditure was 1.8% of GDP in 1998. This compares with 2.5% in the US and 3% in Japan.[128] The last two spending reviews have included substantial, real-terms increases in public expenditure. In contrast, private sector RD&D spend has changed little in recent years. The European Commission, supported by the UK, has stated an aspiration that total RD&D spend in the EU should reach 3% of GDP by 2010, with two thirds from private sources.[129] Outside the pharmaceutical sector, the oil and gas companies perform well in the RD&D scoreboard but elsewhere in the energy sector investment is not so high. **We are pleased that the UK Government supports an EU target of 3% of GDP invested in RD&D but given the strong link between investment and productivity, we are disappointed that it has not adopted this "aspiration" for the UK. We recommend that the Government does so.**

88. The lack of private RD&D investment is barely recognised in the White Paper. The Government says it will "work to create a policy environment that encourages the private sector to bring the key technologies forward, and play a key role in the delivery of major new infrastructure".[130] It announces new money for capital grants to bring laboratory research to the market, which is welcome, but nothing to provide new incentives for industry to invest its own money in RD&D. This is a regrettable. Tom Delay, Chief Executive of the Carbon Trust, told us that to get anywhere near to 20% renewable generation billions of pounds of private investment in innovation would be required and that this is "very hard to envisage at the moment".[131] Sir David King told us that, of the £100 million going into the DTI's LINK programme, over half was from industry.[132] He felt that the £28 million going into the Research Councils' Sustainable Energy Programme would have the same effect in providing leverage from the private sector. To get anywhere near to the billions of pounds mentioned by Mr Delay a huge amount of leveraging will required. Brian Wilson told us that a liberalised energy market in Europe would force companies to invest in RD&D through self-interest.[133] Given the effect of liberalisation on the UK market it is clear to us that this is unrealistic.

89. Government encouragement for companies to conduct RD&D falls into two categories: direct incentives such as the RD&D tax credit; and indirect incentives that create a fiscal and technological environment in which RD&D investment is more likely. The latter category, including Renewables Obligation and the Climate Change Levy will be considered later.

90. An RD&D Tax Credit for SMEs was introduced in April 2000. The Chancellor said it would underwrite almost one third of research and development costs for small business.[134] In the 2000 Budget the Chancellor announced that this would be extended to

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[128] DTI, *Our Competitive Future: Building the Knowledge Economy*, December 1998, Cm 4176, para 2.32
[129] Barcelona European Council, 15–16 March 2002
[130] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 7.28
[131] Qq 254–255
[132] Q 577
[133] Q 612
[134] www.dti.gov.uk/support/taxcredit.htm

larger companies, albeit with relief at 125% (as opposed to 150% for SMEs). This came into force in April 2002.[135] We asked our witnesses for their views on this initiative and to what extent it had changed, or is likely to change their RD&D investment strategy. Dr Bernard Bulkin, Chief Scientist at BP, welcomed the tax credit, but stated that "It has not been the force that drives us to where we do our RD&D".[136] He commented that the cost of conducting RD&D in China is a quarter of that in the UK or the US. Sir David King insisted that it was too early to determine the effect of the tax credit but that "there is now ... a much greater degree of willingness to look into this issue.[137]

91. For other energy companies the tax credit is purely hypothetical. As Powergen pointed out, if you have no taxable profits then it will make little difference, and it would rather the Government provided cash payments.[138] Given that a feature of the energy market is difficulty for companies, particularly the generators, to make any money, the tax credit is particularly ill-suited as a stimulus for innovation in this sector. **The Government should recognise that even companies not regularly making a profit need to think long term and invest in RD&D and should consider introducing mechanisms that provide that incentive.**

92. Of equal concern to us is the complexity of the rules. In giving evidence to us, neither Innogy nor Powergen seemed particularly sure as to what qualified under the tax credit's rules and what did not.[139] Private companies are not usually reluctant to employ the tax system to their benefit. Don Spearman from Vent-Axia also revealed hesitancy over what would qualify for the tax credit. He had only just heard of it when he came in to give evidence: "I took it through to our accountant and he told me that our group company had considered the sort of work that we were involved with and felt that it was not appropriate and I told him to go back and ask again".[140] **The existence and nature of R&D tax credits are not well understood by companies—particularly the smaller ones—and the rules of the R&D tax credit seem to be too complicated or inadequately explained. The Government should remedy these problems, since if energy RD&D is to be resuscitated in the UK in the field of low carbon technologies, a clear and significant tax incentive is much-needed.**

93. A combination of EU rules on state aid and the Government's unwillingness to interfere with the market has meant that the Government has been unwilling to intervene to fund RD&D in industry.[141] The Japanese Government is more interventionist. The DTI's policy of not supporting research that is close to market or should be conducted by industry contrasts with Japanese companies being subsidised heavily to conduct research on priority technologies. We were struck that while Japanese industry has a impressive record of conducting RD&D, it was clear from our discussions that much of the research conducted by companies such as Sanyo in photovoltaics and fuel cells would not be taken on in the absence of Japanese Government funding and subsidies for installation. Given the more benign energy market in Japan, it is not surprising that UK industries are hesitant about investing in RD&D. **The Government has failed to encourage an environment that encourages technical innovation, to provide sufficient direct investments and to make any significant response to the scale of market failure.**

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[135] HM Treasury, *Budget Report 2002*, April 2002, paras 3.54–3.58
[136] Q 540
[137] Q 579
[138] Ev 166
[139] Qq 205–206, Ev 166
[140] Q 504
[141] DTI, *European Community State Aids*, June 2001

SKILLS

94. Concern about the supply of skilled people is at two levels: that which is energy or even technology-specific, and that relates to scientists and engineers more generally. The more general issue about the supply of scientists and engineers was considered by Sir Gareth Roberts in his review published in April 2002.[142] Sir Gareth found that there was a problem, with fewer people choosing to study science and engineering, and one which was particularly serious in the physical sciences. He identified a series of measures, including increased payment to postgraduate and postdoctoral researchers.

95. In the course of this inquiry we have sought to establish to what extent skills shortages are affecting energy RD&D and the industry more generally. According to the Government, the energy sector is skewed towards older people. Apart from the more general issue about the supply of scientists and engineers, it identified three reasons for this:

- the traditional routes of entry—apprenticeships or graduate traineeships with big employers such as the CEGB, Gas Board, ICI etc—have disappeared;
- the sector is perceived to be in decline and is unpopular with young people;
- past recruitment moratoria have produced gaps in the age structure.

The Government concludes that "current levels of recruitment are a fraction of what is required to replace the workforce".[143]

96. The problem has been most clearly identified by the Tyndall Centre, which undertakes transdisciplinary research into climate change. The Centre's Director, Professor Mike Hulme has found, over the last two years, "difficulty in recruiting suitably skilled and qualified researchers to work, particularly on our energy related projects. This is not a problem that we find in the environmental and social side of our research".[144]

97. Among the measures being taken by the Government are the retraining of redundant steel workers as gas installers and the introduction of more modern apprenticeships. It also points to the significant investment by the EPSRC in doctoral and masters training in low/non-carbon energy.[145] We are puzzled by this latter point as the evidence submitted by the EPSRC suggested a decline, not an increase in PhD studentships in non-carbon energy. In 2001–02 there were 21 new studentships, only half the figure in the preceding two years.[146] In response to our query, Dr Peter Hedges told us "The numbers do vary a little bit and the indiction in the figures is that numbers are going down. My guess is that if you had figures for the following year they may be going up".[147] When the EPSRC supplied the project studentship figures for 2002–03, we found that the figures had not gone up at all.[148]

98. This is all the more curious since Dr David Lynn from NERC described the skills issue as "something which concerns all of us as research councils".[149] Professor O'Reilly told us "Skills is a very big issue. It is a big issue for EPSRC and it is a lot of what we do. It is certainly the case that we need to put a big focus on skills".[150] Of course postgraduate training is only one part of the solution but we are disappointed to see so little commitment to it in the past, the effects of which we are now seeing in the workplace. We are slightly

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[142] HM Treasury, *SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review*, April 2002
[143] Ev 103
[144] Q 129
[145] Ev 103–104
[146] Ev 74
[147] Q 45
[148] Ev 159
[149] Q 83
[150] Q 42

reassured to see the skills issue mentioned in the Research Councils' submission on the proposed UK Energy Research Centre as part of its role in building research capacity.[151] The Centre and Network could facilitate much of the "discipline hopping" identified as being so important by Professor Hulme.[152] **The proposed UK Energy Research Centre and Network should play a crucial role in bringing forward the next generation of skilled people for the energy sector. We recommend that it adopt this as a key part of its mission.**

99. The ERRG report recommended that UK public energy RD&D investment was brought in line with its nearest EU competitors.[153] It would be deplorable if this aspiration were thwarted, not by Government parsimony, but by the lack of people available to do the job. In the 2002 Spending Review, the Government announced an increase in the PhD stipend with above average rises in areas where recruitment is difficult.[154] While lack of skilled people can hamper investment, it is equally true that lack of investment limits the opportunities for training. The BRE makes this point forcefully in relation to energy efficiency technologies: "The under-funding by Government and its agencies of this vital area of research has resulted in a chronic shortage of appropriately qualified researchers and technology transfer specialists".[155] **We recommend that the Government recognises low and non-carbon energy as a shortage area, recognising its importance in combating climate change.**

100. The problems faced by companies in recruiting skilled people have been keenly felt by many of our witnesses:

- Dr Andrew Garrad: "We have recently been advertising for people and we have received pretty well zero applicants with any experience". As a result his company has been forced to continue to do its own training in-house or recruit from overseas.[156]

- Mr John Acton of Compact Power: "We are particularly short of experienced and even at postgraduate level chemical engineers and process engineers in particular".[157]

- Dr Derrick Farthing from Powergen: "if we want to recruit somebody with energy industry know-how, often we find that there are any number of graduates, but there are not the right graduates that actually have the knowledge that we need".[158]

101. There are signs that shortages in some skills will prove an obstacle in achieving the Government's renewable energy targets. Professor Robin Maclaren from Scottish Power identifies it as something we need to address: "we have a fairly low number of power engineering graduates come out and in research and development as well—and with the challenge that faces us for renewables over the next 20/30 years I do think we need to increase the output of technically capable people".[159] Professor Goran Strbac of UMIST highlighted skills as a problem in connecting embedded generation to the grid, an important element in increasing the input from renewable energy sources: "it is now very clear that ... industry will find it difficult just to continue business as usual, never mind the challenges which we have got in front of us".[160]

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[151] Ev 137
[152] Q 131
[153] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, p 1
[154] OST, *The Science Budget 2003–04 to 2005–06*, p 12
[155] Ev 135
[156] Q 276
[157] Q 278
[158] Q 198
[159] Q 446
[160] Q 181

102. The larger energy companies are in a position to tackle the problems themselves. Shell, which admits it let things slip, has introduced a range of collaborations with universities. It also helps to have an established name with a reputation, according to Dr Martin Booth: " We are lucky in that we get some of the best ones, particularly the pre-university students where word gets around that we have a good scheme and that exposes them to the sort of things we are doing in my particular area of transportation fuels which helps to attract them".[161] Dr Bulkin agreed that Shell and BP were in a strong position but pointed out that there was very strong competition for chemical engineering graduates since it was a very demanding degree and few students had the aptitude.[162]

103. We are delighted that the picture in wave and tidal power is more positive. Dr Tony Trapp from the Engineering Business told us "Twelve per cent of our staff have PhDs and another 10 per cent have first-class honours degrees... We advertised recently and I think we got about 300 applicants out of which we were able to select half a dozen people that we employed. We work very closely with a number of universities, particularly Newcastle University, and we take students on placements. We then transfer them and they come and work for us. It works out well".[163] Young people are clearly attracted by the opportunity of working in the sustainable energy industry.

Nuclear skills

104. The state of the nuclear sector, the uncertainty over its future and the unpopularity of engineering and physical science among students has led to concerns about the availability of skilled people to the industry. The sector is likely to grow, even without new-build, primarily in the clean-up area. Responding to potential growth, without new build, and replacing people leaving the sector on retirement means that the sector may need to recruit 1,000 graduates and 530 apprentices per year.[164]

105. The DTI's nuclear skills report was published in December 2002.[165] It found that 56,000 were employed in defence, power generation, fuel cycle and clean up. It found that there was no immediate problem in the energy sector but there was cause for concern. Among its recommendations were that the industry should encourage industry support of education, training and research and that the Government should establish a Nuclear Skills Task Group to forge collaboration between employers across the sector. BNFL, in response to the dwindling nuclear skills base, set up University Research Alliances which have created 140 positions in four universities. BNFL's Dr Robin Clegg pointed out, however, that all these researchers were working on safety and current systems. Mr Kevin Routledge said NNC had been able to recruit all the graduates they needed but that "there are a lot less science graduates around now so everybody is scrambling for the same people. The other problem is they are not coming out with any nuclear skills whatsoever so we are having to do all the training in-house".[166] Dr Chris Anastasi said British Energy faced a similar problem: "Last year we recruited 36 new graduates and it costs us an enormous amount of money every year to train these staff".[167] **It is hard to imagine the nuclear skills situation improving, since the Energy White Paper has all but ruled out new nuclear build. Even with no new nuclear build, nuclear engineers will be needed for many years to come to deal with decommissioning and storage but few graduates will be inspired to join an industry in its death throes.**

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[161] Q 546
[162] Q 551
[163] Q 278
[164] DTI, *Nuclear and Radiological Skills Study*, Report of the Nuclear Skills Group, December 2002
[165] As above
[166] Qq 386–388
[167] Q 332

106. The situation with fusion is encouraging and we hope that the transfer of the UK fusion budget to EPSRC will further encourage the influx of skilled people necessary to maintain the status of UK fusion research.[168]

107. The Energy White Paper recognised that many of the skills problems in energy are generic and reflect those being experienced by the economy more generally.[169] There are no simple answers to the skills problem faced by many parts of the energy sector but we are delighted that the Government is at last showing signs of agreeing with us that the school science curriculum is having a corrosive effect on our students' passion for science.[170] **We argued in our report on Science Education from 14 to 19 that science education needed to be made more relevant. There are few better examples of a subject that could enthuse our schoolchildren than non-carbon energy, which has the power to tackle the potentially catastrophic effects of climate change.**

INNOVATION IN FOSSIL FUEL TECHNOLOGIES

Carbon sequestration

108. CO_2 sequestration is the process by which CO_2, following captured during fossil fuel electricity generation, is transported to a facility for permanent sequestration. In the transition to a non-carbon fuel economy, the process could be used to restrict CO_2 emissions. CO_2 has few uses and hence sequestration is the only solution for removing it from the atmosphere; however, it can also be used for enhanced oil recovery, in which the CO_2 is injected into the reservoir to force oil to the surface. This would maximise oil recovery from the North Sea.[171]

109. Drawbacks to the technology include the cost of the process, its legality and its safety. The DTI is currently undertaking a review of the viability of CO_2 sequestration, due out this spring, and the Government says it will consider providing support for a demonstration facility to "kick start" investment or introducing fiscal incentives.[172] The EPSRC plans to spend £67,000 on CO_2 sequestration in 2002–03.[173]

110. Shell and BP are members of an international consortium called the CO_2 Capture Project.[174] The project, formed in 2000, aims to "to research and develop technologies aimed at reducing the cost of CO_2 separation, capture and geologic storage".[175] The US, the EU and Norway provide matching funding. **We consider CO_2 sequestration to be a necessary part of the transition to a non-carbon fuel economy. Nevertheless, it is important that its use should not act as a disincentive to the elimination of carbon-based fuels.**

111. Given the potential of CO_2 sequestration in the North Sea, we are surprised that none of the major UK generators is involved in the CO_2 Capture Project. Indeed, only one generating company project, Norsk Hydro, is involved, and it has no presence in the North Sea. The UK's input to CO_2 sequestration research is modest yet the ERRG report says that "The UK is well-placed to take a lead, because the North Sea offers opportunities to

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[168] Ev 20
[169] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 7.19
[170] Department for Education and Skills, *14–19: Opportunity and Excellence*, section 3.1, January 2003
[171] Ev 109
[172] Ev 109
[173] Ev 76
[174] The members are BP, ChevronTexaco, Eni, Norsk Hydro, PanCanadian, the Royal Dutch/Shell Group of Companies, Statoil and Suncor Energy.
[175] Ev 98

use CO_2 for enhancing oil production, while exhausted fields provide possible storage facilities" and identifies it as one of its six priority areas for research.[176] We were encouraged to learn that a Government review "appears to be reaching a very similar conclusion to [the ERRG] on the potential of CO_2 sequestration".[177] In January 2003, the DTI commissioned AEA Technology to carry out a major study on CO_2 capture and storage in the UK, bringing together power generators, plant manufacturers and oil companies and due to report at the end of April/early May 2003.[178] The White Paper contains a welcome impetus for CO_2 sequestration and recognises the potential and urgency of the situation, promising to set up a "detailed implementation plan with the developers, generators and the oil companies to establish what needs to be done to get a demonstration project off the ground".[179] **We commend the Government's positive approach to CO_2 sequestration. There is a real opportunity in the North Sea with enhanced oil recovery as the initial economic driver. Policy mechanisms are needed to ensure that it happens and that there is an agreement on the legal and environmental issues of CO_2 storage.**

Clean coal

112. The use of coal for UK electricity generation has declined substantially in recent decades. In 1950 it made up 89.5% of the UK's primary fuel but by 2000 this had declined to 15%.[180] It produces relatively high levels of CO_2 in generating electricity and the decline in its use has contributed enormously to the advantageous position of the UK in respect of its Kyoto target. Nevertheless, the UK still has substantial coal reserves and the continued use of coal would do much to address concerns over the security of other fuels, notably gas.[181] As the ERRG report concluded, "Coal could make a considerable contribution to maintaining the UK's energy security".[182] Clean coal technology which involves technologies to improve combustion efficiency or co-firing with other fuels, therefore offers many of the advantages of CO_2 sequestration and indeed the technologies complement one another. Coal can also be used as a source of hydrogen fuel, through gasification.[183]

113. The DTI's Cleaner Coal Technology programme provides support for RD&D projects, most of which are concerned with developing greater efficiencies in fuel boilers as well as co-firing coal with other fuels such as biomass and natural gas. The budget for the Cleaner Coal Technology Programme is £21.7 million over three years of which government funding is £8 million.[184] The development of clean coal technology offers significant export opportunities, particularly south east Asia, as the Trade and Industry Committee reported in 1998. The Trade and Industry Committee also noted that without Government support for demonstration projects, these opportunities will not be realised.[185] The Government acknowledged the importance of the technology to India and China but decided not to fund demonstration projects.[186] We note that the US Government is investing $2 billion over 10 years on clean coal technology.[187] The Energy White Paper says the Government will continue to fund clean coal RD&D.[188]

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[176] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, paras 51,7
[177] As above, para 52
[178] www.aeat.co.uk
[179] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 6.63
[180] Performance and Innovation Unit, *The Energy Review*, February 2002, para 2.4
[181] Ev 24
[182] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, para 49
[183] As above, para 58
[184] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, para 28; Ev 109
[185] Fourth Report of the Trade and Industry Committee, Session 1997–98, *Coal*, HC 404, para 35
[186] DTI, *Conclusions of The Review of Energy Sources for Power Generation and Government response to fourth and fifth Reports of the Trade and Industry Committee*, October 1998, Cm 4071, paras 11.12–11.13
[187] National Energy Policy Development Group , *Reliable, Affordable, and Environmentally Sound Energy for America's Future*, p 5.15
[188] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 1.25

114. The UK's most efficient coal-powered generation plants, at Drax, have an efficiency of 39%, and there are hopes that clean coal technology could improve this to 52%.[189] The Confederation of UK Coal Producers recommends that the Government follow-up the supercritical boiler retrofit project at an existing coal fired power station, as recommended by the DTI.[190] As with CO_2 sequestration, we are happy to see clean coal technology pursued, but not at the expense of renewable sources of energy. **We believe that the UK should play to its strengths and exploit its natural resources. As such, the continued use of coal has a role in the UK's energy mix provided that CO_2 emissions are substantially reduced. We therefore support investment in clean coal technologies, for export as well as UK use, in tandem with CO_2 sequestration.**

INNOVATION IN RENEWABLE ENERGY TECHNOLOGIES

115. The background and status of energy generation technologies has been well covered by the ERRG review group. We will not attempt to reproduce its analysis but add some observations of our own.

Energy efficiency and construction

116. The PIU report concluded that energy efficiency had a vital role to play in reducing the UK's carbon emissions, arguing that it should be prioritised "at the highest levels of Government" and calling for a 20% improvement in domestic energy efficiency by 2010 and a further 20% by 2020.[191] This reflects the views of the Energy Savings Trust which has found that the average home in England and Wales consumes 20% more energy than equivalent home in Denmark.[192] The Trade and Industry Committee has identified energy efficiency as the most important mechanism to alleviate fuel poverty.[193] The ERRG report recommends that energy efficiency be a research priority.

117. Energy efficiency falls principally within the remit of DEFRA, the Energy Savings Trust and the Carbon Trust, through its Action Energy programme. Little support is given to RD&D by these bodies and the Research Councils' interest seems to be restricted to a few studies funded by the ESRC into the uptake of technologies. The Tyndall Centre is undertaking a £240,000 research programme into energy efficiency and low emission housing.[194] The Government says that it "has supported energy efficiency since the 70s in the form of demonstration schemes, subsidised surveys, good practice guides and support for RD&D. For the future, government support may well be needed for more generic RD&D at a pre-competitive stage".[195]

118. Professor David Strong from the BRE was concerned by the fragmentation of Governmental schemes, pointing out that the DTI, DEFRA, the Office of the Deputy Prime Minister, the Energy Savings Trust, the Carbon Trust and the devolved administrations all have an interest. This fragmentation meant that none of the projects in this field had a critical mass or any impact.[196]

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[189] Ev 109
[190] DTI, *Review of the case for government support for cleaner coal technology demonstration plant*, December 2001.
[191] Performance and Innovation Unit, *The Energy Review*, February 2002, paras 9.12, 7.63
[192] Energy Savings Trust, *Putting Climate Change at the Heart of Energy Policy*, Energy Saving Trust Submission to the Energy White Paper, September 2002, p 24
[193] Sixth Report of the Trade and Industry Committee, Session 2001–02, *Fuel Poverty*, HC 814, para 34
[194] Ev 92, 101, 110
[195] Ev 110
[196] Ev 489–490

119. The BRE is highly critical of Government investment in energy efficiency RD&D:[197]

> "Recent changes to departmental research responsibilities have resulted in a situation where very little underpinning research is being undertaken in the UK. Furthermore, possible sources of funding are now highly fragmented and invariably require matching funding from industry, which is often difficult (or impossible) to obtain".

Professor Strong suggested that a proportion of the Energy Efficiency Commitment could be ring fenced and used to fund some of the underpinning research.[198] He felt that a figure of around £35 million would provide the research investment required. The BRE suggests that there were some easy targets that could be attacked, in particular thin-film insulation for solid-walled housing which would have a big effect on energy consumption.[199] The Energy White Paper accepts the ERRG's recommendation that energy efficiency be priority research area: "The research and development to enable these technologies to make a contribution in the years to come needs to start now. The Carbon Trust's Low Carbon Innovation Programme ... provides funding to enable that to happen".[200] As we commented in paragraph 44 above, **the Carbon Trust's RD&D budget is not very large and we dispute the Government's assertion that it has the funding to make a significant impact on energy efficiency RD&D.**

120. We were concerned to hear Mr Wright's views that there is a lot of energy-efficient technology that has been tried and tested but is not being deployed.[201] Don Spearman from Vent-Axia told us that "most of our European neighbours seem to be well ahead of us in terms of energy saving products, and therefore we are building products that will go into Holland, Germany, Japan, North America, and waiting for the necessary legislation to happen in this country to catch up with them and have the products available to do that".[202] Mr Spearman pointed out that companies such as his wanted well-signalled changes in regulations from government, giving them time to develop the right products: "the sort of developments we get involved with typically can take four or five years and ... can use up 5 per cent of our budget on one product".[203]

121. Mr Spearman was concerned about the drawing up of new regulations. He felt that the Government tended to find out what products were available rather than ask manufacturers what they would be prepared to develop. He told us "We had an industry meeting yesterday and even manufacturers that do not have these products, if they know they are going to be needed in five years' time, will go away and develop them, and certainly have them ready by the time those requirements are there".[204] Mr Wright commented that when people buy a new house, energy efficiency is unlikely to be a major factor in their decision-making: "The housing industry does not innovate to compete. The housing industry is driven by legislation. It has always been driven by legislation. The houses are designed to meet the minimum requirements of the building regulations".[205] Professor Strong pointed out that new regulations can provide major business opportunities.[206]

122. The Energy White Paper says that improving energy efficiency is the "cheapest, cleanest and safest way of addressing our energy policy objectives" and that the Government expects half of the UK's emissions reductions by 2020 to come through improved energy

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[197] Ev 135
[198] Q 509
[199] Ev 135
[200] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 3.47
[201] Q 491
[202] Q 491
[203] Q 493
[204] Q 495
[205] Q 495
[206] Q 496

efficiency.[207] The Government "will start work immediately on the next major revision of the building regulations, which we will aim to bring into effect in 2005".[208] **The housing market is driven by Government regulations and it is our view that these have not been tough enough in the past. We welcome the Government's pledge to make major revisions of its building regulations and recommend that these are demanding, recognising that they can be a powerful stimulus to innovation by manufacturers.**

123. It is disappointing that apart from various support schemes there is very little incentive to install energy efficient technologies into buildings. Professor Strong welcomed the new EU Directive on the energy performance of buildings, which will require houses to be labelled. This, he said, "will provide a very useful differentiation for house builders to differentiate the mediocre house from the more energy efficient house".[209] He also felt that the removal of VAT from insulating materials would be a valuable move.[210] The Budgets of 2000 and 2002 reduced the amount of VAT payable on some forms of energy efficiency from 17.5% to 5%.[211]

124. **We await the revised building regulations in the hope they will provide the market pull for innovative energy-efficient products. We hope they are able to compensate for the lack of technology push generated by the feeble level of public RD&D funding in this area.**

Hydroelectric

125. Hydro power is a commercial technology and accounts for a significant proportion of the UK's renewable output. Total electricity generated from renewables in 2001 amounted to 10100GWh, 38% of which was from large-scale hydro generation. Hydro makes up half of current renewable energy production in the UK. There are difficulties in the further expansion of hydro stemming from the lack of new available sites and the environmental disruptions.[212] The technology is getting very little support. In its evidence to the inquiry, NERC drew our attention to a report by the International Energy Agency published in 2001. It claimed that "hydro is the most environmentally friendly of all forms of electricity generation based on categories of emissions (including greenhouse gas emissions)... and it is technically feasible that hydro generation could treble in capacity and so provide 30% of the [UK] Government's targets for renewable energy generation by 2010 and 2026 respectively".[213] **We find it hard to reconcile the Government's apparent lack of interest in a relatively mature technology with the enthusiasm of the International Energy Agency. We recommend that the Government follow up the IEA's report with its own assessment of the role that hydro can play in the UK's energy supply.**

Solar

Photovoltaics

126. Photovoltaic (PV) technology converts daylight into electricity. The DTI has had an RD&D programme since the mid 1990s at an annual level of £0.5–1 million, largely targeted at paper studies addressing technical and infra-structural barriers and monitoring the few existing installations. EPSRC has a major programme of PV research, amounting

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[207] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, paras 3.2, 3.5
[208] As above, para 3.16
[209] Q 500
[210] Q 508
[211] HM Treasury, *2002 Budget Report*, para 7.24
[212] Ev 34
[213] Ev 91

to £3.5 million in 2001–02. The ERRG recommended PVs as a priority research area but the Energy White Paper was rather non-commital.[214]

127. The DTI has run a series of schemes in recent years. In 1999, the DTI made available £5 million over 2–3 years for PV components and systems. This was followed up by £1 million for the Domestic PV Systems Field Trial and £3 million for the Large Scale Building-Integrated PV Field Trial (for public sector buildings). In March 2002, the Government announced the first phase of the Major PV Demonstration Programme which is worth £20 million.[215]

128. We were interested in the approach from Intersolar. Phillip Wolfe's company is developing a product that is "to all intents and purposes a building product but incorporates the photovoltaics ... With our solar slate, every solar slate replaces a slate which would otherwise go on to that roof so we get an economic trade-off which helps make the economic case for photovoltaics".[216] We were pleased to hear that Persimmon Homes is collaborating on this programme. Less encouraging were the views from Stephen Wright of Gusto Homes: "It does not stack up financially at the moment ... we have been getting problems when trying to put photovoltaics on roofs".[217]

129. The Government has clearly decided that PVs are a priority since it attracts the highest amount of DTI RD&D funding for any technology other than nuclear fusion. But we are not sure on what basis this decision has been made. The ERRG report acknowledges that Japan and Germany have a significant lead over the UK but it recommends PV as a priority research area on the basis that the UK could make an impact on the next generation of PV technologies. This is despite concluding that the UK's competitive position is no more than "tenable".[218] Mr Philip Wolfe, who runs a company manufacturing PV roof tiles, indicated that "we are a long way short of the cutting edge ... we need to or have indeed already selected prospective winners but we have not converted that into RD&D effort and support for the industry".[219] In other words we are very close to missing the boat with PVs. Sir David King seemed confident that the UK has a real opportunity of taking the lead in the next generation of photovoltaics, based on Britain's strength in new plastics, currently being employed in flat screen technologies.[220] We were interested to hear that Sanyo is moving into the European PV market. Having visited Sanyo's Solar Ark, the world's largest solar array, during our visit to Japan, it will be interesting to see how UK companies can cope with this competition.

130. The Government describes the PV demonstration programme as a "major market stimulation programme" intended to be analogous to the schemes run in Japan and Germany. This may be its intention but given that the Japan's NEF residential PV subsidy programme had a budget of around £130 million in 2002, the UK's programme is comparatively minor. In January 1999, the German Government launched a 100,000 Roofs programme for photovoltaics in which it assigned a bank to issue 10-year, interest-free loans covering almost 40% of the cost of a PV system. The programme will cost almost €500 million and will run until 100MW has been installed.[221]

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[214] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.57
[215] Ev 113
[216] Q 312
[217] Q 506
[218] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, p 22
[219] Q 307
[220] Q 600
[221] British Embassy Berlin, Background on Renewable Energy, July 2002

Solar heating and cooling

131. This embraces two technologies. Passive solar design uses building design to capture, store and distribute solar energy. There seems to be little Government support for RD&D, although the Carbon Trust, through its Action Energy programme, and DEFRA provide support for its deployment. Support for the technology comes from Professor David Strong from the BRE:

> "An intelligent architectural design can exploit the natural systems that are available for free, so as to drive the ventilation systems to provide daylight and so on. These are extremely important renewable technologies which in the UK we have a world lead on in many respects and yet we are not particularly good at capitalising on this expertise because it is not a tangible product in the way that photovoltaics are and in the way that wind power is".[222]

132. Solar thermal or active solar heating is a mature and proven technology and has an "established but small market", according to the Government.[223] The Energy Conservation and Solar Centre (ECSC) describes solar heating as the "Cinderella of renewable energy systems".[224] The ECSC argues that the technology is cheap and capable of being installed in any building, yet was dismissed, it says, in one sentence by the PIU. The White Paper says that revisions to the building regulations will encourage solar water heating.[225]

133. Professor Strong's sentiments strike a chord with us. It is easy to focus on electricity generation and ignore perhaps simpler technologies that can deliver reductions in CO_2 emissions at lower cost. We have suggested earlier that the Government should prioritise more with its RD&D strategy and we risk accusations of inconsistency by demanding attention to some technologies. However, we are concerned that the relative benefits of non-PV and PV solar have not been adequately established. The ERRG report lumps non-PV solar in with energy efficiency technologies and while efficiency is given priority status, there is no sign that non-PV solar should benefit. Professor Strong indicates that the UK has a world lead in passive renewables. **We recommend that the Government commission a cost-benefit assessment of different solar technologies.**

Wave and tidal

134. Wave and tidal energy has huge potential in the UK, with one estimate suggesting that 1,000 MW could be installed by 2012–13.[226] Set amid oceans, with strong currents, Britain has a massive natural resource. Tidal energy is more reliable than wind and solar power but in terms of technological development it is well behind both. Current generation costs are relatively high although we have been told that in the long term it has the potential to be one of the cheapest forms of electricity generation.[227] The UK has RD&D strengths in these technologies, with a small number of companies who lead the development of the technologies as well as a number of universities with a significant research capability in this area.[228] EPSRC has a moderate investment in wave and tidal research, having risen from nothing in 1999–2000 to around £0.5 million in 2001–02. The DTI expects to spend £1.6 million on RD&D in 2002–03 and has recently announced that two companies—Wavegen

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[222] Q 507
[223] Ev 113
[224] Ev 69
[225] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 3.16
[226] Ev 160
[227] Ev 160
[228] Ev 114

and Tidal Hydraulic Generators—will receive £3.7 million between them to develop prototype tidal generators off the coasts of Islay (west Scotland) and Pembrokeshire (see Table 6). Wave and tidal were considered priority areas of research by the ERRG report, stating that they were technologies with "good long-term prospects of yielding very large reductions of carbon emissions" with "the potential to play a significant role in helping to meet the challenge of a secure, sustainable, low-carbon energy supply".[229] Brian Wilson told us that he was a fan of wave and tidal technologies and that the DTI had managed to support all credible projects in wave and tidal energy, which begs the question as to why there are so few credible projects.[230] Mr Wilson seemed very confident about the future of the technology, suggesting that the current commercial generator on Islay only needed to be scaled up and mass produced like sausages.[231] We hope the Minister is right and it really is that simple. We were pleased to see his announcement of new funding for wave and tidal projects two days after appearing before us.[232]

135. Wave and tidal power was the subject of an inquiry by our predecessor Committee in the last Parliament and it remains a particular concern of ours.[233] The report concluded that there were no major technological barriers to its exploitation and criticised the Government for its lack of funding. It recommended a managed programme by the EPSRC for wave and tidal and a "significant proportion" of the £100 million announced by the Prime Minister for renewables in March 2001. **We are pleased to see that wave and tidal energy has received greater governmental attention since our predecessors' report. We hope that the recent increases in funding represent the first stage in building capacity, leading to investment commensurate with the potential of wave and tidal energy. We can look forward in the near future to investment commensurate with wave and tidal energy's potential impact on the UK's energy supply.**

136. A further recommendation of our predecessors was that a National Offshore Wave and Tidal Test Centre should be set up. In its reply, the Government said that it had taken the first steps in setting up a Marine Energy Test Centre at Stromness in the Orkneys. We welcome this development and look forward to its opening "later this year".[234] There is clearly progress in this field but the Government would do well to note these comments from the Engineering Business:

> "Tide and wave energy technology developers are intending to make huge progress on large-scale systems in a very short time scale, all on low budget programmes. The challenge for government is to decide how desirable it is to generate significant power from wave and tide resources, and how important it is to develop these new industries based on British companies using existing UK skills and infrastructure. If the answer to both of these questions is yes, then we are confident that we can deliver and the only requirement is to provide market conditions that encourage this to happen".[235]

Severn Barrage

137. The Severn Tidal Power Group was formed in 1984 to assess the potential of building a tidal barrage to generate electricity. The tides in the Severn Estuary have the second highest range in the world and the Group estimates that it could supply 6% of the current electricity demand of England and Wales.[236] The project stalled following privatisation of the industry and has faced objections from environmentalists because of

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[229] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, paras 42, 70
[230] Q 596
[231] Q 597
[232] DTI press release, Seachange for Western Isles, 21 March 2003
[233] Seventh Report of the Science and Technology Committee, session 2000–2001, *Wave and Tidal Energy*, HC 291
[234] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.53
[235] Ev 161
[236] Unprinted memorandum from the Severn Tidal Power Group.

disruptions to wildlife habitats.[237] In February 2002 the Group submitted a "Definition Study" to determine whether re-appraisal of the Barrage was justified, with the not unsurprising conclusion in the Energy White Paper that it was.[238] We are not in a position to form a judgement on this project, except to say that there is plenty of scope for installing renewable energy generation with little or no environmental impact and that these should be given priority. We agree with the Government's conclusion that "plans for a Severn Barrage would raise strong environmental concerns and we doubt if it would be fruitful to pursue it at this stage. Tidal barrages may be capable of offering major renewable projects which will help us reach our goals and we will continue to explore opportunities".[239]

138. **Wave and tidal energy has enormous potential and can deliver a clean and predictable energy supply. We recommend that the UK should make a major investment in this niche market and aim to generate at least 5% of its electricity using wave and tidal technologies by 2020.**

Wind

139. According to the British Wind Energy Association, the UK has "over 33% of the total European potential offshore wind resource—enough to power the country nearly three times over".[240] A report commissioned by Greenpeace concluded that wind farms off the coast of East Anglia could supply a quarter of UK electricity needs by 2020.[241] The Government expects wind to make the largest contribution to its 2010 renewables target and, with biomass, to the 2020 "ambition".[242] Brian Wilson said he was looking to offshore to provide the big hits to reach 10% renewables target by 2010. He said there had been a bias towards wind with the DTI's capital grants scheme, but not at the expense of other technologies.[243] This is a curious statement since in a limited budget funding is always at the expense of something else.

140. A distinction is usually drawn between onshore wind and offshore wind. The Government considers that "Onshore wind is an extensively deployed and commercially viable technology and so relatively little government research and development money is allocated to it". In contrast, "Offshore wind requires further development, demonstration and assessment before it becomes a proven and commercial technology". The ERRG describes offshore wind as "near market" but that it has "long-term prospects of yielding very large reductions of carbon emissions".[244] The EPSRC clearly considers that little basic research is necessary and in 2001–02 invested only £330,000, although this is scheduled to rise to £481,000 in 2002–03. This reflects the fact, quite reasonably, that the technical obstacles are largely to do with siting major marine engineering projects in harsh environments. The Government published a consultation document, *Future Offshore*, in November 2002, which proposes a strategic planning framework as a basis for major expansion of the offshore wind industry.

141. We have heard criticism of the Government's research policy on wind. Dr Andrew Garrad, a wind energy consultant, argues that RD&D investment is still required on wind. The British Wind Energy Association agrees: "there is a need for continued fundamental research to achieve projected cost savings and performance improvements" into condition

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[237] Friends of the Earth press release, 11 February 2002
[238] The Severn Barrage—Definition Study for a New Appraisal of the Project. Final Report: January 2002 ETSU Report No. T/09/00212/00/rep
[239] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.54
[240] http://www.offshorewindfarms.co.uk/info.html
[241] Sea Wind East, a report for Greenpeace by AEA Technology; Q407
[242] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, p 55
[243] Q 568
[244] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, paras 12, 42

monitoring and novel and larger turbine designs.[245] The technology may be mature by the standards of other renewable energy sources, but even with conventional power stations, there is still work to be done on improving reliability and efficiency. The same is true for wind.

Geothermal

142. Geothermal energy uses subterranean heat to generate electricity or provide heating. The UK has a number of sites in which geothermal heat can be extracted from aquifers near to the surface. Southampton has a city centre district heating system fed in part by geothermal heat. A much larger resource could be tapped if access could be gained to hot rocks deep underground. Typically, two bore holes are drilled to around 3–4 miles depth in suitable locations. Geological fractures in the rocks are then formed to connect the bottom ends of the bore holes. Water is injected down one bore hole so that it percolates through the fracture pattern to re-emerge up the other bore hole as steam. The concept was pioneered in the UK and the USA but the UK RD&D programme ceased over 10 years ago on the basis that it was never likely to become commercially viable. There is an EU co-ordinated programme in France and Japan is conducting research in geothermal energy.[246]

143. The NERC states that geothermal energy has potential for domestic or small-scale commercial use but that demonstration projects are urgently needed. The adaptation of North Sea rigs also offers some possibilities although the NERC suggests that the window of opportunity is short.[247]

Combined heat and power

144. CHP is not strictly a non-carbon technology. Rather, it is a highly efficient energy technology (70–90% fuel efficiency compared with 40–50% for most power stations) which employs the heat given off as a by-product of electricity generation. CHP schemes may use a variety of fuels on a range of scales: for industries with large heat requirements, at a community level, or so-called micro-CHP for domestic users. The Government has set a target of 10,000 MWe (megaWatt equivalents) by 2010. It believes the long-term potential of CHP to be "considerable" with 600,000 SMEs and half of UK homes hosting a unit. BG MicroGen told us that a quarter of the UK's Kyoto Commitment could be delivered through micro-CHP alone if all 13 million suitable UK homes were converted.[248]

145. EPSRC spent £267,000 on CHP research in 2001–02. It is our impression that while technological improvements could do much to improve the viability of CHP (including fuel cells), many of the problems relate to the need for effective demonstration programmes and market issues, such as net metering .[249]

146. CHP has a valuable role in reducing carbon emissions and we welcome the Government's ambitious targets for its installation. We note the Environmental Audit Committee's concern that NETA, which was intended to encourage CHP, was having the opposite effect.[250] We were impressed during our visit to Japan the support given to CHP and were impressed by the demonstration programme by Osaka Gas. There is progress

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[245] Ev 26
[246] DTI, *Sustainable Energy Technology Route Maps 6: Geothermal Energy*. www.dti.gov.uk/energy
[247] Ev 91
[248] Ev 147
[249] Ev 91,108
[250] Fifth Report of the Environmental Audit Committee, *A Sustainable Energy Strategy? Renewables and the PIU Report*, session 2001–02, HC 582-I, para 71; HC Deb 27 November 2002, 298W; HC Deb 12 December 2002, col 434W

being made in the UK. We are aware that Woking Council has become the first UK local authority to supply customers with electricity on private wire CHP networks.[251] On the down side, we note the fact that the amount of electricity generated by CHP, having increased steadily throughout the 1990s to a peak in 2000, subsequently fell in 2001.[252]

147. It has been suggested to us that micro-CHP needs further support. BG MicroGen calls for a direct grant support from the Government and the extension of 5% VAT to accredited micro-CHP.[253] The Energy White Paper is enthusiastic about the technology but contains no new measures to encourage its deployment beyond support for further field trials and asking the Carbon Trust and the Energy Saving Trust to review current and future CHP programmes.[254]

Fuel cells

148. Fuel cells are essentially batteries with a continuous supply of fuel. This, along with the fact they have no moving parts, allows their long-term operation. They are not non-carbon technologies as such, as this depends on the fuel used, but typically they have high efficiencies and can be employed for CHP. Fuel cells have a number of applications, including:

- portable generators and battery replacement;
- battery replacement products for hand-held electronic devices;
- commercial cogeneration;
- residential and commercial CHP;
- distributed and central generation; and
- automotive applications.[255]

149. After photovoltaics, fuel cells attract the largest share of the EPSRC's renewable energy funding. In 2002–03, its research funding is expected to be around £1.5 million. This compares unfavourably with Japan's Government research investment. In 2002, NEDO had a budget of ¥10.53 billion (around £55 million) for its fuel cell programme. US RD&D on fuel cells and hydrogen was reported to be $27.7 million (around £18 million) in 2001.[256] The DTI considers that "A number of serious techno-economic issues remain to be overcome before mass market applications in the fields of transport (replacement for the internal combustion engine) or stationary power generation (distributed generation/CHP) will be possible... Commercialisation for niche applications is widely expected within the next 2–5 years". We understand that the Carbon Trust and DTI will undertake a joint market assessment of RD&D needs in relation to the commercial application of fuel cells.[257]

150. According to Professor Gary Acres, UK activity in hydrogen fuel cells has been "pretty low key" until now. Professor Acres has worked for Johnson Matthey, which has been working with fuel cells for 30 years but only because of its global interests. Now, many organisations in the UK had shown an interest "almost to the point where we cannot cope with it".[258] Dr Nigel Brandon of Imperial College and Ceres Power, a spin-off

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[251] Energy Savings Trust, *Energy Services Case Study 06, Woking Borough Council's Thameswey Joint Venture Project*; Ev 152
[252] HC Deb 27 November 2002, col 298W
[253] Ev 150
[254] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.18
[255] Ev 151–153
[256] OST, *Report of the Chief Scientific Adviser's Energy Research Review Group*, February 2002, p 37
[257] Ev 63
[258] Qq 171–172

company developing fuel cell technologies has identified three main barriers to the commercialisation of fuel cells:[259]

- the current regulatory environment makes it extremely difficult to install fuel cell technologies;
- extensive demonstration and field trials are critical to commercialisation; and
- market entry support is needed to help "push" the technology in early years.

According to Dr Brandon, "UK industry has the potential to become an important supplier of high value components to original equipment manufacturers... UK developers anticipate sales of around 50 MWe per annum into this sector by 2010". Dr Brandon told us that the DTI had been funding small projects but was not able to fund demonstration programmes.[260]

151. The creation of Fuel Cells UK was one of the principal announcements in the Energy White Paper. It aims to "foster the development of a UK industry, to raise the profile of fuel cell activity in the UK, and to act as central liaison point for national and international activity".[261] The Government also announced that it would review, with the EPSRC, the supply of doctorates and MScs with the requisite skills.[262]

Hydrogen

152. The hydrogen economy is considered by some to be the holy grail of energy policy, with hydrogen generated from renewable energy sources and possibly used as a fuel for local electricity generation or in vehicles (see Box 3). The timescale for this is long (30–50 years) but the deployment of hydrogen technology may begin considerably earlier—hydrogen-powered cars are already available. The DTI does not currently have a hydrogen programme but it is reconsidering this in the light of the recommendation by the ERRG report that it be given priority status. The UK Government's stance can be compared with that of the US: President Bush announced a $1.2 billion package in his State of the Union address on 28 January 2003 to develop the technologies and infrastructure needed to produce, store, and distribute hydrogen for use in fuel cell vehicles and electricity generation. This will bring total US expenditure on hydrogen research to $1.7 billion over the next five years. The EPSRC identifies hydrogen as a priority area but spending until now as been modest (£0.5 million in 2002–03), although it forms one of SUPERGEN's four themes and a virtual research centre was been set up in early 2003, coordinated by Birmingham University.[263]

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[259] Ev 151
[260] Q 264
[261] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, p 59
[262] As above, para 4.59
[263] Ev 2

Box 3: The hydrogen economy[264]

Hydrogen is the most common element in the universe although it does not exist in large quantities in a useful form. It can be produced from water or from hydrocarbons in fossil fuels or biomass. Hydrogen can be converted into energy using existing energy technologies, such as fuel cells, engines, and combustion turbines, with water the only waste product. It can be used as a fuel for vehicles (where development is progressing rapidly), as a means of storing energy, to provide heat or in stationary applications to generate electricity. It is therefore both a fuel and an energy carrier. An energy infrastructure that relies on hydrogen could enable much greater use of distributed energy systems in which small, modular electricity generators can be placed right where they are needed for heating, cooling, and powering offices, factories, and residences. In the short term, hydrogen will come from fossil fuels with CO_2 produced as a by-product but its use would have advantages particularly in fuel cells whose higher efficiencies could lead to reductions in carbon emissions. Although on a weight for weight basis, hydrogen has more energy than any other fuel, it has a very low density. The production of hydrogen from non-carbon sources provides a significant challenge, as do storage and transport.

153. Industry is taking a keen interest in hydrogen. Shell Hydrogen has a large RD&D programme spending £18 million annually, mostly conducted in the Netherlands. BP spends £8 million a year but unlike Shell's activities, which are directed primarily at transport, BP is taking a broader perspective, looking at hydrogen generation, transportation and storage.[265] Intriguingly, the nuclear industry is taking an interest. BNFL's evidence to the inquiry describes how nuclear generation could be used to produce hydrogen, with high temperatures making the electrolysis more efficient.[266]

154. Technological progress is needed on transportation and storage. Hydrogen has a low density and so techniques are needed to store it in a space-efficient manner. **We welcome the attention being given to hydrogen RD&D by the Government. There is a UK big opportunity to take the lead here in a key area of energy research.**

Storage technologies

155. The intermittency of many renewable sources is likely to be an increasing problem as their contribution exceeds 10% of electricity generation, as the Trade and Industry Committee discussed in their report on Security of Energy Supply.[267] National Grid envisages that more short-term generation will be required. Currently storage in England and Wales consists of hydropower plants, in which water is pumped up to a reservoir and used to generate electricity at peak times. Hydrogen is one solution and another is fuel cells. Innogy is developing a form of fuel cell technology called Regenesys in which electrical energy is converted into chemical potential energy. On demand the process can be reversed. EPSRC is funding research in this area.[268]

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[264] Parliamentary Office of Science and Technology, *Prospects for a Hydrogen Economy*, Postnote number 186, October 2002
[265] Q 531
[266] Ev 49
[267] Second Report of the Trade and Industry Committee, *Security of Energy Supply*, session 2001–02, HC 364, para 35
[268] Ev 156

Bioenergy

156. Bioenergy is the use of crops to provide an energy source. Crops are carbon-based and their combustion provides energy but releases CO_2. Since the crops have "fixed" the same amount of CO_2 during their growth, their use for energy is considered carbon-neutral (although there is some net production of CO_2 through energy expenditure during growth and processing). Plants can be used in three ways to provide energy:

- direct generation of electricity through combustion of either specially grown crops or plant residues;
- as a source of fuel through processes such as gasification or pyrolysis (the controlled thermal degradation of biomass to derive energy and chemical products); and
- as direct sources of liquid fuels with applications in transport.[269]

157. Bioenergy RD&D is supported by the BBSRC, amounting to £255,000 in 2001–02, and by the EPSRC, amounting to £540,000 in 2001–02.[270] Departmental funding is split between the DTI, DEFRA and the Forestry Commission, with annual expenditures of £3–4 million, £600,000 and £300,000 respectively. This embraces emergy crop trials and the installation of conversion technologies. Further support will also come from the capital grants scheme led by the DTI and the New Opportunities Fund. DEFRA also has a budget of £32.5 million for energy crops establishment and infrastructure.[271] The ERRG report decided not to recommend bioenergy as one of its priority areas, describing it as having "good medium term prospects".

158. The Institute of Biology describes Government support as "piecemeal and lacking policy-driven direction".[272] The cross-Research Council programmes on "Towards a Sustainable Energy Economy" and "Rural Economy and Land Use" should offer a degree of coordination at the basic research level.[273] **We are struck by the particularly high number of public funding bodies active in bioenergy. The Government should simplify its support schemes in this area.**

159. Crucial to the uptake of biofuels is stimulation of the market. The Government has reduced the duty on biodiesel to 20pence/litre below the standard diesel rate and proposes to introduces the same incentive for bioethanol, subject to EU agreement. The Government envisages that these fuels could make up 5% of total fuel use by 2020. We welcome these initiatives. The Government must employ fiscal incentives to encourage the greater use of low-carbon fuels. We were interested to hear Brian Wilson's thoughts in this area but left disappointed: "Can we pass on biofuels ... I do not want to be over-departmental but biofuels is more on the transport and DEFRA side.[274]

Energy from waste

160. Energy recovery from waste includes a number of established and emerging technologies. Many wastes are combustible and energy can be recovered through incineration with electricity generation. We were pleased to see energy from waste included in the Government's submission to this inquiry but mystified as to why it received no

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[269] Ev 81
[270] Ev 76
[271] Ev 108
[272] Ev 67
[273] DTI, *Science Budget 2003–04 to 2005–06*, November 2002, pp 25–28
[274] Qq 601–603

mention in the ERRG report. Of greater concern were the comments from John Acton from Compact Power, a company "My perception is that it is a political hot potato because it is too far down the recycling and reuse, the normal cycle that if somebody stands up and says, 'We believe in energy from waste', they are actually saying that they are going to encourage waste being diverted into energy resources and I feel that that was really the pressure that came on perhaps from other sources".[275] The Government states that it is "keen to support the development of this sector" without explaining how it goes about doing this, other than hoping that the Renewables Obligation will provide the necessary incentive.[276] Certainly the modest investment by the EPSRC in energy from waste (£125,000) will do little do stimulate the sector.

161. We are aware of these tensions identified by Mr Acton but we note with interest the policies abroad identified by the recent Strategy Unit (formerly PIU) report on waste management. It found that even countries with high recycling rates incinerate a large proportion of their waste. The Netherlands incinerate around 30% of their waste (the UK currently incinerates about 9% of its waste) and in Italy, despite having kerbside recycling and other measures in place to tackle waste, the Government has recently decided to build some incinerators. It comments that incineration is widely used in other nations as a means of recovering some energy as electricity and heat. The report discussed the waste pyramid set out in the EU's Framework Directive on Waste, in which waste strategies were classified in the following order of priority:

- waste reduction;
- re-use;
- recycling and composting;
- energy recovery with heat and power;
- energy recovery;
- landfill with energy recovery; and
- landfill.

The report argued that efforts should be made to move up the hierarchy.[277] We look forward to the conclusions of the Environmental Audit Committee and the Environment, Food and Rural Affairs Committee in their inquiries on "Winning the War on Waste" and "The Future of Waste Management: Moving up the Waste Hierarchy" respectively.

162. **We support policies to encourage less wastage and more reuse and recycling but it is inevitable that there is waste and Government policy should place no obstacles in the way of technologies that can harness waste which cannot be recycled to generate power.** We commend Mr Acton's initiative in moving his technology forward: "quite frankly we could not take the risk that we would not be decided to be the winners, so we have made our own independent arrangements".[278]

INNOVATION IN NUCLEAR FISSION

163. Nuclear power accounted for around 23% of UK electricity generation in 2001. It produces no greenhouse gas emissions and therefore, compared with the rest of the generation sector, plays a significant role in helping the UK meet its emission targets. Generation is expected to peak in 2005 (around 25% of electricity supplied). In 2025, only 1 of the 16 existing nuclear stations will be left (Sizewell B) unless new reactors are built. Publicly funded research into fission reactors mirrors this decline and began to decline with

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[275] Q 284
[276] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.51
[277] Council Directive 75/442/EEC on waste, para.2.9.3.1; Strategy Unit, *Waste not, Want not: A strategy for tackling the waste problem in England*, November 2002, paras 5.6–5.12
[278] Q 275

the privatisation of the electricity sector in 1990–91. In 1989–90 the Department of Energy (later amalgamated with the DTI) invested £164 million in nuclear research but this has decreased to almost zero. DEFRA continues to fund safety and storage research.[279] BNFL calculates that in 1974 around £500,000 (at 2000 prices) was spent by the Government on nuclear RD&D.[280] There has also been a significant decline in university-based-fission—related research over the same period. EPSRC is currently the largest sponsor of fission-related RD&D with commitment for areas such as materials research of approximately £350,000 per annum, although BNFL considers this to be in "specialised or niche areas of little relevance to industry".[281] This decline in public RD&D funding is also reflected in the private sector: while Nuclear Electric spent £116 million on RD&D in 1989, British Energy and BNFL combined spent £115 million in 1999–2000, representing a considerable reduction in real terms.

164. Perhaps not surprisingly, the withdrawal of Government support for nuclear RD&D is not welcomed by BNFL, who argue that Government is relying too much on the industry. It argues that when BNFL was set up in 1971 it was envisaged that UKAEA would "continue to underpin the UK's nuclear science base". Yet UKAEA research centres at Harwell and Winfrith have been run down and the AEA Technologies, a part privatisation of UKAEA, has withdrawn from nuclear research.[282] The British Nuclear Energy Society is concerned that there is no coherent research strategy in nuclear fission.[283] The situation is not welcomed by Professor Bill Lee from the University of Sheffield, who is concerned that those researching in the nuclear field are almost all employed by BNFL and British Energy. He feels that these scientists may have a conflict between commercial interests and the long-term plans for the disposal of waste and that there is limited communication between nuclear research teams.[284]

New reactor technologies

165. There is currently no Government funding into new reactor technologies and little takes place in the UK (BNFL spent £1 million, out of its total 2001–02 RD&D budget of £113 million, on reactor research). The UK does have a stake in reactor RD&D following the purchase by BNFL of the US company Westinghouse and as a member, along with British Energy, of the Generation IV consortium (see below). British Energy ceased RD&D into future nuclear systems in the mid-1990s.[285]

166. BNFL argues that research into future nuclear systems is the only area of energy research that Government does not fund. The ERRG indeed made clear that "Research into the development of any new reactor designs should be chiefly a matter for the industry".We note the report's use of the word "chiefly" since as far as we can tell the Government's position is that nuclear systems research is exclusively a matter for industry.

167. The US Department of Energy set up an initiative known as Generation IV at the end of 2000 to consider future nuclear energy systems that could be deployed by 2030. The Generation-IV International Forum was set up in July 2001 comprising nine countries with interests in the future of nuclear energy RD&D. Governments, industry and the research community are represented at the Forum. The aim is to develop reactor designs that are safe, economical, proliferation-resistant and produce minimal waste. The UK, through the

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[279] Ev 112
[280] Ev 46
[281] Ev 47
[282] Ev 9,11,46
[283] Ev 10
[284] Ev 1
[285] Ev 47

DTI, is a member of the Forum but while the US has spent £9 million to fund American participants, the DTI left it to the UK participants (BNFL, British Energy and NNC) to fund their own involvement. As a result, BE has decided to leave and NNC may soon follow. BNFL argues that UK participation in Generation IV is important "to assure access to future energy options, while sharing the costs with the international community".[286] The Minister for Energy and Construction, Brian Wilson, said in a Written Answer on 3 December 2002 that "the framework for international research under the Generation IV initiative has yet to be put in place and the extent of any UK financial commitment to research has yet to be decided".[287] **For the Government to keep the nuclear option open, participation in the Generation IV Forum is essential to give the UK a stake in the direction of future technologies. We recommend that provision is made for British companies to participate actively.**

168. Mr Kevin Routledge, Deputy Chief Executive Officer of NNC, claims that the UK Government's lack of investment in fission RD&D weakens its position. "I think it is fundamental that the UK Government makes some level of investment so that they can talk to other governments who are spending quite a lot more money and leverage that opportunity". He suggested that £10 million should be the starting figure.[288] Dr Sue Ion of BNFL felt that half of this could be spent domestically on to keep skills and capabilities in the programmes with the remaining £5 million contributing towards the international programmes.[289]

169. We were interested to learn of the progress in the development of the pebble bed modular reactor (PBMR). The technology was developed initially in Germany in the 1950s but an accident at a reactor and the deployment of light water reactors hampered further progress. Interest in the technology has increased recently with research being undertaken in South Africa. In May 2000, BNFL made a "substantial" investment in the technology (it has a 22.5% stake[290]) and it expects PBMRs "to be the safest, cleanest and most efficient nuclear power source option for the future".[291] The PBMR website forecasts commercial operation in 2006 although BNFL feels that it will not become a viable product until the next decade. **We applaud BNFL's investment in pebble bed reactors and the long-term view it is taking of reactor technologies in an uncertain climate. We will watch the development of the technology with interest.**

170. New reactor designs are already available. Dr Ion told us of BNFL's interest in deploying the AP1000 in the UK, a form of light water reactor, to generate 10 GW. The AP1000 is still at the design stage but the design has been licensed. BNFL argue that the costs and waste associated with the AP1000 are such that they would become economically viable if the market conditions improved. It is undeniable that **public opinion is a major obstacle to new nuclear build but this should not preclude the funding of research which could go a long way to addressing public concerns into the waste and safety of existing systems. We believe that the Government should not underestimate the public's pragmatism and should not be afraid of people's ability to balance its legitimate concerns with the great dangers posed by climate change.**

171. An obstacle to any future nuclear build is economics. With electricity suppliers currently selling at 1.6p/kW and with 20% overcapacity in the market, no company is considering building new generation, but the problems with British Energy and BNFL are particularly serious. For new nuclear systems technologies to make it to the marketplace,

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[286] Ev 52–53
[287] HC Deb, 3 December, col 688W
[288] Qq 336–338
[289] Q 339
[290] www.pbmr.com. The other partners are Eskom (30%), Exelon (12.5%), and the Industrial Development Corporation of South Africa (25%). The remaining 10% is reserved for black empowerment investment.
[291] www.bnfl.co.uk

companies need to have some confidence about the long-term market conditions. Indeed, this is vital if private investment is forthcoming in any new energy technologies.

Existing reactor technologies

172. The UK's nuclear generators BNFL and British Energy conduct research into improving the efficiency, functioning and longevity of reactors, and in the latter's case, the £19 million that the company spends represents almost all of its RD&D budget. This work is valuable but it is a largely a short to medium term commercial issue for the companies concerned.

Safety and storage

173. The Health and Safety Executive administers nuclear safety research programmes of around £8 million per annum, which is funded by a levy on the nuclear generators.[292] There is concern that this fund may become under threat as the nuclear reactors are closed.[293] DEFRA spends around £700,000 on research into the safe handling and storage of radioactive wastes and the Department of Health funds research into the health effects of exposure to man-made and naturally occurring radiation.[294] The UK Government also contributes around £4.5 million a year to the Euratom budget for research into radiation protection, waste management and plant life management and safety.

174. Nuclear safety and storage research was undertaken in the past principally by BNFL, UKAEA and Nirex. Nirex, which was was set up in the early 1980s by the nuclear industry, with the agreement of the Government, to examine safe, environmental and economic aspects of deep geological disposal of radioactive waste, spent around £8,5 million on research in 2001–02.[295] In July 2002 the Government announced the formation of the Liabilities Management Authority as an NDPB, which will relieve the industry of its historic waste liabilities.[296] The LMA will play a strategic role in dealing with the nuclear waste legacy and as such will oversee the research being undertaken by BNFL and UKAEA and ensure coordination with DEFRA and the Health and Safety Executive. It will fund research itself into technology which improves safety and reduces environmental impact, timescales and costs. For example, improvements in vitrification and cementation technology could make the immobilisation of wastes easier, faster and cheaper. The ERRG report recommended nuclear waste research as a priority area and the high-level group set up by Sir David King will work with the LMA in taking this forward.[297]

175. The Institute of Physics and the Institution of Electrical Engineers have raised the possibility of the transmutation of nuclear waste. Waste plutonium could be "burnt" in a fast reactor or in a specialised accelerator facility.[298] Transmutation converts long-lived radioactive elements to shorter-lived ones, decreasing the long-term problems of nuclear waste storage from thousands of years to perhaps decades. The technology has its problems in that it will not work with all radioactive elements, large amounts of waste will still result and there are issues concerning nuclear proliferation. The House of Lords Science and Technology Committee considered the technology in its report on the *Management of Nuclear Waste* in 1999 and concluded that the time to deployment meant that it could not

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[292] Ev 47
[293] Ev 9
[294] Ev 112
[295] Ev 13
[296] DTI, *Managing the Nuclear Legacy: A strategy for action*, July 2002, cm 5552
[297] As above, paras 3.36–3.40
[298] Ev 15, 23

be considered as a solution to current waste problems.[299] Nevertheless, **we recommend that the Government monitor technological developments in transmutation and keep it under review as part of its radioactive waste management strategy.**

176. BNFL says that the next generation of fission reactors, such as the AP1000, will create far less waste than their predecessors. Dr Robin Clegg of BNFL told us "If we were to replace the current nuclear generating capacity with new nuclear technology and to run that technology for its design life, for 25 to 40 years, and generate 20 to 25 per cent of the UK's electricity from that ... this new technology would only add ten per cent to the volumes which we have got already".[300] If this can be independently verified then the waste issue cannot be used as an argument against further nuclear build.

177. Greenpeace argues that allowing new nuclear reactors to be built will weaken the impetus to introduce renewable forms of energy generation. This is a risk, but the risk of failing to reduce our carbon emissions is also great. In our view the only strong grounds for the Government to oppose any new build by BNFL or British Energy is that the companies are not on a sure enough financial footing to be able to guarantee safe operation for the lifetime of the reactors. The ability of BNFL and British Energy to compete successfully in the market depends on the Government. It is right that nuclear generators bear the external costs of their generation but it is must remembered why we are discussing this subject at all. It is largely because the use of fossil fuels for energy has started to have a dangerous effect on global climate. CO_2 should be seen as waste and the Climate Change Levy barely begins to account for the external costs of dealing with it. It is hard to imagine that the nuclear legacy will ever be as serious as global climate change.

178. The PIU report argued that the nuclear option must be kept open.[301] According to Mr Adrian Ham from the British Nuclear Industry Forum, the option is not open at present.[302] The Government's Energy White Paper agrees that the nuclear option should remain but only just. It says:

> "While nuclear power is currently an important source of carbon-free electricity, the current economics of nuclear power make it an unattractive option for new generating capacity and there are also important issues for nuclear waste to be resolved. This White Paper does not contain proposals for building new nuclear power stations. However, we do not rule out the possibility that at some point in the future new nuclear build might be necessary if we are to meet our carbon targets. Before any decision to proceed with the building of new nuclear power stations, there would need to be the fullest public consultation and the publication of a White Paper setting out the Government's proposals."[303]

The implication is that in a couple of years' time the Government will look at the progress being made towards the 10% renewables target. If progress is slow then, it will then reconsider nuclear. It is clear from our evidence that the 10% target is unlikely and we see nothing in the White Paper to suggest that progress will be speeded up dramatically. **The Government's announcement that new nuclear build would require another public consultation and another White Paper is perplexing. The Government says with great pride that this is "the most significant consultation on energy policy ever carried out in the UK".[304] There would have been no shortage of views expressed on the nuclear**

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[299] House of Lords Report of the Select Committee on Science and Technology, session 1989–99, HL Paper 26 *Management of Nuclear Waste*, paras 3.10–3.11
[300] Q 358
[301] Performance and Innovation Unit, *The Energy Review*, February 2002, para 7.78
[302] Q 387
[303] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.68
[304] DTI press release 24 February 2003

issue and unless the situation changes substantially, which seems unlikely, a further consultation would simply involve the same people repeating the same arguments.

179. **The nuclear industry faces a continuing decline unless positive steps are made now. The only way to keep the nuclear option open is for the Government to indicate that it would in have no objection in principle to granting permission for new reactors to be built, even on a modest scale, to send a clear message that the technology has a future. It should benefit from its status as a carbon-free source of energy.**

180. **The next generation of fission reactors is likely to be the last. Nuclear fission power should be used to keep the UK's CO_2 emissions as low as possible until fusion power and other non-carbon technologies are commercially available.**

FUSION

181. Nuclear fusion is the fusing of hydrogen atoms to release energy, a process similar to that which powers the sun and other stars. Harnessing this power offers the potential of an almost limitless source of energy for future generations but it also presents some formidable scientific and engineering challenges. It involves heating the hydrogen atoms to very high temperatures (100 million ºC and above), creating a state called a plasma, confining the plasma and devising materials to withstand the conditions in the reactor. The most established form of fusion reactor is a Russian design called the tokamak.

182. Almost all of the UK's fusion research is undertaken at UKAEA's facilities at Culham in Oxfordshire. Here, the UK hosts JET (Joint European Torus), the world's largest fusion reactor, which is funded from the European Commission's EURATOM programme and direct from EU Member States. Britain's domestic research programme, headed by the MAST (Mega Amp Spherical Tokamak), also takes place at Culham. The CCLRC conducts some fusion research in collaboration with RIKEN in Japan. Its evidence draws attention to its work on lasers and their application to fusion.[305]

183. The current annual UK Government spend on fusion for 2002–03 is £14.63 million of which just under £6 million is the premium paid to host JET. In the 2002 Spending Review UKAEA was given an extra £1 million a year, although this will fund increased costs at JET for enhancements and for essential maintenance.[306] The EURATOM programme is funded by the EU, but the UK's annual contribution to the EURATOM fusion funding at Culham can be calculated at £23.5 million. From 2001–02, the DTI's fusion budget was transferred to the EPSRC following a review. This is discussed in paragraph 28 above.

184. JET is an experimental machine, operating for a few seconds at a time, and represents the main-line in fusion development. A demonstration project called ITER (International Thermonuclear Experimental Reactor), essentially a scaled up version of JET, is the next stage in fusion development and will take over from JET and other major programmes. ITER is a worldwide collaboration, the partners being the EU, Japan, Russia, Canada, China, the USA and possibly South Korea. The Americans had pulled out of the project, citing the cost of the project but announced that they were re-entering negotiations to rejoin on 30 January 2003.[307] The site has yet to be established but there are bids from Canada, Japan and two from the EU (Spain and France), with a European site most likely. JET is scheduled to close at the end of 2004 but we understand that it is very likely that it

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[305] Ev 84
[306] Unpublished memorandum from UKAEA
[307] Speech by US Energy Secretary Spencer Abraham, Princeton Plasma Physics Laboratory, 30 January 2003.

will continue for a further year. Beyond 2005 its lifetime depends on the rate of progress with ITER and the amount of money for fusion in the Framework 7 budget.

185. The focus of the UK's national programme is MAST, which represents a more long-term research programme and has an annual budget of £7.6 million out of a budget of £12 for the UK programme. MAST's spherical shape has some advantages over JET and a commercial reactor may well turn out to be based on MAST technology. It also has a role as training facility. EURATOM contributes £3 million a year to the national programme. The Government funds being spent on fusion are large compared with any other energy technology, even taking account of the hosting fee for JET. At the same time, the UK is spending much less on fusion research than Italy, France and Germany and only a fraction of that invested by Japan and the US. American fusion research approached $250 million in 2001 and German domestic spend on fusion was €120 million in 2002.[308] UKAEA estimates that as a function of GDP, the UK is spending 25% of Japan's expenditure and 60% of the Unites States'.[309]

186. Energy from fusion has been an exciting area of energy research for several decades, with the prospect of fusion power not apparently getting any nearer. This has prompted a degree of scepticism that the technology will ever be viable. *The Economist* published an article in July 2002, crediting fusion research for establishing a new universal constant: 30 years, the time until fusion power becomes a reality.[310] There are also complaints that the UK's funding for fusion research is disproportionately high and that it needs to be better balanced with research expenditure on other innovative energy technologies.[311] The UKAEA's defence of the criticism aimed at fusion research is that very substantial progress has been made in recent years, and that this progress has been made against a backdrop of continually decreasing funding.[312]

187. The Chief Scientific Adviser has been pushing for a fast-track approach to fusion development, advocating the establishment of an International Fusion Materials Irradiation Facility (IFMIF) to work in parallel to reactor development at ITER.[313] The Energy White Paper says that "We are a long way from a commercial power plant, but the technical feasibility of fusion power generation could be demonstrated within 25 years given adequate resources, possibly leading to full-scale power generation within 30 years".[314]

188. We have taken a close interest in the state of fusion research and its prospects for power generation. During our visit to Japan, we visited the JAERI (Atomic Energy Research Institute) tokamak at Naka and the research programme at Culham on our return. It was easy to be impressed by the scale of the scientific achievement at both sites but this should not cloud our view of the research's viability and the substantial resources being spent; and the time when it will become technically and commercially viable is still several decades off. Nevertheless, **we conclude that the progress in fusion research has been substantial in recent years. Together with the huge impact that fusion could have in reducing carbon emissions, we consider it to be foolish not to at least maintain the current level of resources invested in UK fusion research.**

189. Our concern is less that fusion power may not become a reality, more that when it does the UK will have lost its knowledge base and will resort to importing expertise and hardware. During our visit to Culham we were told that Japanese companies such as

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[308] Parliamentary Office of Science and Technology, *Nuclear Fusion,* Postnote Number 192, January 2003; German Helmholtz Research Programme proposals for 2004–2008
[309] Ev 21
[310] It's Impossible. And What's More, it's Improbable, *The Economist,* 20 July 2002.
[311] Ev 43
[312] Ev 146
[313] Q 605
[314] DTI, *Our energy future—creating a low carbon future,* Cm 5761, February 2003, para 7.37

Hitachi were already prepared to build and sell a tokamak. That the UK was poorly placed to take commercial advantage of JET in the long term was a concern of Derek Robinson, the late Director of the UKAEA Fusion Programme. Sir David King felt that this could be rectified but that the UK's engineering scene would need a big boost. We were impressed at both Naka and Culham by the international perspective of the researchers, who see that this is a global pursuit that transcends national boundaries. This is admirable research but we feel that someone needs to be looking after the UK's interests when it comes to the maintenance of skills and expertise. As UKAEA says itself, the UK is in a fortunate position, largely at other people's expense.[315]

190. We were pleased to see the positive approach to fusion set out in the White Paper. It considers that by 2020 fusion will be at an advanced stage of development.[316] We were also pleased to see that the Government is not content to rely on ITER as the UK's contribution to fusion research: "The UK has considerable expertise in fusion and a complementary national fusion programme will also be needed to maximise the benefit from this expertise".[317] What is lacking is any detail as to how this can be achieved and how much money the Government will commit. We were pleased that Sir David King will be lobbying to keep JET operational until ITER is up and running but less so that he could give no assurances about the future of the UK's domestic programme, principally MAST, saying that "by putting quite significant funds and growing funds into the international project, national projects will have to be run down".[318] **From 2003, EURATOM funding for the UK's national fusion programme will decline from 25% to 20%. We would like the Government's reassurance that it will compensate UKAEA for this loss in income.**

191. We were concerned during our visit that UKAEA was not actively lobbying for a continued fusion programme in the UK after JET was shut down and suggested that it submit to the inquiry a "vision" for the future of Culham.[319] The UKAEA's submission contains, we believe, a sensible blueprint for the future, maximising the UK's input to ITER in the short term and proposing a "major facility of strategic value to the 'fast track' when JET operations end". UKAEA says the decision point for such a facility is some way off but we believe that UKAEA should start making the case now to position itself for any bid. It is our impression that UKAEA does not lobby aggressively enough. We were told during our visit to Culham that when the issue the UK submitting a bid for ITER was raised in 1997, the then Science Minister did not pursue it. Little attempt seems to have been made to persuade him and we consider this to have been a lost opportunity. Sir David King told us that he wished the UK had bid for ITER and that he would recommend that the UK seek to host IFMIF, although this would be unlikely to succeed if one of the European bids for ITER were successful.[320] **The UK has been fortunate to host JET but it must not waste this good fortune. We recommend that the Government invests resources to maintain the UK's domestic fusion programme with a view to building a major facility in the future. We believe that fusion power will become a reality and the UK must benefit from the fruition of this technology.**

INTERNATIONAL COLLABORATION

192. International collaboration in energy RD&D has many advantages such as exposure to the best of overseas innovation and technology and the participation of UK scientists in the best international research. It also enables the UK to take part in programmes that it

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315 Ev 143
316 DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, p 19
317 As above, para 7.37
318 Q 605
319 Ev 143–147
320 Qq 608, 610

would otherwise not fund and provides a critical mass, a benefit provided that the UK gets a proportional return. As Tom Delay from the Carbon Trust put it: "there are some technologies that really will only succeed if managed and invested in on a collaborative basis between nations, companies and so on".[321] Over-reliance on international collaboration could result in UK interests not being reflected in the technology or the timescale of the project. The Government also has a concern that components and services are sourced from overseas with UK companies losing out.[322]

193. The Government identifies three forms of international collaboration: the European Union's Framework Programme for Research and Development, the International Energy Agency's Implementing Agreements, and bilateral Memoranda of Understanding, such as that with US Department of Energy.

194. We considered the energy funding from the European Commission's Framework Programme in paragraphs 53–56. We are addressing this funding stream in our inquiry "UK Science in Europe: Value for Money?". We aim to establish whether Framework 6 and the European Research Area promote valuable collaborations or simply alliances of convenience, and whether research collaborations are flourishing in Europe outside of the Programme. We plan to report in summer 2003.

195. DTI has a Memorandum of Understanding with the US Department of Energy "to continue, expand, and maximise cooperation in energy research and development". It was signed in 2000 and runs for 10 years. The areas covered are fossil energy; renewable energy; waste management and the environment; energy end-use technologies; and policy research.[323] Sir David King told us the value of this agreement, although it is hard to believe that the US is being quite as generous as he implies.[324]

196. The International Energy Agency, of which the UK is a member, runs a number of international collaborative energy RD&D projects known as Implementing Agreements. Countries can choose to participate in these collaborations, or not. As of November 2002, the UK participated in all but six of the 42 programmes (including nine through EURATOM).[325]

197. There is a danger that international collaboration is seen as an alternative to a strong domestic programme. This cannot be allowed to occur. Britain needs the researchers to ensure that the UK can apply the research to its own needs; moreover the UK needs to develop researchers who are competent to take part in international collaborations. **The UK can only play a significant role in international programmes if it is done from a strong national base. Participation in multinational ventures must be used to complement a strong domestic RD&D base.**

OBSTACLES TO A NON-CARBON FUEL ECONOMY

198. RD&D cannot be considered in isolation from the electricity transmission network, the market and its regulation. Although our inquiry's focus is on RD&D, there are distinct disincentives to RD&D and these will be dealt with here.

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[321] Q 257
[322] Ev 105
[323] Ev 106
[324] Q 577
[325] www.iea.org

Infrastructure

199. We have considered some of the RD&D issues facing transmission companies. Some of the infrastructural changes required to facilitate the large scale installation of the renewable energy sources require the application of well-established technologies, however. Many renewable energy sources are likely to be located away from major urban centres and so the Grid will need to be strengthened in certain areas to ensure transmission from generator to consumer.[326] For historical and economic reasons, the flow of electricity in England and Wales is largely from North to South, with 10,000 MW being transferred regularly. Many of the renewable sources of electricity are found in the north, west and in particular Scotland. The three British transmission-owning companies—National Grid, Scottish Power and Scottish and Southern Electric—have conducted a study on behalf of the DTI into the changes necessary to increase flows. The study concluded that "substantial transmission development and investment will be required, including the upgrade of some distribution circuits and building some new substations, if renewable developments on this scale are to take place and indeed if the Government's targets for 2010 are to be met".[327]

200. The White Paper recognises the substantial strengthening of the transmission network necessary to exploit renewables such as onshore wind and marine technologies, stating that "Transmission companies must start preparing now to strengthen the network to enable the UK to increase substantially its deployment of renewables". We note that "Discussions are currently taking place between Ofgem and the transmission operators on plans to upgrade the transmission network across the whole country".[328] We look forward to finding out the results of those discussions and in particular how the "rewiring" referred to by Brian Wilson will be paid for. He indicated that the utilities will have to pay for it but that this investment would have to be recognised by Ofgem.[329] The concept of a West Coast Interconnector was favoured by Mr Wilson as it would avoid a lot of the planning difficulties. It seems that its high cost will mean that it is unlikely that it ever gets built.[330]

201. A further issue for the transmission companies is the task of ensuring that the second-by-second demand for electricity is supplied. It has been suggested that the intermittent nature of some renewable energy sources, particularly wind, could lead to technical problems in balancing the system. National Grid has conducted a study into the implications of a larger proportion of renewable generation and concluded that the target of 10% renewable generation by 2010 would not be constrained by the current technology but there are costs involved. National Grid estimates that if wind made up the full 10% it would cost £60–80 million a year. Beyond 10%, no technical problems are foreseen but there would be cost implications.[331] Stand-by generation and large-scale storage may be required.

202. We discussed the technical issues necessary to connect distributed generation to local networks in paragraphs 75–80. But these are only one part of the problem. The White Paper concludes that "Very substantial changes will be needed in the way in which our distribution networks are designed, organised and financed ... DNOs will also need to take a more proactive approach to distributed generation". It goes on "Under the present price control rules there is no financial incentive for the DNOs to connect distributed generation to their networks. We therefore believe that the regulatory framework needs to be amended

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[326] Ev 126
[327] Ev 126
[328] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.25
[329] Q 616
[330] Q 619
[331] Ev 126

so that the DNOs connect and use higher levels of distributed generation.[332] **At present the transmission companies and network operators have little obligation or incentive to invest in bringing forward and installing the technology needed to make large-scale renewable generation a reality. The lack of these incentives discourages industry to tackle the problems remaining with many exciting new energy technologies. We are pleased that the Government appreciates the need to revise the regulatory framework. In selecting the methods of energy generation for the future, account will need to be taken of the potential changes needed in the distribution network infrastructure.**

Planning

203. The PIU report describes the problems in gaining planning permission for energy projects as "persistent theme of the review" which it attributes to different concerns of potential developers and local residents. This is not just a problem for mature technologies as demonstration projects may have to face the same obstacles and the any barriers to the deployment of new technologies will inevitably have an impact on RD&D investment. A particular problem is with offshore developments. There is no authorisation process offshore comparable to the planning process onshore and offshore developers must gain a series of consents. There are also likely to be conflicts with other offshore activities such as fishing, transport, defence activities, and oil and gas infrastructure. The PIU recommended a range of measures, of which the principal ones were:

- The DTLR (now ODPM) with the DTI should update national planning guidance, making it clear when there is a national case for new investment in energy-related facilities;
- Regional planning bodies should give greater prominence to energy developments in regional planning guidance; and
- Local authorities should ensure that greater emphasis is placed on proactive planning for energy developments in sub-regional plans.[333]

The Government's response in the Energy White Paper accepts the first recommendation. It says it will work with local planning authorities to obtain better statistics on the number of renewable projects that are achieving planning approval and why others are being rejected.[334]

Market and trading arrangements

204. NETA (New Electricity Trading Arrangements) came into operation on 27 March 2001, replacing the Electricity Pool. It put in place market-based trading arrangements. Under NETA, electricity suppliers and generators are required to contract directly with each other, and penalties are imposed where demand exceeds contracted levels or generation falls short of it. Most electricity is traded on such a bilateral basis but around 2% is traded through the NETA balancing mechanism, operated by the National Grid Company.[335]

205. NETA has forced down prices by exposing the overcapacity in UK electricity generation. This has made it uneconomic to build any major generating plant; indeed generators have mothballed some facilities. Many generators are losing money and the market is characterised by mergers and acquisitions. Also, small generators have been penalised by the severe penalties risked by failing to fulfil contracts, affecting CHP in particular. The result is a climate that does not encourage investment in RD&D. The

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[332] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, paras 4.21–4.22
[333] Performance and Innovation Unit, *The Energy Review*, February 2002, paras 8.38–8.43
[334] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.32
[335] As above, p 50

Environmental Audit Committee concluded that "The failure to carry out a thorough environmental appraisal of the proposals at the very start of the process was a material factor in the Government's failure to achieve its environmental objectives for the New Electricity Trading Arrangements".[336] The PIU report found that the renewables industry suffered from "the excessive discount which, following the introduction of the New Electricity Trading Arrangements, is currently imposed on the prices paid to small and intermittent generators".[337] The Government comes close to admitting as much in the White Paper:

> "some generators, in particular renewables and CHP, were exposed to very high costs as a result of the mechanism used to balance the electricity system. NETA is evolving to deal with these problems. It is important that the balancing mechanism reflects costs and that the system as a whole provides a realistic route to market for all generators".[338]

206. The Government has published a draft bill on the formation of a nationwide electricity trading system called British Electricity Trading and Transmission Arrangements (BETTA).[339] The Trade and Industry Committee is undertaking pre-legislative scrutiny of the draft Bill.

Renewables Obligation

207. The Government's principal tool for stimulating renewable technologies is the Renewables Obligation, which requires electricity suppliers, from January 2002, to obtain a specific but increasing proportion of electricity from eligible renewables. Suppliers present "certificates" to the regulator demonstrating that they have fulfilled this obligation (known as ROCs). These certificates are tradeable. The Renewables Obligation requires electricity suppliers to obtain an increasing proportion of electricity from "eligible" renewable sources. The proportion will rise from 3% in 2002-03 to 10.4% in 2010-11, and will remain at that level for at least the duration of the Renewables Obligation (until 2026-27). The Government has stated that it may increase the level of the obligation after 2010. Before this, the main policy mechanism in England and Wales for promoting renewable energy was the Non-Fossil Fuel Orders (NFFO). Interested parties could bid for contracts to supply specific forms of renewable electricity. Electricity suppliers were obliged to buy the output, the extra costs being financed from a levy on customers' electricity bills. Unfortunately, as the Environmental Audit Committee reported, "the fact that contracts exist to develop projects on specific sites does not guarantee that those projects will be developed. Indeed, only 25 per cent of projects have been developed so far".[340]

208. The Renewables Obligation has been accused of being an indirect tool for stimulating renewables compared with the strategies adopted in Germany, Denmark and Japan.[341] Nevertheless, our witnesses have been positive about the mechanism, although for some it is too early to tell, and that now that we have a liberalised electricity market, more direct intervention would not be appropriate. A further concern is that the Renewables Obligation places a flat rate on the tradeable value of a certificate. The result is that the cheapest and most mature renewable technologies, such as onshore wind, have been given a boost and prompted increased interest from the major generators. The alternative would have been a banded system but the Government rejected this option on the grounds that it would be too complicated and would necessitate picking winners. We do not share the Government's view. The Energy White Paper says that it will review the Renewables Obligation in 2005,

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[336] Fifth Report of the Environmental Audit Committee, *A Sustainable Energy Strategy? Renewables and the PIU Report*, session 2001–02, HC 582-I
[337] Performance and Innovation Unit, *The Energy Review*, February 2002, p 11
[338] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, para 4.27
[339] DTI, Draft Electricity (Trading and Transmission) Bill, January 2003
[340] Fifth Report of the Environmental Audit Committee, *A Sustainable Energy Strategy? Renewables and the PIU Report*, session 2001–02, HC 582-I, paras 37–38
[341] As above, para 83

yet the Minister for Energy and Construction seemed to rule out any significant changes on the grounds that the market needed certainty. **If the UK is to stand a chance of reaching its renewables target, it needs to stimulate development of less mature technologies now. The Renewables Obligation fails to provide this incentive. It should be reformed or replaced with a mechanism that will.**

Climate Change Levy

209. A second strand of the Government's policy to stimulate renewables is the Climate Change Levy, to which eligible renewables are exempt. The CCL raises around £1 billion annually and is channelled back to industry through reduced National Insurance contributions, although some money is used to finance the Carbon Trust.[342] It has been suggested to us that a greater proportion of the CCL receipts (around £1 billion a year) should used to fund the innovation cycle: energy RD&D; tax incentives for innovation and commercialisation of promising options; grant and public procurement programmes for innovation; and education and training in energy and the environment. The Royal Society has argued that the Levy should be modified to become a Carbon Tax.[343] As Professor Dennis Anderson comments "Currently it takes the form of an energy tax, and provides little or no incentive for the development of non-carbon energy forms".[344] The primary objective of encouraging renewables is to reduce carbon emissions to moderate the rate of climate change. Sir David King, in giving evidence to us, stressed the need to internalise the external costs of energy production, which in the case of fossil fuel energy is dealing with CO_2 emissions and their effects.[345] The logical implication of this argument is that some form of carbon tax should replace the Climate Change Levy. We were disappointed that Brian Wilson was unwilling to discuss fiscal issues.[346] **We recommend that the Government introduce a tax incentive that distinguishes between: fossil fuel with carbon capture; carbon neutral technologies; nuclear fission and mature non-carbon technologies; maturing non-carbon technologies 10 to 15 years into the market; non-carbon technologies 5–10 years into market; and nascent renewable technologies in their first 5 years of commercial use.**

Emissions trading

210. In December 2002, the European Union Council of Ministers reached initial agreement on a new European carbon emissions trading scheme. This is expected to begin in 2005. Participants will be set a target level of emissions and receive tradeable allowances to this value. They can then either meet their target, reduce their emissions below their target and trade their excess or emit carbon above their allowance and buy allowances from other participants. At present the scheme covers major industrial energy consumers but it is planned to extend it to the electricity industry. The Energy White Paper says it will make the scheme a "central plank of our future emissions reduction policies".[347]

211. The Government says it will consider the effect of the emissions trading scheme on the Climate Change Levy but that any tax changes will be a matter for future budgets.[348] It says it will do so in the light of the European Commission's plan to modify its rules on the taxation of energy products.[349]

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[342] HM Treasury, Press release, 21 March 2000
[343] The Royal Society, *Economic instruments for the reduction of carbon dioxide emissions*, November 2002
[344] Ev 163
[345] Q 582
[346] Q 585
[347] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, paras 2.25–2.28
[348] As above, para 2.30
[349] As above, para 2.31

Ofgem

212. Ofgem's principal objective, set out in the Utilities Act 2000, is to protect the interests of consumers (both present and future), wherever appropriate, by promoting effective competition. It does not have statutory duties in relation to RD&D, reflecting the Government's view, presented in the White Paper *Modernising the Framework for Utility Regulation*, that it was no longer sensible to put the energy regulator under a duty to exercise functions so as to promote research and development in generation, transmission and supply. A discussion paper produced for the PIU noted in 2001 that "On the distribution side of RD&D, the fall in expenditure [following liberalisation] was influenced by regulatory allowances and incentives which did not encourage innovation".[350] Nevertheless, Ofgem does consider that it has a role in facilitating the development of new technologies.[351]

213. The narrowness of Ofgem's remit has been a concern. Ofgem does have a statutory duty for the environment but for some this is not sufficiently explicit. According to Professor Dennis Anderson, Ofgem has been "contenting itself with cost efficiency and leaving all long-term matters regarding energy and the environment to others and to policies imposed on it by the Government".[352] This point is conceded by the Government in its White Paper. It says it will "raise the profile of environmental considerations in OFGEM's regulatory decision-making".[353] Brian Wilson told us that the lowering of prices caused by Ofgem's regulation had had collateral effects.[354] We still lack any loosening in the allowable costs for RD&D, although we were slightly encouraged to hear the Minister say that this might be one of the things the Government discuses with Ofgem.[355] **Ofgem should establish a more supportive framework for innovation and RD&D in the new "climate friendly" technologies. Ofgem must be more willing to allow RD&D against companies' profits when looking at prices.**

The renewables environment

214. Ernst & Young published a Renewable Energy Country Attractiveness Index in January 2003. The index provides scores for 15 countries based on their national renewable energy markets, renewable energy infrastructures and their suitability for individual technologies. The UK scores well (see Table 9) with the report concluding that renewables are relatively protected from the market through the Renewables Obligation, there are good general capital allowances and targeted capital grants for emerging technologies. The environment for wind was particularly good, according to the report, but not on other emerging technologies. The UK's "All renewables index" is high because the authors gave a high weighting to wind.

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[350] PIU, *Discussion Paper: Electricity Market Liberalisation in a Carbon Constrained World*, November 2001, para 11
[351] Ev 63
[352] Ev 163
[353] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, paras 9.14–9.15
[354] Q 580
[355] Q 612

Table 9: Renewable energy country attractiveness index

	Renewables infrastructure index	Wind index	Solar index	Biomass and other resource index	All renewables index
US (RPS)[356]	72	76	82	65	75
Germany	61	76	70	62	73
Spain	64	75	71	63	73
UK	64	79	42	51	72
Italy	63	67	73	50	64
Greece	60	64	55	39	59
France	41	60	60	50	59
Portugal	47	59	52	51	57
Sweden	57	56	39	61	55
Ireland	51	58	32	40	53
Denmark	54	57	40	43	53
Netherlands	40	55	50	43	52
Norway	55	46	34	54	46
Belgium	48	46	36	37	43
Austria	44	36	42	47	38

THE ENERGY WHITE PAPER

215. The Energy White Paper, published on 24 February 2003, has been long-awaited, not least by ourselves. Sir David King told us that the aim of reducing emissions to 60% of their 1990 levels by 2050 was new and a very real objective.[357] It is a very admirable objective but we were looking for some very real policies to give us confidence that the objective was achievable. We have looked in vain. Brian Wilson was right to say that it is not all about new funding, but new funding and new incentives are still very important.[358] He told us that it firmly restated the target of 10% renewable generation by 2010.[359] We expected more than restated aims. **While we agree with many of its sentiments, we remain disappointed with the White Paper, largely because that is what it is, a document full of sentiments with few practical policy proposals that give us any confidence that its targets (and aspirations) can be met. It has ducked a central issue—whether to provide a future for the nuclear power industry—and failed to give a lead. On the specific issue of RD&D, it makes all the right noises but fails to pledge**

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[356] US (RPS) refers to states in the US with a favourable renewable portfolio standard and strong wind resource.
[357] Q 567
[358] Q 567
[359] Q 561

any further investment nor provide any further direct incentives to industry to do so. RD&D investment in the UK is set to remain at the bottom of the international league table.

CONCLUSIONS

216. **There is no prospect of achieving the target of 10% renewable generation by 2010 or the aspiration of 20% by 2020. There is no chance of meeting the Government's targets for CO_2 reductions if current policies and market conditions remain in place.** We asked the Minister for Energy who was responsible for meeting the Government's renewables targets. His lame response was that it was a collective Government responsibility along with Ofgem.[360] This increases our concern that the Government's energy policy is too fragmented. Brian Wilson seemed to agree with our suggestion that reforming a Department of Energy would help to solve this, stating that its abolition had been a political statement. The White Paper was the perfect opportunity to right a wrong yet the Government missed its chance. There is no effective legislative stimulus to renewable development and there is a strong disincentive to new investment in any generation technology, renewable or otherwise, under the present market arrangements. We see little point in having ambitious targets if the policies in place give little hope that they can be achieved. There are two courses of action:

- Introduce targets that are achievable; or
- Change the policies and make a far more concerted effort to reach the targets.

217. **Given the importance of reducing UK carbon emissions, we propose that a Renewable Energy Bill be introduced at the earliest opportunity. The Bill should include the following provisions:**

- **The establishment of a Renewable Energy Authority (REA) with UK-wide responsibility for co-ordinating and promoting RD&D in renewable energy and disbursement of funds for that purpose.** The REA should encompass the numerous public or quasi-public bodies currently involved in renewable RD&D such as the Carbon Trust and the UK Energy Research Centre. It should have such planning powers as are necessary to facilitate deployment of renewable generators in co-ordinate their location. The Government's White Paper insists that no new organisation is necessary to deliver changes in energy generation and usage, but "effective interdepartmental working" and an ad hoc Ministerial group will not drive through the profound changes that we need.[361]
- **The replacement of the Climate Change Levy and the Renewables Obligation with a unified Carbon and Renewable Energy Tax to be levied on the electricity generators, the yield from which should be hypothecated to the REA**. The tax should provide for credits for new renewable technologies at different stages of development. Table 10 illustrates how such a tax could be structured.
- The terms of reference of OFGEM should be changed to give equal weight to environmental considerations as to free competition and security of supply.
- There should be a statutory requirement for grid and supply companies to make any alterations to their transmission systems that are necessary for the connection of new renewable resources.
- Supply companies should be required to provide net metering for domestic and commercial embedded generators.

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[360] Q 570
[361] DTI, *Our energy future—creating a low carbon future*, Cm 5761, February 2003, paras 9.6, 9.9

Table 10: Carbon and Renewable Energy Tax to be levied on the electricity generators.

Tax(credit) p/kwh[362]	Category of generation
2.0	All CO_2 emitting generation
1.0	Fossil fuel with carbon capture
0.0	Non-CO_2 emitting and sustainable sources already commercially established, e.g. onshore wind, hydro, nuclear fission, biomass
(1.0)	Maturing renewable technologies 10–15 years into the market.
(2.0)	Renewable technologies 5–10 years into market
(3.0)	Nascent renewable technologies in first 5 years of commercial use.

218. **Despite recent increases in Government energy RD&D funding, investment is pitiful in absolute terms and in comparison with out international competitors. We believe the UK should be investing more, on economic grounds and to ensure that the technology is suited to Britain's national needs and takes advantage of our strengths. By repeating the not picking winners mantra, the Government has failed to take a lead. We consider the following areas to be our strengths, reflecting the UK's natural sources and research strengths:**

- **Offshore technologies—wind, wave and tidal**
- **Nuclear fusion**
- **Nuclear fission**

Offshore technologies should be funded at least on a par with fusion (currently £23.5 million a year) and fission should be funded at £10 million a year to fund participation in the Generation IV Forum and boost the academic skills base.

219. Investments in RD&D must be complemented by policies to stimulate the market. Grants for deployment and tax incentives must be employed to greater extent, commensurate with the threat from global climate change.

220. The Energy White Paper presents a bold vision in which the UK's CO_2 emissions will be 60% lower than they were in 1990. This is no easy task and requires a powerful drive from the Government to make it happen. Unfortunately we see no evidence that the present Government, or at least the Minister for Energy, has either the passion or the commitment to change the way we produce and use our energy supplies. We are left with a disparate set of modest or vague policy instruments that will have little impact.

[362] These figures are illustrative.

LIST OF RECOMMENDATIONS AND CONCLUSIONS

1. **We agree with the value of a target for renewable electricity generation but we must not lose sight of the principal objective, which is to introduce non-polluting, sustainable forms of energy on a large scale (paragraph 15).**

2. **The EPSRC has a large area of science to fund but it is hard to accept that energy research, given its economic and environmental importance to the UK, should receive such a small slice of the cake (paragraph 22).**

3. **Half the membership of the EPSRC's council is from industry and we fear that this may lead to conservatism. We regret that technologies with the potential of wave and tidal or hydrogen are given so little funding. The EPSRC should be given a stronger lead by Government to ensure that investment is consistent with wider energy policy (paragraph 23).**

4. **We appreciate that striking the right balance between funding applied and blue-skies research is difficult but we urge EPSRC to ensure that researchers with innovative, if risky, projects get the funding they need (paragraph 26).**

5. **We agree with the Government that there are merits in placing fusion research under the auspices of the EPSRC but we have reservations about its commitment to the technology. To maintain the UK's position in this field, we believe it should remain a special case for funding with a ring-fenced budget. We will be watching the operation of the new funding arrangement for nuclear fusion research at Culham with great interest (paragraph 28).**

6. **It is pleasing to see that the Research Councils are beginning to improve the way they are working together and in particular that they put in a successful joint bid to the Spending Review on sustainable energy (paragraph 29).**

7. **We urge the Research Councils to make an early decision on the continuation of funding of the Tyndall Centre to avoid any interruptions in the Centre's research programme, and to increase its resources (paragraph 32).**

8. **We welcome the cross-Council programme on sustainable energy. The Research Councils' expenditure on energy research has been pitiful and this investment is a step in the right direction. But it only remains a step, which we hope will be followed up vigorously in the future. If UK technologies are to succeed the scale of investment must increase rapidly (paragraph 34).**

9. **We will await the development of a UK Energy Research Centre and a National Energy Research Network with great interest but we are concerned that its remit is too narrow and aims to modest to turn energy RD&D into deployed technologies (paragraph 35).**

10. **We understand that UKERC will provide "a focal point for data and information on UK energy research funding". If this means that the Centre will provide a one-stop shop for those seeking energy-related RD&D funding then it is a proposal that we warmly welcome (paragraph 36).**

11. **We have no doubt that the Research Councils are funding world-class research into low carbon energy, but is our impression that instead of driving these exciting new technologies forward they have a passive, unadventurous**

approach. There will be few sleepless nights in our competitor countries (paragraph 37).

12. We do not understand why the functions of the Carbon Trust could not have been taken on by existing Government bodies. We suspect that its formation was primarily a political gesture to bolster the Government's green credentials (paragraph 41).

13. It is too soon to judge the effectiveness of the Carbon Trust but we detect a lack of urgency. It must be an active partner of the UK Energy Research Centre in its provision of advice and information on funding (paragraph 42).

14. The DTI seems to be looking for reasons not to invest in RD&D. The Government must be doing more than filling in the gaps left by the private sector and drive forward important technologies (paragraph 47).

15. The Government has expressed its concern that the UK does not derive sufficient commercial benefit from the excellence of its science base. The DTI's inability to fund properly energy RD&D projects is a clear case of its policies betraying the fine words of its Ministers (paragraph 48).

16. The UK is spending much less than its competitors on energy RD&D. The PIU money and the Research Councils' new Sustainable Energy Programme provide a welcome and long-overdue boost to energy RD&D in the UK. We are pleased to see the Chief Scientific Adviser recommending further increases in the future and strongly urge the Government to make a commitment to this end over a defined period (paragraph 57).

17. We support the idea of a single entry portal for those seeking support for RD&D in fuel cells but believe there is merit in extending the concept to embrace all new energy technologies (paragraph 60).

18. The coordination of public funding bodies and research policy in the field of energy RD&D has been poor. We shall be monitoring the progress of Government and the Research Councils in improving coordination with great interest. The establishment of a UK Energy Research Centre is a step forward but we have little confidence that it has the remit to solve the problem (paragraph 61).

19. It is reasonable to ask how the Government can have an energy RD&D policy that does not embrace a vision of which technologies should be backed (paragraph 65).

20. The Government has the option of creating a framework of incentives, such as tax credits for RD&D, which will devolve the responsibility for picking winners (and inevitably some losers) to industry; but it also has to make choices and take risks too, especially in its support for RD&D, where it cannot avoid setting some priorities. The Government has an important role in identifying those of Britain's strengths that are consistent with the industrial environment and the market. It should provide a clear and unambiguous focus. (Paragraph 65).

21. The Government seems nervous of being accused of picking winners. As a result tough decisions have been avoided. We should be selecting all of those research projects for funding which we have the capacity to execute and which have a reasonable chance of delivering solutions and significant benefit for UK society (paragraph 67).

22. Britain's energy structures are too complicated. As a result, efforts to stimulate RD&D are fragmented and directionless. No public body or Minister is taking responsibility for driving forward technological innovation and deployment (paragraph 68).

23. Much bolder action is needed to make non-carbon technologies play a significant contribution to the UK's energy mix. For this reason, we recommend the creation of a Renewable Energy Authority. It should emulate the function of UKAEA in driving the nuclear industry after the World War II. The Authority would subsume the UKERC and the Carbon Trust, the DTI's energy programme and the energy policy unit. It would:
1. **conduct applied research and development in selected technologies;**
2. **conduct demonstration programmes, usually but exclusively in collaboration with industry;**
3. **provide a fast-track planning service to non-carbon energy applications; and**
4. **supervise infrastructural modifications to the grid and distribution netwoks to facilitate the connection of distributed generation (paragraph 68).**

24. We are puzzled by the Government's assertion that privatisation and liberalisation has not led directly to a decline in energy RD&D—it has led to a dramatic decline, by far the largest decline in all OECD countries. The forces that drove innovation in the past are at least as strong as they ever were and it seems hard to believe that the Chief Scientific Adviser's energy group and several of our witnesses are so ill-informed. We are concerned that the Government is poorly placed to stimulate energy RD&D investment in industry if it is in a state of denial over its causes (paragraph 71).

25. The fall in private sector RD&D expenditure has been higher than would have been expected from simply improving its focus. We conclude that there has been a real and damaging reduction in the amount of private energy RD&D spend since privatisation and liberalisation of the market (paragraph 72).

26. We recommend that the Government establish demonstration projects to establish how distributed sources of electricity generation can be incorporated into local networks, in particular the development of metering systems to allow domestic generation to export power to the network (paragraph 79).

27. United Utilities rightly recognises the value of non-technical research into commercial and regulatory initiatives for distribution networks. We recommend that the Economic and Social Research Council make provision for such studies (paragraph 80).

28. We appreciate the commercial constraints on companies and recommend that the Government and the regulator work to create a better environment for RD&D (paragraph 82).

29. It is disappointing that the UK's experience in the North Sea oil and gas industry is not being employed to develop new marine energy technologies. Clearly the incentives for oil and gas companies are insufficient, a situation which the Government should remedy (paragraph 85).

30. We are pleased that the UK Government supports an EU target of 3% of GDP invested in RD&D but given the strong link between investment and

productivity, we are disappointed that it has not adopted this "aspiration" for the UK. We recommend that the Government does so (paragraph 87).

31. The Government should recognise that even companies not regularly making a profit need to think long term and invest in RD&D and should consider introducing mechanisms that provide that incentive (paragraph 91).

32. The existence and nature of R&D tax credits are not well understood by companies—particularly the smaller ones—and the rules of the R&D tax credit seem to be too complicated or inadequately explained. The Government should remedy these problems, since if energy RD&D is to be resuscitated in the UK in the field of low carbon technologies, a clear and significant tax incentive is much-needed (paragraph 92).

33. The Government has failed to encourage an environment that encourages technical innovation, to provide sufficient direct investments and to make any significant response to the scale of market failure (paragraph 93).

34. The proposed UK Energy Research Centre and Network should play a crucial role in bringing forward the next generation of skilled people for the energy sector. We recommend that it adopt this as a key part of its mission (paragraph 98).

35. We recommend that the Government recognises low and non-carbon energy as a shortage area, recognising its importance in combatting climate change (paragraph 99).

36. It is hard to imagine the nuclear skills situation improving, since the Energy White Paper has all but ruled out new nuclear build. Even with no new nuclear build, nuclear engineers will be needed for many years to come to deal with decommissioning and storage but few graduates will be inspired to join an industry in its death throes (paragraph 105).

37. We argued in our report on Science Education from 14 to 19 that science education needed to be made more relevant. There are few better examples of a subject that could enthuse our schoolchildren than non-carbon energy, which has the power to tackle the potentially catastrophic effects of climate change (paragraph 107).

38. We consider CO_2 sequestration to be a necessary part of the transition to a non-carbon fuel economy. Nevertheless, it is important that its use should not act as a disincentive to the elimination of carbon-based fuels (paragraph 110).

39. We commend the Government's positive approach to CO_2 sequestration. There is a real opportunity in the North Sea with enhanced oil recovery as the initial economic driver. Policy mechanisms are needed to ensure that it happens and that there is an agreement on the legal and environmental issues of CO_2 storage (paragraph 111).

40. We believe that the UK should play to its strengths and exploit its natural resources. As such, the continued use of coal has a role in the UK's energy mix provided that CO_2 emissions are substantially reduced. We therefore support investment in clean coal technologies, for export as well as UK use, in tandem with CO_2 sequestration (paragraph 114).

41. The Carbon Trust's RD&D budget is not very large and we dispute the Government's assertion that it has the funding to make a significant impact on energy efficiency RD&D (paragraph 119).

42. The housing market is driven by Government regulations and it is our view that these have not been tough enough in the past (paragraph 122).

43. We welcome the Government's pledge to make major revisions of its building regulations and recommend that these are demanding, recognising that these can be a powerful stimulus to innovation by manufacturers (paragraph 122).

44. We await the revised building regulations in the hope they will provide the market pull for innovative energy-efficient products. We hope they are able to compensate for the lack of technology push generated by the feeble level of public RD&D funding in this area (paragraph 124).

45. We find it hard to reconcile the Government's apparent lack of interest in a relatively mature technology with the enthusiasm of the International Energy Agency. We recommend that the Government follow up the IEA's report with its own assessment of the role that hydro can play in the UK's energy supply (paragraph 125).

46. We recommend that the Government commission a cost-benefit assessment of different solar technologies (paragraph 133).

47. We are pleased to see that wave and tidal energy has received greater governmental attention since our predecessors' report. We hope that the recent increases in funding represent the first stage in building capacity, leading to investment commensurate with the potential of wave and tidal energy. We can look forward in the near future to investment commensurate with wave and tidal energy's potential impact on the UK's energy supply (paragraph 135).

48. Wave and tidal energy has enormous potential and can deliver a clean and predictable energy supply. We recommend that the UK should make a major investment in this niche market and aim to generate at least 5% of its electricity using wave and tidal technologies by 2020 (paragraph 138).

49. We welcome the attention being given to hydrogen RD&D by the Government. There is a UK big opportunity to take the lead here in a key area of energy research (paragraph 154).

50. We are struck by the particularly high number of public funding bodies active in bioenergy. The Government should simplify its support schemes in this area (paragraph 158).

51. We support policies to encourage less wastage and more reuse and recycling but it is inevitable that there is waste and Government policy should place no obstacles in the way of technologies that can harness waste which cannot be recycled to generate power (paragraph 162).

52. For the Government to keep the nuclear option open, participation in the Generation IV Forum is essential to give the UK a stake in the direction of future technologies. We recommend that provision is made for British companies to participate actively (paragraph 167).

53. We applaud BNFL's investment in pebble bed reactors and the long-term view it is taking of reactor technologies in an uncertain climate. We will watch the development of the technology with interest (paragraph 169).

54. Public opinion is a major obstacle to new nuclear build but this should not preclude the funding of research which could go a long way to addressing public concerns into the waste and safety of existing systems. We believe that the Government should not underestimate the public's pragmatism and should not be afraid of people's ability to balance its legitimate concerns with the great dangers posed by climate change (paragraph 170).

55. We recommend that the Government monitor technological developments in transmutation and keep it under review as part of its radioactive waste management strategy (paragraph 175).

56. The Government's announcement that new nuclear build would require another public consultation and another White Paper is perplexing. The Government says with great pride that this is "the most significant consultation on energy policy ever carried out in the UK". There would have been no shortage of views expressed on the nuclear issue and unless the situation changes substantially, which seems unlikely, a further consultation would simply involve the same people repeating the same arguments (paragraph 178).

57. The nuclear industry faces a continuing decline unless positive steps are made now. The only way to keep the nuclear option open is for the Government to indicate that it would in have no objection in principle to granting permission for new reactors to be built, even on a modest scale, to send a clear message that the technology has a future. It should benefit from its status as a carbon-free source of energy (paragraph 179).

58. The next generation of fission reactors is likely to be the last. Nuclear fission power should be used to keep the UK's CO_2 emissions as low as possible until fusion power and other non-carbon technologies are commercially available (paragraph 180).

59. We conclude that the progress in fusion research has been substantial in recent years. Together with the huge impact that fusion could have in reducing carbon emissions, we consider it be foolish not to at least maintain the current level of resources invested in UK fusion research (paragraph 188).

60. From 2003, EURATOM funding for the UK's national fusion programme will decline from 25% to 20%. We would like the Government's reassurance that it will compensate UKAEA for this loss in income (paragraph 190).

61. The UK has been fortunate to host JET but it must not waste this good fortune. We recommend that the Government invests resources to maintain the UK's domestic fusion programme with a view to building a major facility in the future. We believe that fusion power will become a reality and the UK must benefit from the fruition of this technology (paragraph 191).

62. The UK can only play a significant role in international programmes if it is done from a strong national base. Participation in multinational ventures must be used to complement a strong domestic RD&D base (paragraph 197).

63. At present the transmission companies and network operators have little obligation or incentive to invest in bringing forward and installing the

technology needed to make large-scale renewable generation a reality. The lack of these incentives discourages industry to tackle the problems remaining with many exciting new energy technologies. We are pleased that the Government appreciates the need to revise the regulatory framework. In selecting the methods of energy generation for the future, account will need to be taken of the potential changes needed in the distribution network infrastructure (paragraph 202).

64. If the UK is to stand a chance of reaching its renewables target, it needs to stimulate development of less mature technologies now. The Renewables Obligation fails to provide this incentive. It should be reformed or replaced with a mechanism that will (paragraph 208).

65. We recommend that the Government introduce a tax incentive that distinguishes between: fossil fuel with carbon capture; carbon neutral technologies; nuclear fission and mature non-carbon technologies; maturing non-carbon technologies 10 to 15 years into the market; non-carbon technologies 5–10 years into market; and nascent renewable technologies in their first 5 years of commercial use (paragraph 209).

66. Ofgem should establish a more supportive framework for innovation and RD&D toward the new "climate friendly" technologies. Ofgem must be more willing to allow RD&D against companies' profits when looking at prices (paragraph 213).

67. While we agree with many of its sentiments, we remain disappointed with the White Paper, largely because that is what it is, a document full of sentiments with few practical policy proposals that give us any confidence that its targets (and aspirations) can be met. It has ducked a central issue—whether to provide a future for the nuclear power industry—and failed to give a lead. On the specific issue of RD&D, it makes all the right noises but fails to pledge any further investment nor provide any further direct incentives to industry to do so. RD&D investment in the UK is set to remain at the bottom of the international league table (paragraph 215).

68. There is no prospect of achieving the target of 10% renewable generation by 2010 or the aspiration of 20% by 2020. There is no chance of meeting the Government's targets for CO_2 reductions if current policies and market conditions remain in place (paragraph 216).

69. Given the importance of reducing UK carbon emissions, we propose a Renewable Energy Act at the earliest opportunity. The Act should include the following provisions:

1. **The establishment of a Renewable Energy Authority (REA) with UK-wide responsibility for co-ordinating and promoting RD&D in renewable energy and disbursement of funds for that purpose.**
2. **The replacement of the Climate Change Levy and the Renewables Obligation with a unified Carbon and Renewable Energy Tax to be levied on the electricity generators, the yield from which should be hypothecated to the REA (paragraph 217).**

70. Despite recent increases in Government energy RD&D funding, investment is pitiful in absolute terms and in comparison with out international competitors. We believe the UK should be investing more, on economic grounds and to ensure that the technology is suited to Britain's national needs and takes advantage of our strengths. By repeating the not picking winners mantra, the

Government has failed to take a lead. We consider the following areas to be our strengths, reflecting the UK's natural sources and research strengths :
1. Offshore technologies—wind, wave and tidal
2. Nuclear fusion
3. Nuclear fission (paragraph 218).

71. Offshore technologies should be funded at least on a par with fusion (currently £23.5 million a year) and fission should be funded at £10 million a year to fund participation in the Generation IV Forum and boost the academic skills base (paragraph 218).

72. Investments in RD&D must be complemented by policies to stimulate the market. Grants for deployment and tax incentives must be employed to greater extent, commensurate with the threat from global climate change (paragraph 219).

LIST OF ABBREVIATIONS USED IN THE REPORT AND EVIDENCE

BBSRC	Biotechnology and Biological Sciences Research Council
BETTA	British Electricity Trading and Transmission Arrangements
BNFL	British Nuclear Fuels
BRE	Building Research Establishment
CCLRC	Council for the Central Laboratory of the Research Councils
CHP	Combined heat and power
DEFRA	Department for Environment, Food and Rural Affairs
DNO	Distribution Network Operators
DTI	Department of Trade and Industry
EAC	Environmental Audit Committee
ECSC	Energy Conservation and Solar Centre
EPSRC	Engineering and Physical Sciences Research Council
ERRG	Energy Research Review Group
ESRC	Economic and Social Research Council
EST	Energy Saving Trust
IFMIF	International Fusion Materials Irradiation Facility
ITER	International Thermonuclear Experimental Reactor
JAERI	Japan Atomic Energy Research Institute
JET	Joint European Torus
LCIP	Low Carbon Innovation Programme
LMA	Liabilities Management Authority
RCEP	Royal Commission on Environmental Pollution
MAST	Mega Amp Spherical Tokamak
Mwe	Mega Watt equivalents
NEDO	New Energy and Industrial Technology Development Organisation
NEF	New Energy Foundation
NERC	Natural Environment Research Council
NERN	National Energy Research Network
NETA	New Electricity Trading Arrangements
NFFO	Non-Fossil Fuel Orders
NNC	National Nuclear Corporation
OECD	Organisation for Economic Co-operation and Development
PIU	Performance and Innovation Unit
RD&D	Research, development and demonstration
REA	Renewable Energy Authority
UKAEA	UK Atomic Energy Authority
UKERC	UK Energy Research Centre
TXU	Texas Utilities Company
UMIST	University of Manchester Institute of Science and Technology

ANNEX 1: VISITS MADE IN THE COURSE OF THE INQUIRY

Japan: Monday 16 September—Friday 20 September 2002

Monday 16 September

Morning: British Embassy, Tokyo

The Committee received briefings from Embassy staff on its work generally and specifically on its role in science and technology, energy and environment, and trade promotion.

Afternoon: Miraikan Museum of Emerging Science and Innovation

The Committee visited the museum and held a meeting with the museum's director.

Tuesday 17 September

Morning: Ministry of Economy, Trade and Industry's Agency for Natural Resources and Energy; New Energy Foundation

The Ministry of Economy, Trade and Industry is Japan's equivalent of the UK's Department of Trade and Industry. It is responsible for energy policy. The Committee held a meeting with Director General of Energy Conservation and Renewable Energy Department of the Agency for Natural Resources and Energy and heard presentations from officials.

The New Energy Foundation is non-profit organisation. It surveys research and the introduction and deployment of new energy technologies and administers the Government's domestic photovoltaic installation programme. The Committee met the Chairman of the New Energy Foundation and staff briefed us on the organisation's role and its photovoltaic programme.

Afternoon: New Energy and Industrial Technology Development Organization

The New Energy and Industrial Technology Development Organization is a semi-governmental organization under the Ministry of Economy, Trade and Industry. It activities include development and promotion of new energy and energy conservation technologies and the management of industrial technology research and development projects. The Committee held a meeting with President with presentations on fuel cell, hydrogen and solar energy development.

Wednesday 18 September

Morning: Japan Atomic Energy Research Institute, Naka Fusion Research Establishment

Naka is the centre of Japan's fusion research programme. The Committee held a meeting with scientists and toured the JT-60 tomamak and the establishment's research facilities on plasma heating and superconducting magnets.

Afternoon: Misawa Homes Institute of Research and Development

The Committee visited the company's zero emission solar energy house and received a presentation on its building product made from recycled wood chips and plastic.

Thursday 19 September

Morning: RIKEN Yokohama

The Committee visited the RIKEN facilities, focusing on its genomics sciences division.

Afternoon: British Council

The Committee received briefings on the work of the British Council, Tokyo in promoting a more positive image of the UK.

Friday 20 September

Morning: Sanyo Electric

The Committee received presentations on Sanyo's development of fuel cell cogeneration systems and photovoltaic cells and toured the Sanyo Solar Ark, the world's largest solar array.

Afternoon: Osaka Gas

Osaka Gas is the gas distribution company for the Kansai region. It has a demonstration programme in its company apartments using hydrogen fuel cells for residential cogeneration. The Committee visited this project along with the company's research facilities and a hydrogen fuel filling station it was developing.

UK Atomic Energy Authority's Culham fusion research: 11 November 2002

The Committee were given a tour of the UK's MAST facility, a spherical tokamak at an early stage of development and the European JET project. The Committee received presentations on the development of fusion technology and the role of the UK.

PROCEEDINGS OF THE COMMITTEE RELATING TO THE REPORT

WEDNESDAY 26 MARCH 2003

Members present:

Dr Ian Gibson, in the Chair

Mr Parmjit Dhanda	Dr Andrew Murrison
Mr Tom Harris	Geraldine Smith
Dr Brian Iddon	Bob Spink
Mr Robert Key	Dr Desmond Turner
Mr Tony McWalter	

The Committee deliberated.

Draft Report (Towards a Non-carbon Fuel Economy: Research, Development and Demonstration), proposed by the Chairman, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 220 read and agreed to.

Resolved, That the Report be the Fourth Report of the Committee to the House.

Ordered, That the notes on visits made in the course of the inquiry be annexed to the Report.—(*The Chairman.*)

Ordered, That the Chairman do make the Report to the House.

Ordered, That the provisions of Standing Order No. 134 (Select committees (reports)) be applied to the Report.

Several papers were ordered to be appended to the Minutes of Evidence.

Ordered, That the Appendices to the Minutes of Evidence taken before the Committee be reported to the House.—(*The Chairman.*)

Several papers were ordered to be reported to the House.

[Adjourned till Wednesday 2 April at Four o'clock.

LIST OF WITNESSES

Wednesday 23 October 2002

ENGINEERING AND PHYSICAL SCIENCES RESEARCH COUNCIL

RESEARCH COUNCILS

Wednesday 30 October 2002

TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH

POWERGEN AND INNOGY

Wednesday 6 November 2002

THE CARBON TRUST

BRITISH ENERGY

Wednesday 13 November 2002

GREENPEACE AND FRIENDS OF THE EARTH

Wednesday 20 November 2002

Wednesday 19 March 2003

DEPARTMENT OF TRADE AND INDUSTRY

LIST OF APPENDICES TO THE MINUTES OF EVIDENCE

LIST OF UNPRINTED EVIDENCE

Additional written evidence has been received from the following and has been reported to the House, but to save printing costs it has not been printed and copies have been placed in the House of Commons Library where it may be inspected by Members. Other copies are in the Record Office, House of Lords, and are available to the public for inspection. Requests for inspection should be addressed to the Parliamentary Archives, Record Office, House of Lords, London, SW1A 0PW(Tel 020 7219 3074). Hours of inspection are from 9.30 am-5.30pm on Mondays to Fridays.

1. Water Power Engineering

2. Dr P R Rowland

3. Mitsui Babcock

4. Severn Tidal Power Group