HOUSE OF COMMONS SESSION 1988–89

ENERGY COMMITTEE

Sixth Report

ENERGY POLICY IMPLICATIONS OF THE GREENHOUSE EFFECT

Volume I

Report together with the Proceedings of the Committee

Ordered by The House of Commons *to be printed*
4 July 1989

LONDON
HER MAJESTY'S STATIONERY OFFICE
£8.70 net

192-I

The Energy Committee is appointed under SO No 130 to examine the expenditure, administration and policy of the Department of Energy and associated public bodies, and similar matters within the responsibilities of the Secretary of State for Northern Ireland.

The Committee consists of a maximum of 11 Members, of whom the quorum is three. Unless the House otherwise orders, all Members nominated to the Committee continue to be members of it for the remainder of the Parliament.

The Committee has power:

(a) to send for persons, papers and records, to sit notwithstanding any adjournment of the House, to adjourn from place to place, and to report from time to time;

(b) to appoint specialist advisers either to supply information which is not readily available or to elucidate matters of complexity within the committee's order of reference;

(c) to communicate to any other such committee its evidence and any other documents relating to matters of common interest; and

(d) to meet concurrently with any other such committee for the purposes of deliberating, taking evidence, or considering draft reports.

The following were nominated Members of the Committee on 2 December 1987:

Mr Michael Brown
Dr Michael Clark
Mr Geoffrey Dickens
Mr Eric Illsley
Mr Ted Leadbitter
Sir Ian Lloyd
Mr Geoffrey Lofthouse
Mr Rhodri Morgan
Mr Peter Rost
Mr Alex Salmond
Mr Tony Speller

Sir Ian Lloyd was elected Chairman on 9 December 1987.

Mr Tony Speller was discharged and Mr Malcolm Moss was added on 28 October 1988.

Mr Rhodri Morgan was discharged and Mr David Clelland was added on 18 January 1989.

The cost of printing and publishing this Report is estimated by Her Majesty's Stationery Office at £10,830.
The cost of preparing for publication the Shorthand Minutes of Evidence taken before the Committee was £2,972.35.

TABLE OF CONTENTS

* Minutes of Evidence relating to this Report are published in Volume III.
** Memoranda relating to this Report are published in Volume II.
FOOTNOTES: In this Report, references to Memoranda published in Volume II are indicated by the abbreviation "*Ev*" followed by a page number and those in Volume III by "*Min of Ev*" followed by a page number.
References to replies given in oral evidence are indicated by the letter "Q" followed by the number of the question.

LIST OF WITNESSES

LIST OF MEMORANDA

UNPUBLISHED MEMORANDA

Additional memoranda have been received by the following bodies and individuals and have been reported to the House, but to save printing costs they have not been printed and copies have been placed in the House of Commons Library where they 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 Record Office, House of Lords, London SW1 (tel. 01-219 3074). Hours of inspection are from 9.30 am to 5.00 pm on Mondays to Fridays:

Challis, James

The Green Party

Institution of Electrical Engineers

Johnson Matthey

Power Management Associates

Shell UK Limited

CONTENTS OF THE REPORT

ENERGY POLICY IMPLICATIONS OF THE GREENHOUSE EFFECT

SELECTED GLOSSARY OF ABBREVIATIONS

The following acronyms and abbreviations are used in the Report:

ACE	Association for the Conservation of Energy
BC	British Coal Corporation
BG	British Gas plc
BRE	Building Research Establishment
CBI	Confederation of British Industry
CEGB	Central Electricity Generating Board
CFCs	Chlorofluorocarbons
CH_4	Methane
CHP	Combined Heat and Power
CO	Carbon monoxide
CO_2	Carbon dioxide
EC	European Community
EEO	Energy Efficiency Office
ETSU	Energy Technology Support Unit
Ev.	Written evidence to the Committee contained in Volume II
FoE	Friends of the Earth Limited
HC	Document printed in the series of House of Commons Publications
HC Deb	Reference to Official Report of House of Commons Debates (Hansard)
HL	Document printed in the series of House of Lords Publications
IEA	International Energy Agency
Min. of Ev.	Written evidence to the Committee contained in Volume III
NERC	Natural Environment Research Council
N_2O	Nitrous oxide
NO_x	Nitrogen oxides (including NO and NO_2)
NSHEB	North of Scotland Hydro-Electric Board
O_3	Ozone
OECD	Organisation for Economic Co-operation and Development
Q.	Reference to a Question asked in the Minutes of Evidence to the Committee
SERC	Science and Engineering Research Council
SPRU	Science Policy Research Unit, University of Sussex
SSEB	South of Scotland Electricity Board
TUC	Trades Union Congress
UKAEA	United Kingdom Atomic Energy Authority
UKPIA	United Kingdom Petroleum Industry Association Ltd
UNEP	United Nations Environment Programme
WWF	World Wide Fund for Nature

SIXTH REPORT

ENERGY POLICY IMPLICATIONS OF THE GREENHOUSE EFFECT

The Energy Committee has agreed to the following Report:

A. BACKGROUND

1. Introduction: Nature of Remit and Structure of Report

1. The Energy Committee has never embarked upon an enquiry with more broad-reaching implications than the one which is the subject of this Report. We have been dealing with what the Secretary of State for Energy described in answering the final question which we posed as "a problem which is way beyond party and way beyond country".[1]

2. The 1988 Report of the Environment Committee on Air Pollution[2] drew the problems of global warming—or the greenhouse effect—to parliamentary attention. Our sister Committee realised that these problems had profound implications for energy policy, which it could not properly investigate. We thought it our duty to do so. We began by calling in October 1988 for written Memoranda from a number of expert witnesses, and in the early months of 1989 we have examined some of these in oral sessions, culminating with evidence from the Secretary of State on 28 June. We are indebted to our witnesses for the effort which they have made to produce Memoranda of high quality and to accede to our many other requests for information. We are also most grateful to the specialist advisers who assisted us in this enquiry: Mr John Chesshire and Professor John Surrey of the University of Sussex Science Policy Research Unit, Professor Gerald Manners of University College London and Emeritus Professor Walter Murgatroyd of Imperial College, London.

3. There is no shortage of material to assist the Committee in its work. Worldwide concern about the greenhouse effect has grown apace over the last year. An important statement, which we took as one of the bases of our enquiry, was issued from the Toronto Conference on the Changing Atmosphere: Implications for Global Security, held from 27–30 June 1988. International work is continuing in a variety of contexts: the European Community (EC), the Commonwealth, the Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA) and world organisations such as the United Nations Environmental Programme (UNEP), the World Meteorological Organisation and the Intergovernmental Panel on Climate Change (IPCC).[3] In the UK, the importance with which government is treating the issue is evidenced by the Prime Minister's speech to the Royal Society on 27 September 1988, and by the almost unprecedented holding of a seminar on the greenhouse effect at 10 Downing Street on 26 April 1989, attended by scientists, industrialists, politicians, academics, civil servants and others.

4. Readers outside Parliament may not appreciate that departmental Select Committees, such as the Energy Committee, are obliged to concern themselves solely with the policy of the Government Department which they monitor. We are not well-resourced research organisations. Consequently, we have necessarily had to be modest in our ambition. We are not a scientific think-tank which can assess the uncertainties associated with global warming. We do not have responsibility for investigating policy in fields like overseas aid, agriculture and transport. Siren voices have encouraged us to make recommendations on matters as diverse as rescheduling the debts of less developed countries[4] or increasing the provision of bus lanes.[5] We have paid some attention to transport matters because of the high level and continuing growth of fuel use in the transport sector,[6] but we have concentrated on the responsibilities of the UK Department of Energy and its associated public bodies—the nationally-owned electricity, nuclear and coal industries. We readily accept that fossil fuel combustion in the UK is only a minor contributor to the world-wide problem.

---

[1] Q.560.
[2] First Report from the Environment Committee, Session 1987–88, *Air Pollution*, HC 270.
[3] *Ev.* pp. 34–35.
[4] Greenpeace, Q.485.
[5] WWF, *Ev.* p. 113.
[6] 17,994 million therms out of a total of 59,542 million therms in 1988: *Energy Trends*, April 1989.

5. Because our enquiry is necessarily limited to UK energy policy, we believe that other departmental Committees in the House of Commons should also examine the implications of the greenhouse effect for policies within their areas of competence. We have the Transport, Foreign Affairs and Agriculture Committees particularly in mind. We are also aware of the important enquiry being undertaken into the Greenhouse Effect by Sub-Committee II of the House of Lords Select Committee on Science and Technology, with whom we have enjoyed excellent co-operation. We look forward to their Report in the Autumn. We hope to join members of this Committee in a visit to Washington in September when we shall follow up some of the important work being done in the USA.

6. We begin this Report by reviewing the background to the problem. We describe the greenhouse effect, and the uncertainties associated with it, and we place the UK contribution in the world-wide context. We then review the proposals made by the Toronto Conference and the feasibility of their implementation in the UK and the world. After dealing briefly with the other energy-related greenhouse gases, we describe the role of carbon dioxide (CO_2) and analyse its sources by country, by cause and, in the UK, by sector. We also review the possibility of removing CO_2 from emissions. The next major sections of the Report deal with means by which CO_2 emissions may be reduced. The first method we describe is fuel switching, and we review the possibilities for more natural gas use, greater oil use, synthetic fuels and hydrogen, increased nuclear power, renewable sources of energy and, finally, we look at the future role of coal. In our next section we turn to the major potential offered by energy efficiency, and analyse some of the methods by which this potential could be realised. We also deal briefly in this section with the transport sector and combined heat and power (CHP). Our concluding sections look at the limitations of a "market" approach to the problem, and describe how the market may be lubricated to achieve a greenhouse-friendly result. The final chapters set out our principal conclusions.

2. What is the Greenhouse Effect?

7. The greenhouse effect is caused by certain gases in the atmosphere—the so-called greenhouse gases—which allow light and ultra-violet radiation from the sun to reach the earth's surface, but which prevent the escape of the resulting infra-red radiation (ie heat) from the atmosphere. The effect is essential to life; without it our planet would suffer inhospitable temperature variations like the moon and other planets. The effect has existed on earth long before life as we know it. The atmosphere and the oceans contain large stocks of greenhouse gases and there are continuous flows in both directions between them, flows which are augmented by equally large ones between the atmosphere and living and dead plants and animals. These naturally occurring flows, which have fluctuated over the millennia as the earth has passed through its several ice ages, are some 40 times as great as that produced by man's burning of fossil fuel. There is unequivocal scientific evidence that the concentration of the greenhouse gases in the atmosphere has increased over the last 30 years, and that the gases existed in much smaller concentrations before the Industrial Revolution.[7] This is due, at least in part, to Man's activities.[8] There is also evidence that the Earth's average temperature has been increasing this century, as Figure 1 shows. If there is a link, as many scientists believe, between greenhouse gas concentrations and the temperature rise, it is clear that there could be major and undesirable climatic changes—known as global warming—if greenhouse gas concentrations continue to grow.

8. Only one of our witnesses cast doubt on the existence of the greenhouse effect: the British Coal Corporation (BC)[9] argued that there was no clear scientific evidence for it, and that what there was is "extremely flimsy",[10] although even they produced figures for the contribution of various gases to the effect.[11] There was, in fact, broad agreement from our witnesses on the percentage contribution to global warming caused at present by the various gases, apart from water vapour.

---

[7] See Department of the Environment, Proof of Evidence, Hinkley Point 'C' Enquiry; see also Figure 3 for graph indicating increase in CO_2 concentrations.

[8] See for example NERC, *Ev.* p. 72; HMG, *Ev.* p. 38.

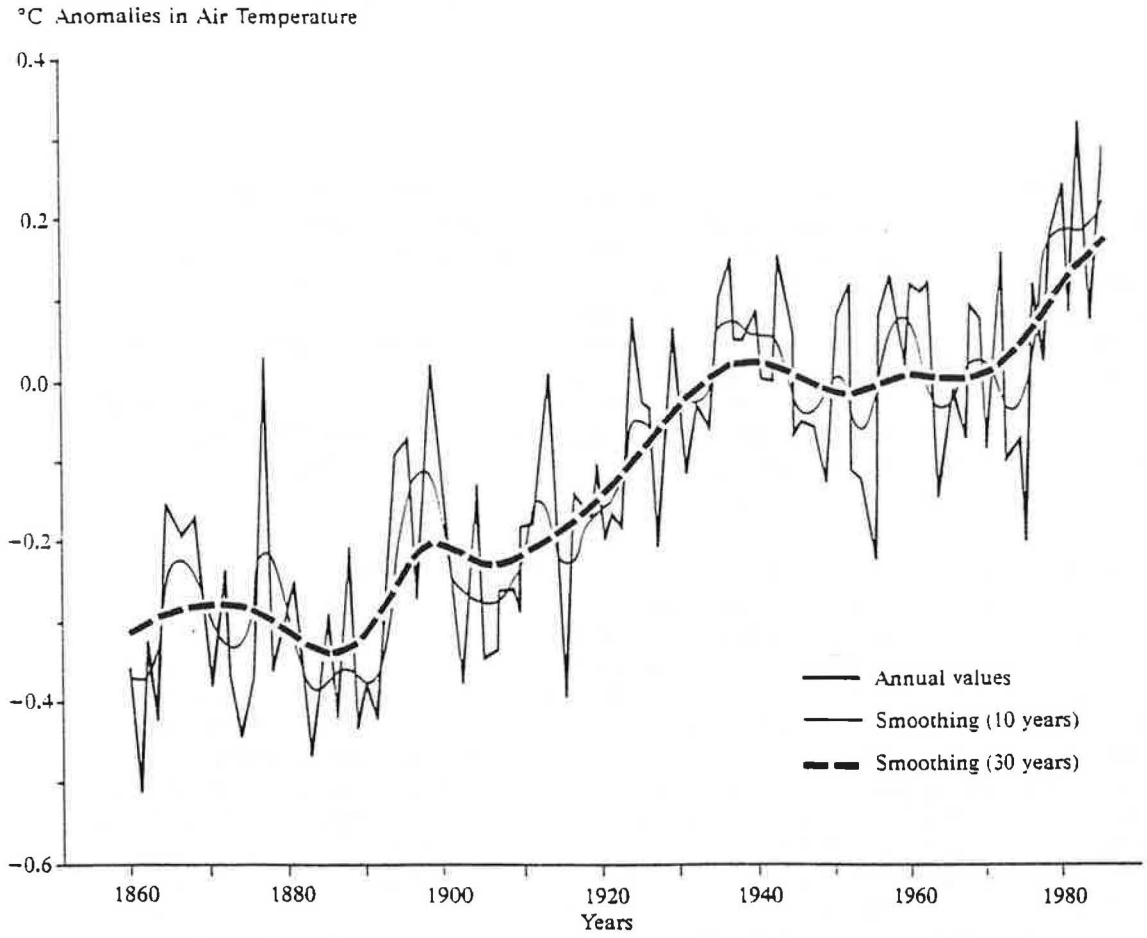
[9] A list of abbreviations is found on page viii.

[10] QQ 296 and 344.

[11] *Ev.* p. 20.

Figure 1

Global climatic curves from 1861 to 1987, summarizing the air temperature above the land masses and ocean surface



Source: P.D. Jones et al. - Nature, Vol. 332, 1988

14. The European Commission have also analysed some of the possible effects of global warming in Europe.[29] They suggest that these could include permanent inundation of many coastal areas; coastal erosion; flooding; storm damage; lack of water for human consumption, power generation, effluent dilution and navigation; changes in plants' growing seasons, agricultural yields and crop certainty and quality; changes in forestry; increase in tropical diseases; more frequent famines and food supply shortages, and impacts on marine life and on the diversity of all life systems.

(ii) *Action or Research?*

15. Although the consequences of global warming may be horrific, the opinion was put to us that no new initiatives were needed just yet to respond in terms of energy policy, and that better scientific evidence for the existence of the enhanced greenhouse effect and of its consequences should be gathered first. The dilemmas could be described as those between research and action or between scientific certainty and political will. If scientists do not agree, politicians cannot be expected to bring forward policies which may be difficult, unpopular or costly. However, there may be a major penalty for mankind if greenhouse emissions continue unabated while there is a delay until scientific consensus is achieved. As the Secretary of State for the Environment has argued in a general context[30] "there will be times when the possible consequences for the environment are so great that action has to be taken in advance of scientific certainty".

16. We examined our witnesses closely on this subject. It is clear first of all that research work on the greenhouse effect will need to continue for many years. For example, the IEA told us that "the nature of the problem is such that a clear resolution is not likely to emerge quickly".[31] At one extreme, the UK Petroleum Industry Association Ltd (UKPIA) seems to believe that the results of this research should be obtained before any action in the energy field is taken. They told us that "the oil industry believes that additional climatic research and improved atmospheric modelling is an essential prerequisite to energy policy planning".[32] This line appeared also to be endorsed by the United Kingdom Atomic Energy Authority (UKAEA)[33] who told us that "assessments of the need to initiate changes in fuel use, energy policy, etc must in the first instance come from the meteorological specialists".[34] At the other end of the spectrum, Friends of the Earth (FoE) told us that "action must be taken immediately if the threat imposed by global warming is to be averted",[35] the Dutch Government has argued that "by the time changes due to the greenhouse effect are being observed, it will no longer be possible to do anything about them",[36] and the European Commission believe that action in the energy field is justified "independent of uncertainties on some scientific aspects of the greenhouse issue".[37] The remark of Genady Goluber, Deputy Director of UNEP, that "advocating patience is an invitation to be a spectator at our own destruction" was also quoted to us.[38] We attach particular importance to the evidence of NERC: "to wait 20 years for temperatures and sea-level rise to 'prove' current predictions is not necessary. By then, the opportunity to avert or ameliorate that outcome will have been lost".[39]

17. BC, the witness who doubted the greenhouse effect most, conceded that "the great public in the West is not prepared to sit around for a decade or two to see whether things warm up so they can decide something ought to have been done",[40] and most of the other

[29] COM(88) 655 final pp. 25ff.
[30] *Policies against Pollution*, Centre for Policy Studies, 1989.
[31] *Ev.* p. 117.
[32] *Ev.* p. 104.
[33] In oral evidence, the Authority seemed to resile from this line—see QQ.395, 413.
[34] *Ev.* p. 100.
[35] *Ev.* p. 44; see Q.484.
[36] Ministry of Housing, Physical Planning and Environment, Report, Changes in Climate as a result of CO_2 and other trace gases, The Hague, July 1987.
[37] COM(88) 656 final p. 11; see also Greenpeace, *Ev.* p. 60.
[38] ACE, *Ev.* p. 2.
[39] *Ev.* p. 82.
[40] Q.296.

energy industry witnesses, including BP, the Electricity Council and the UKAEA under oral examination, agreed that some action needed to be taken at once.[41] However, they were also unanimous in counselling against what BP and the UKAEA called "panic measures"[42] or what the CEGB called "major, highly expensive and . . . socially destructive measures".[43] Baroness Hooper, the Parliamentary Under Secretary at the Department of Energy, also took this line. She believed that it is "sensible to take all the steps we reasonably can to ensure we do not add unnecessarily to the problem", but she argued that "we should avoid being panicked into measures which might ultimately prove unnecessary but in the short term affect our capacity to survive as an industrial nation".[44] However, we note the rather more positive recent resolution of the EC Council of Ministers[45] that the response to global warming "should be made without further delay irrespective of remaining uncertainties on some scientific aspects of the greenhouse effect". We questioned the Secretary of State further about this, and are delighted with his view that "there is no need to wait until we understand the phenomenon fully. The things that we can be doing now are sensible in their own right and justifiable in their own right".[46]

18. **When we began our enquiry we told witnesses that we were collecting evidence on two hypotheses: that global warming exists and that its consequences were deleterious. Although we are not able to prove the first or measure the second, we believe that we are justified in making these two hypotheses and that they are a reasonable basis on which public policy can be formulated. The crucial argument which this Report will address is what action should be taken now, at worst with least regret, and at best with economic advantage as well as with benefit to the world environment.**

19. However, we also believe that research in climatology, atmospheric chemistry and related areas to establish more certainty about the greenhouse effect is vital. This is a subject on which we know that the Lords Committee on Science and Technology will report in much greater detail. We were very concerned that a number of eminent witnesses in our enquiry claimed that research into the science of the greenhouse effect was inadequately funded: NERC, the Science and Engineering Research Council (SERC), the Trades Union Congress (TUC) and the Confederation of British Industry (CBI) all called for a greater and better funded research effort.[47] They were echoed by the Chairman of the UKAEA: "all I would plead is that the necessary funding is made available for those institutions to complete their work", and he claimed that if we applied more money, uncertainty would be reduced.[48]

20. The Government, too, recognises the need for "a great deal more information and study and knowledge of the science".[49] Although the Department of the Environment is the body principally responsible for the funding of this R&D, the Department of Energy also contributes to the research. We were told that £165,000 was being contributed by the Department to the IPCC research. This was not new money, but a re-alignment of priorities within the Department's coal R&D budget.[50] In total, Government plans to spend £15.54 million on global warming R&D in 1989–90, as well as contributing in total £760,000 over two years to the IPCC.[51] To set this in context, the Government will spend £5,500 million on R&D in 1989–90, of which civil science and technology will take up £2,956 million.[52] Out of this total spend, **we believe that much more money must be devoted to R&D into global warming. Although we commend the CEGB for their April announcement of a £1.25 million research programme, and endorse their spokesman's view that "it is essential that we put**

[41] See QQ.286, 92–93, 395, 413.
[42] QQ.374 and 221.
[43] Q.62.
[44] Q.133—see also QQ.147 and 151.
[45] Adopted at Environment Council on 8–9 June 1989.
[46] Q.556.
[47] *Ev*, pp. 80, 86, 96 and 115.
[48] QQ.396 and 405.
[49] Q.556.
[50] QQ.166–172, 182–186.
[51] HC Deb, 25 May 1989, col. 694. The Department of the Environment will also contribute to the IPCC budget, as well as the Department of Energy.
[52] Cm 621 p. 26, Table 21.1.14.

research into higher gear",[53] we believe much of this is basic R&D which no-one other than governments can be expected to fund or to co-ordinate to any great extent.

4. The UK and the World

21. Every country in the world is contributing to the enhanced greenhouse effect. For example, deforestation in Brazil and Guatemala, increased rice production in China and South-East Asia, inefficient coal-burning in the USSR and massive population growth in almost every developing country all play their part. The effects of global warming will also occur throughout the world, since the world climate reflects no "polluter pays" principle. The Prime Minister referred in her speech to the Royal Society to the plight, if sea levels rise, of the 177,000 inhabitants of the Maldive Islands, six feet above sea level at the highest point.[54] The possible catastrophic effect of global warming on those islands will not have been caused by their own emissions. Greenpeace made a similar point—greenhouse gas emissions in the UK may mean deaths in Bangladesh.[55]

22. Because the greenhouse effect is a global problem, the responsibility for the research for which we called is not limited to the British Government. Research should be co-ordinated globally, and must be funded to the best of its ability by every country. To secure this, **we recommend that the UK and its EC partners should consider devoting a sum equivalent to a specified percentage of their gross national product to R&D into global warming.** The EC would then set an example to the rest of the world which Eastern bloc and developing countries might well follow. Global warming may be an assault on the security of the world, and every country should be able to contribute to environmental defence.

23. The UK is in no sense particularly to blame. BC estimated that "total greenhouse gas emissions in the UK are over one per cent of the world total".[56] and this compares roughly with the British percentage of the world population. However, in the case of CO_2 the UK's contribution is proportionately greater. Furthermore, there is an argument that, as industrialised countries account for a higher proportion of the increased stock of greenhouse gases in the atmosphere and are thereby more developed, their contribution to emission reduction should perhaps be greater *pro rata* than flow data suggest. Nevertheless, our witnesses were unanimous in agreeing that global action was necessary: as the Government said, "climatic change is a global problem. To be effective, action will need to be co-ordinated internationally",[57] and similar points were stressed by CEGB, BP, British Gas (BG), South of Scotland Electricity Board (SSEB), CBI and the Association for the Conservation of Energy (ACE) (a pressure group for the energy efficiency industry) among others.[58]

24. If world action is vital, does that mean that unilateral action is pointless? We certainly agree with the CBI that the UK "cannot significantly alter the concentration of gases in the environment by unilaterally eliminating its contribution to global emissions".[59] We note Baroness Hooper's argument that "it would not be appropriate to take unilateral action because it would have little effect in the global context, because it might affect our economic health".[60] We do realise that draconian unilateral action by one country alone would tilt the balance of economic advantage in favour of other countries. Britain cannot be expected to legislate unilaterally to an extent that would make itself economically uncompetitive. It is always depressing to conclude that the outcome of the battle should be determined either by the least brave or the least well-equipped soldier in the army.

25. Fortunately action is in hand for draft international conventions which may pave the way for mandatory obligations on all countries to reduce greenhouse emissions. Britain is in the forefront of this work. Lord Caithness, the Minister of State at the Department of the

[53] CEGB Press Release, 25 April 1989.
[54] Speech to the Royal Society, 27 September 1988.
[55] *Ev.* p. 55.
[56] *Ev.* p. 15.
[57] *Ev.* p. 34.
[58] Q.1; *Ev.* pp. 13, 22, 90, 114; Q.481.
[59] *Ev.* p. 116.
[60] Q.139.

Environment, has proposed a Framework Convention on global warming at a recent UNEP meeting in Nairobi, and the UK, along with Canada and Malta, has been charged with the preparation of this convention. We do not underestimate the task. Resolution of these issues will require what a senior Minister has described as "the most determined and effective international leadership"[61] and what the Secretary of State for Energy described as "massive international collaboration".[62] **We recommend that the government should exert as much pressure as possible in all international fora to ensure that world-wide action is taken to combat global warming.** We very much welcome the decision of the EC Council of Ministers[63] that "the conclusion of an international agreement on climate change is necessary", and that "the Community and Member States must make an important contribution to the preparation of such an agreement". In the meantime, the EC could make a start unilaterally in agreeing a suitable range of policies. It will be easier to do so in the EC than it will worldwide since EC co-operative institutions and mechanisms already exist. As Baroness Hooper said[64] "we are in an even better position on a Community basis to agree and enforce action on an international scale".

26. While international action is awaited, there are a number of arguments in favour of unilateral action, and these were put to us most convincingly by Dr Grubb of Chatham House.[65] The principal of these are: any contribution to the reduction of greenhouse gases is valuable, and the earlier it is done, the more valuable it will be and the less upheaval it will cause in the future: it cannot be guaranteed that international negotiation will be successful, nor is it known how long international negotiation will take: many measures proposed for dealing with greenhouse gases are actually beneficial to national economies, and unilateral actions set a good example to the rest of the world. We find these points very persuasive. We note that the Netherlands Government has decided to take unilateral action, and we will watch with interest to see whether the Dutch people support that action in their forthcoming general election. **We believe that the UK should also consider setting an example to the world by seriously tackling its own emission problems in advance of international action, especially where it is economically prudent to do so. We repudiate the idea that because one cannot do much, there is no point in doing anything at all.** One of our witnesses reminded us[66] of the more elegant words of Edmund Burke: "nobody made a greater mistake than he who did nothing because he himself could only do a little". We are delighted that the Secretary of State modified his early remarks to us that "unilateral action on our part would be little more than a gesture"[67] by later making it plain that there was room for much unilateral action by individual countries[68] and that unilateral actions were being taken by the UK. We shall review these later, and in some cases call for their re-inforcement. **As in the case of energy efficiency where the total effect is the cumulation of many individuals' decisions,[69] so the global response to the greenhouse effect will be the sum of the efforts of individual countries.**

5. The Toronto Conference

(i) *Proposals*

27. Attempts have already been made to design world-wide programmes of action. For example, targets for the world were set by the 1988 Toronto Conference. The Toronto Conference Statement[70] called on governments and industry to cut emissions of greenhouse gases by 50 per cent in order to stabilise the atmosphere, with an initial global goal of reducing CO_2 emissions by approximately 20 per cent of 1988 levels by 2005. Energy efficiency and altered energy supply such as increases in renewables and nuclear power were among the solutions proposed.

[61] Secretary of State for the Environment, *Policies against Pollution*, Centre for Policy Studies, 1989.
[62] Q.560.
[63] Environment Council, 8–9 June.
[64] Q.154.
[65] *Ev.* p. 70.
[66] Q.465.
[67] Q.511.
[68] Q.555.
[69] Q.512.
[70] Reproduced as an Annex to this Report.

(ii) *Problems*

28. There are a number of problems with the 20 per cent Toronto target. First, energy demand in less developed countries is likely to increase much more quickly than in the UK and the rest of the developed world.[71] This would imply that the developed world will need to cut emissions by much more than 20 per cent if the world total is to fall by this amount. This is partly because the world's population is expected to increase by roughly 20 per cent by 2005.[72] Secondly, it would be unfair to expect each country to cut its emissions by the same amount. This would penalise unfairly countries which already have a "good" record in efficiency and would be comparatively more easy for the countries with the worst pollution records.[73] Thirdly, because of anticipated growth in the world economy, a 20 per cent reduction on 1988 emissions will mean a larger reduction on emissions extrapolated to 2005—for example, in the electricity sector in the UK, a 20 per cent reduction on 1988 CO_2 emissions is equivalent on current demand growth projections to an effective reduction of 36 per cent.[74] A final complication is that the Toronto Conference proposed two different targets over two different time scales. The eventual aim is to reduce the effect of emissions by 50 per cent, but the staging post along the way (the 20 per cent target) refers only to reductions in CO_2. Although CO_2 is a very important greenhouse gas because of the sheer volume produced, it may be a more tractable problem than the far longer lasting CFCs or other gases like methane, carbon monoxide, ozone and nitrous oxide.

(iii) *Feasibility*

29. Despite these problems, we asked our witnesses to examine the feasibility of the Toronto targets. They did this both in respect of the UK and the world. First we were presented with some scenarios of what would happen in the UK if nothing was done to meet the targets—what ACE described as the "business as usual" approach. According to them[75] this would result in CO_2 emissions rising by 10 to 13 per cent by 2005. This rise would occur across all sectors. For the electricity sector alone, the CEGB was also pessimistic, believing that a continuation of present slow increases in energy efficiency and technology improvements, coupled with projected unrestricted energy demand, involves CO_2 emissions from electricity generation increasing by 25 per cent by 2005.[76] This is similar to the FoE's "traditional" scenario, where CO_2 emissions grow 17 per cent in the non-transport and non-agriculture sectors of the energy economy.[77] FoE described the "business as usual" scenario as "too frightening to contemplate".[78]

30. A number of witnesses produced scenarios of how the Toronto target might be achieved. The CEGB's second scenario[79] for 2005 examined the possibility of a 20 per cent reduction in CO_2 emissions from electricity generation merely by changing the fuel mix, and leaving demand unrestricted. A large switch to oil and gas firing is made, and an increase in nuclear capacity is necessary, to 20 GW if the Severn and Mersey Barrages were built, and 23 GW if not. This strategy would cause the early retirement of nine GW of coal-fired generating capacity. An extra capital investment of £12 billion would be required. Oil and gas prices would rise, and "the effect on electricity prices would be very severe". The CEGB's third scenario[80] for 2005 also envisages 20 per cent cuts in CO_2 from electricity production and involves maintaining the plant mix of its "business as usual" scenario, but reducing projected electricity demand by 37 per cent through efficiency measures in order to hold demand in 2005 at the 1989 figure. This would reduce the coal burn substantially and the necessary demand reduction would, the CEGB believe, "require Draconian intervention in the energy and equipment markets and considerable social change". The CEGB's final scenario[81] is a more modest blueprint for maintaining CO_2 emissions at their 1988 level (ie

[71] FoE, *Ev.* p. 44; IEA, *Ev.* p. 120. HMG, Q.133.
[72] SSEB, *Ev.* p. 91.
[73] Grubb, *Ev.* p. 69.
[74] CEGB, *Ev.* p. 31.
[75] *Min. of Ev.* pp. 119 and 129.
[76] *Ev.* p. 29.
[77] *Ev.* p. 49.
[78] Q.495.
[79] *Ev.* p. 29.
[80] *Ev.* p. 30.
[81] *Ibid.*

not meeting the Toronto target). This could be done either by maintaining the non-fossil programme and switching 5 GW of planned coal-fired capacity to gas fuelled plant, or by doubling nuclear capacity to 15 GW. In both cases annual demand is fixed at 300 TWh.

31. The Electricity Council in their supplementary memorandum to the Committee[82] believed that a 20 per cent reduction in CO_2 would be possible by a strategy that relied principally on energy efficiency, CHP, and switching power generation plant to nuclear, gas, oil and renewable sources. It would also need efforts from other energy sectors, and would cost nearly £6 billion. They felt that "whether the public is prepared to pay for these changes is very doubtful".

32. BG thought[83] that half of the target could be met by inter-fuel substitution, and that it was possible for energy efficiency to make up the rest of the reductions. A very large increase in nuclear power and considerable investment in renewables would be necessary, to an extent that might be unrealistic. Substitution of coal-fired plant by gas-powered plant, though, would make the target more easily achievable. BC, however, regards a 10 per cent reduction in CO_2 emissions from inter-fuel substitution as "wholly unrealistic"[84] and possibly economically counter-productive. It sees nuclear power as too expensive and ineffective to be of much use in reducing CO_2 emissions, and gas substitution as only having a marginal effect on CO_2 emissions unless done on an unrealistically large scale.[85]

33. BP's written evidence on Toronto[86] argued that the two per cent per annum projected growth of global CO_2 emissions could be halved by energy efficiency, and further reduced by increased fuel switching, but that the Toronto target of an annual 1.6 per cent cut in CO_2 emissions was "extremely ambitious". This view was reiterated in BP's oral evidence to the Committee. Although the witnesses thought that the UK might be able to reduce CO_2 emissions by 20 per cent by increased fuel efficiency, a switch to CHP, more efficient car engines, and some fuel switching to gas from coal,[87] the world as a whole would not. Likely economic growth until 2005 meant that a reduction in CO_2 emissions of around 35 per cent would be necessary,[88] but cuts even of 20 per cent would markedly reduce the UK's international competitiveness.[89]

34. In the OECD context, the IEA[90] believe that for CO_2 emissions to fall, or even remain as they are, energy efficiency will have to improve at a faster rate than has been experienced in the past, or there will have to be a very large shift away from fossil fuels, or both. These responses might involve major changes in energy use and production. The IEA emphasise the crucial role of coal in ensuring diverse and secure energy supplies, and believe that massive reductions in its use are unlikely to be practical.

35. The UKAEA told us[91] that they believed that reducing existing global emissions of CO_2 by 20 per cent would not be possible. In the electricity sector, nuclear and renewable power could not be expanded quickly enough to replace 20 per cent of all existing fossil fuel plant, and a substitution of 50 per cent of all coal plant by gas or oil plant would not be possible either. An energy efficiency improvement of 10 per cent would also be inadequate, bearing in mind the projected increase in energy demand by 2005. In the UK though, the UKAEA nevertheless feel that nuclear power could play a very significant role in reducing CO_2 emissions. By 2030 they believe that 75–80 per cent of electricity plant, that with the highest load factor, could be non-fossil fuelled, with the balance of lower load-factor capacity made up by gas-fired plant. Even without action in any other sectors, total UK CO_2 production could then be cut by as much as 25 per cent.[92]

[82] *Min. of Ev.* p. 32.
[83] *Ev.* p. 23.
[84] *Ev.* p. 18.
[85] *Ev.* p. 17.
[86] *Ev.* p. 11.
[87] QQ.224–225.
[88] Q.228.
[89] Q.224.
[90] *Ev.* p. 120.
[91] *Ev.* p. 101.
[92] *Min. of Ev.* p. 99.

42. It is therefore vital to try to curb methane and other hydrocarbon emissions. BG told us that "considerable effort" was being devoted to eliminating methane leaks from their system, which mainly occur from the older parts of the transmission system.[112] They estimated losses to be less than one per cent of throughput. Nevertheless, this is a most substantial figure, and will be added to by losses in production in the UK's gas fields. BP also told us of the work being done to study and to curb vapour emissions by the oil industry.[113] However, it was clear from their oral evidence that *legal* restrictions on these emissions in the USA had resulted in a number of practical measures to prevent leaks taking place beyond what is happening in the UK.[114] **We recommend that the British government also consider introducing measures to curb these emissions further unless it becomes clear that the gas and oil industries are making satisfactory progress voluntarily.** Of course, any reduction in the use of transport fuels, as well as curbing CO_2 emissions, would also result in a reduction in emissions of hydrocarbons.[115]

3. Landfill Methane

43. From an energy point of view, the most important source of methane leakage in the UK is from landfill refuse sites. The Open University estimates that the methane produced from these could be equivalent to 10 per cent of all the CO_2 produced in the UK[116] and BG told us that emissions of methane from landfill sites were equivalent to about seven per cent of the gas they supplied annually.[117] If the methane from these sites is simply burnt so producing CO_2, the net greenhouse effect is less.[118] However, it would be much more prudent to ensure that the methane from landfill sites is gathered and used for electricity generation, possibly with CHP and district heating, while future refuse disposal is based on the incineration of waste with the heat produced being used for district heating or CHP.

44. We agree with the recommendation of the Environment Committee in their Report on Toxic Waste[119] that "local authorities and others should work with the private sector, in planning imaginative municipal incineration schemes combining refuse disposal and energy recovery through electricity generation and sale to the supply companies and/or district heating. This should be encouaged by the DoE in consultation with the Department of Energy". We are also encouraged by the Government's response to this recommendation:[120] "The Government wish to see as much positive use of waste as possible. The Department of the Environment is currently revising Waste Management Paper 1 on the options for waste management which will include an appraisal of the potential for energy recovery from waste. This includes the generation of electricity, combined heat and power schemes, and refuse derived fuel. The Government agree that waste can play a part in our energy supplies and wish to see full co-operation between local authorities and the private sector for future investment in energy recovery from waste. The Government's proposals for the future role and functions of local authorities in waste management are intended to encourage this co-operation". Some progress is being made, and the Secretary of State told us that, by the end of 1990, he expected 42 MW of capacity to be generated by landfill methane. This will involve about 20 sites.[121] Nevertheless, there is room for further development and **we recommend that the Government and local authorities take further steps positively to promote the use of methane from landfill sites.** This will act as a considerable spur to the development of these sites for electricity generation. The potential is enormous: if half of all the waste produced annually[122] were used to generate heat and electricity, that would reduce emissions

[112] *Ev.* p. 22.
[113] *Ev.* p. 14.
[114] QQ.232–237.
[115] One other source of methane was referred to by one of our witnesses. We were told by Greenpeace that some scientists believe that submarine deposits of methane may be found in UK waters where the extraction of gas, oil or coal takes place, and that these deposits may become unstable. *Ev.* p. 64.
[116] *Ev.* p. 144.
[117] *Ev.* p. 22.
[118] CEGB, *Ev.* p. 25.
[119] Third Report from the Environment Committee, Session 1988–89, *Toxic Waste*, HC 22.
[120] Cm 679 para. 4.22.
[121] Q.528.
[122] Including straw.

by the equivalent of five per cent of our current annual CO_2 production.[123] Energy Paper 55[124] classified the combustion of dry wastes and the use of landfill gas as "economically attractive" renewable technologies. Their environmental attractiveness is also beyond doubt.

4. NO_x and Carbon Monoxide

45. The oxides of nitrogen are also involved in the greenhouse effect. N_2O is a direct greenhouse gas which has a life of 170 years in the atmosphere (compared with 8–10 years for methane).[125] NO and NO_2 are involved in the formation of tropospheric ozone. 35 per cent of British nitrogen oxide production comes from power stations and 47 per cent from transport.[126] In the case of carbon monoxide (CO), which is also implicated in the greenhouse effect,[127] 85 per cent is produced from the transport sector.[128] The importance of the transport sector for the production of these gases reinforces the need for action to be taken in that area. We shall return to this later.[129] As far as power station production of oxides of nitrogen are concerned, their involvement in global warming is an added reason to hasten methods to secure their reduction. We note the progress being made by the CEGB in its low NO_x development and retrofit programme, and we are pleased that the CEGB's successor bodies have pledged to fit special burners reducing nitrogen oxide emissions to all major existing coal-fired stations.[130] However, **we recommend that, as technology advances, HM Inspectorate of Pollution also require a rolling programme of more rigorous standards by the industry in the emissions of oxides of nitrogen.**

46. A reduction in pollution caused by emissions of methane, carbon monoxide and the oxides of nitrogen is desirable for reasons unconnected with global warming. However, it was clear from the UKAEA's evidence that the involvement of these gases in the greenhouse effect still needed considerable study.[131] This is a practical illustration of the sort of research which we believe should be funded by government and which could remove an important area of uncertainty.

5. The Carbon Cycle

47. A good deal of uncertainty also still exists about the complex subject of the carbon cycle and thus about the future trend in CO_2 concentrations in the atmosphere. We reproduce a useful chart from the evidence of NERC which describes graphically the global carbon cycle.

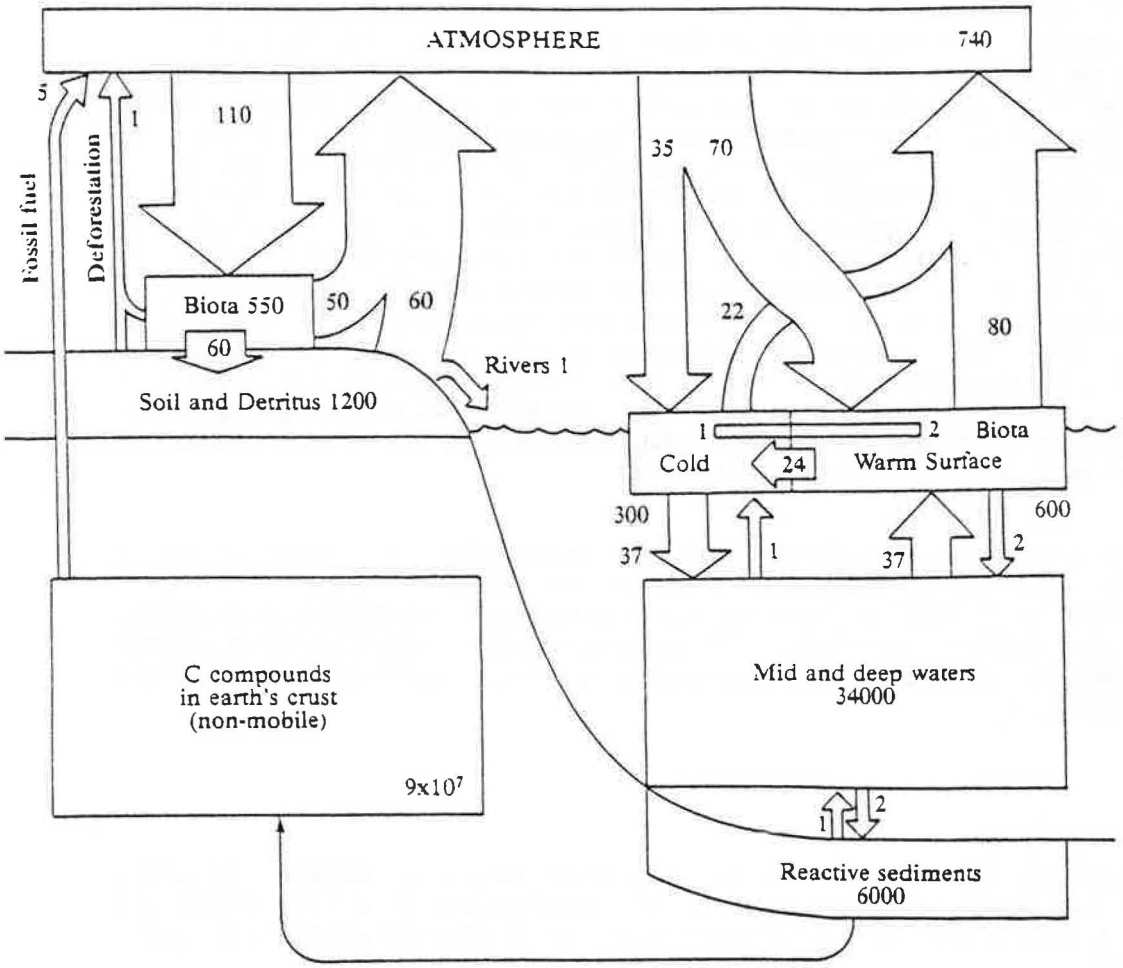
48. From Figure 2 it will be apparent that photosynthesis, both in the sea and on land, removes far larger amounts of CO_2 from the atmosphere than is produced by "non-natural" causes such as fossil fuel burning and deforestation.[132] However, the cycle's stability may be crucially affected when more CO_2 is being deposited in the atmosphere than is being removed. Evidence suggests that vegetation may absorb some of the extra CO_2 by growing more vigorously in a CO_2 enriched atmosphere, while the oceans may also take up some of the extra CO_2 produced. Our witnesses emphasised to us that complicated "feed-back" mechanisms may exist in the world carbon cycle which are not yet understood.[133] Moreover,

---

[123] ETSU paper for No. 10 Seminar, p. 2 (paper submitted to Committee by HMG, and placed in the Library of the House).
[124] Energy Paper Number 55, *Renewable Energy in the UK: The Way Forward*, HMSO 1988.
[125] Greenpeace, *Ev.* p. 64.
[126] Digest of Environmental Protection and Water Statistics, HMSO, 1989, p. 18.
[127] As an agent removing from the atmosphere the hydroxyl radicals which act as a sink for methane. Greenpeace, *Ev.* p. 62.
[128] Digest of Environmental Protection and Water Statistics, HMSO, 1989, p. 18.
[129] See paras 120–123.
[130] CEGB Press Release, 17 May 1989.
[131] QQ.397 and 410.
[132] BC, Q.299.
[133] Eg NERC, *Ev.* p. 84; BP, *Ev.* p. 10; BG, *Ev.* p. 21.

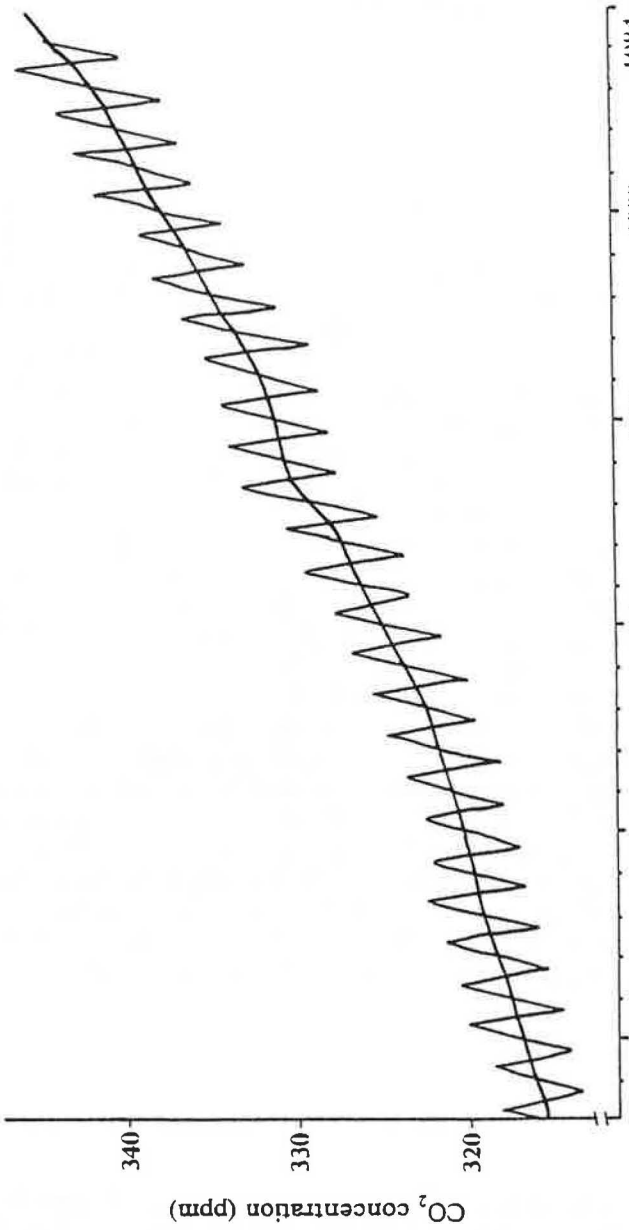
Figure 2

Global carbon cycle



Fluxes: 10^{15}gC yr^{-1} Reservoirs: 10^{15}gC

Figure 3



The rising level of atmospheric carbon dioxide at Mauna Loa Observatory in Hawaii. A marked seasonal cycle caused by the growth and decay of vegetation in the Northern Hemisphere is superimposed on the steady trend upwards.

Source: **Bolin, B. How much CO_2 will remain in the atmosphere? In: *The Greenhouse Effect, Climatic Change and Ecosystems*. Bolin, B. and others, editors. SCOPE 29. Wiley, Chichester, 1986.**

"the relationship between CO_2 emissions and CO_2 concentration in the atmosphere is still poorly understood".[134] Baroness Hooper did not believe that there would be full understanding of the science of the carbon cycle until the next century.[135] We are obviously not in a position to make an informed judgment on these matters. They are subjects which again should be properly researched with adequate funding available to scientists to do so. However, that the volume of atmospheric CO_2 is increasing is apparent from Figure 3 on p. xxv.[136]

6. Deforestation

49. Deforestation is at least partially a cause of this. Deforestation causes CO_2 build up in two ways: the forests are burned, so producing the gas directly. They are also not replaced, and this removes a sink for the gas produced elsewhere. It is outside our responsibility to suggest how deforestation may be prevented. So far as it is a problem in the tropics, overseas aid policies may help. In the UK, however, reforestation may marginally reverse the trend as well as provide a small source of energy itself. According to ETSU,[137] about 10 per cent of the UK is wooded and this could be expanded to 25 per cent. If the area were merely doubled, and the extra land devoted to broadleaf species, three million tonnes of carbon would be absorbed per annum. If the trees were used as fossil fuel, and were constantly replaced by new trees, no net CO_2 would be added to the atmosphere, and other fossil fuels could be replaced.[138] The EC believe that the use of wood for heating or cooking is feasible in developing countries,[139] but Power Management Associates[140] suggested that "one million hectares planted with short-rotation coppice would provide seven per cent of the UK's electricity requirements, and a return for the grower at least as good as that for cereals. If derelict woodlands and other non-productive areas were similarly exploited, it would be possible to provide 20 per cent of the UK's electricity requirements". At the time of Energy Paper 55,[141] the production costs for energy forestry were still being determined, and the technology was assessed as "promising but uncertain". **We recommend that the Government reassess the possibilities which energy forestry may offer as a means of producing energy in the UK while at the same time helping to counter global warming by making a modest contribution to the take up of CO_2 by trees.**[142] In world terms, serious thought should be given to the possibilities which reforestation, and the subsequent substitution of wood for other fuels, may offer. The CEGB told us that an area a quarter the size of Brazil would need to be planted with trees to achieve the Toronto target of 20 per cent reduction in world CO_2 emissions.[143] This is equivalent to an area over eight times the size of the UK. To do this would be an enormous task, but global warming may call for extraordinary remedies.

7. The Sources of CO_2

50. From the evidence we received, it is possible to draw up a number of tables indicating the different sources of CO_2, the areas of the world in which it is produced and, for the UK, its principal sources. We set these out below.

---

[134] IEA, *Ev.* p. 120.
[135] Q.139.
[136] These data were collected at the Mauna Loa Observatory in Hawaii which is an ideal location for sampling since it is distant from any source of CO_2 emissions.
[137] Paper delivered by Dr Currie to Seminar at 10 Downing Street on 26 April 1989 (paper submitted to the Committee by HMG and placed in Library of the House).
[138] CEGB, *Ev.* p. 26.
[139] COM(88) 656 final, p. 46.
[140] Unpublished evidence.
[141] Energy Paper Number 55, *Renewable Energy in the UK: The Way Forward*, HMSO, 1988.
[142] We understand that this is among the subjects which are being investigated by the Agriculture Committee in its current enquiry into Land Use and Forestry.
[143] CEGB, *Ev.* p. 26.

TABLE 7

UK CO_2 Emissions by Weight

million tones (selected years)

	1977	*1980*	*1983*	*1985*	*1987*	*Per cent of total 1987*
Power stations	238	247	221	217	233	37
Industry (1)	170	136	123	124	125	20
Road transport	73	80	82	88	98	16
Domestic	85	85	81	87	87	14
Commercial/public service	34	33	33	34	32	5
Refineries	25	24	21	20	21	3
Others (2)	28	31	30	29	31	5
Total	654	635	591	601	627	100

(1) Excludes cement and energy industries.
(2) Includes cement, gas production and flaring, and agriculture.
Source: *Digest of Environmental Protection and Water Statistics*, HMSO, 1989 (1985 figure affected by the miners' dispute).

TABLE 8

Shares of UK CO_2 by Fuel

	Proportion of UK CO_2 (per cent)				
Source	*Coal*		*Gas*	*Oil*	*Other fuels*
	(power)	*(other)*			
ACE[164]	——— 42 ———		22	28	8
DoE[165]	——— 44 ———		18	29	9
FoE[166]	36.4	7.4	18.2	28.6	9.4

TABLE 9

UK CO_2 by Type of Fuel

(as MTonnes of carbon)

	1983	*1985*	*1987*	*Per cent of total 1987*
Solids fuels (1)	69.2	65.9	71.9	45.1
Gas (2)	34.5	37.7	40.4	25.4
Oil (3)	45.6	49.7	46.9	29.5
of which,				
Petrol & DERV	22.4	23.9	26.6	16.7

(1) Principally coal, but also includes smokeless fuel.
(2) Natural gas and petroleum gases.
(3) Transport fuels, heating oils and refinery fuel.
[Source: *Min of Ev.* p. 46 (1985 figure affected by the miners' dispute).]

TABLE 10

Relative Production of CO_2 per joule by Fuel

	MT carbon per Exajoule	*Ratio*
Coal	24	1
Oil	19	0.8
Natural gas	14	0.6

[Source: BG *Ev.* p. 22.]

[164] *Ev.* p. 3.
[165] HC Deb. 9 December 1988, cols. 351–352 (extrapolation).
[166] *Ev.* p. 47.

TABLE 4

World CO_2 Emissions by Cause

		(per cent) Fossil fuel burning		
Sources	*Deforestation*	*Coal*	*Oil*	*Gas (incl flaring)*
ACE.[144] BP[145] DEn.[146] NERC[147]	20	—	80	—
EC[148]	20	33	33	14
Greenpeace[149]	20–25	—	75–80	—
CBI[150]	25	—	75	—
BC[151]	26	30	32	12
UKAEA[152]	27	—	73	—

TABLE 5

World CO_2 Emissions by Geographical Origin

(per cent world CO_2 emissions)

Information source	*UK*	*W Europe*	*E Europe incl USSR*	*North America*	*China*	*Pacific*	*LDCs*	*Others*
ACE[153]	— 15 —		25	27	9	7	5	13
CBI[154]	2.9	7.8+	23.1+	26	9.2	4.7+	— 15.4 —	
CEGB[155]	3	–	–	–	–	–	–	–
DoE[156]	3	–	–	–	–	–	–	–
EC[157]	— 16.5 —		24.2	26.7	8.5	5.8	12.2	6.0
Greenpeace[158]	3	15	26	25	11	6	— 16 —	
Open University[159]	3	–	–	–	–	–	–	–

TABLE 6

UK CO_2 Emissions by Sector

(per cent)

Information source	*Power stations*	*Industry*	*Transport*	*Domestic*	*Commercial public etc*
DoE[160]/SPRU[161]	38.7	24.3	16.6	14.5	5.9
CEGB[162]	36	25	17	15	7
WWF[163]	36.6	19.4	17.7	19.7	6.6

[144] *Ev.* p. 2 (1987).
[145] *Ev.* p. 14 (Year not specified).
[146] *Ev.* p. 38 (Year not specified).
[147] *Ev.* p. 72 (Year not specified).
[148] COM(88) 656 final, p. 13 (Year not specified).
[149] *Ev.* p. 59 (Year not specified).
[150] *Ev.* p. 114 (1980s).
[151] *Ev.* p. 20 (1984).
[152] *Ev.* p. 97 (Year not specified).
[153] *Ev.* p. 2.
[154] *Ev.* p. 114. Figures not all directly comparable because of CBI's classification only of the 12 largest CO_2 producing countries.
[155] *Ev.* p. 26.
[156] Proof of evidence for the Hinkley Point 'C' Public Enquiry, para. 16.
[157] COM(88) 656 final.
[158] *Ev.* p. 60. The figure for China includes other centrally planned Asian economies.
[159] *Ev.* p. 126.
[160] HC Deb. 9 December 1988, col. 352 (1987).
[161] Quoted in *Ev.* p. 88.
[162] *Ev.* p. 33, Appendix 2 (1987) (see ACE Supp Memorandum, para 2.3 where the CEGB adjustment of the DoE figures is regarded as the more accurate of the two sets of statistics).
[163] *Ev.* p. 109 (1986).

51. These illustrative tables demonstrate that **no one sector of the energy economy, no one fuel and no region of the world is particularly to blame for CO_2 emissions.** As BC said, it would be a "quite misleading perspective to equate the greenhouse effect with coal-fired power stations".[167] As far as world emissions are concerned, most commentators expect the use of fossil fuels to grow most in Asia: electricity demand in Asia has already quadrupled in the last 20 years, and a further doubling by 2000 is expected. At present 39 per cent of Asia's electricity is coal generated; by 2000, 50 per cent will be.[168]. The Secretary of State graphically illustrated this. He told us that with best practice Britain might reduce its CO_2 emission by 50 per cent or approximately 80 million tonnes of carbon by 2020. During the same period, the Chinese would increase theirs by 20 times our savings.[169] In the UK, emissions in the domestic and commercial sectors have remained relatively stable since 1977. Power station emissions have fallen slightly as have industrial emissions. The principal growth has been in the road transport sector, which constituted 11 per cent of the total in 1977, while making up 16 per cent in 1987.

8. Final Energy Demand Sectors in the UK

52. Recent trends in CO_2 emissions from these major end use sectors are summarised in Table 7. The table shows that CO_2 emissions in the domestic and commercial sectors have remained relatively stable over the past 10 years. This is despite growth in primary energy demand, especially in the domestic sector (see Tables 15, 17 and 19). In both sectors this is largely explained by the decline in use of coal for heating and the increased penetration of natural gas (with its lower CO_2 emissions factor). Table 7 also shows that CO_2 emissions from the industrial sector have declined by over a quarter between 1977 and 1987. This trend is explained by a reduction in energy use of a similar magnitude (see Table 18) as a result of the substantial decline in output of the energy-intensive, "smoke stack" industries (such as iron and steel) and structural adjustment towards lighter manufacturing (eg electronics). Given that natural gas consumption in industry has remained relatively constant over the past decade (see Table 18), inter-fuel substitution has been of less significance than in the domestic and commercial sectors. Reductions are also partly the result of energy efficiency measures which have been taken in recent years[170]—the Secretary of State estimated that pressure to use and produce energy more efficiently had resulted in the saving of 122 mtce in the last 15 years.[171]

53. CO_2 emissions in the transport sector have increased rapidly, by over a third, since 1977 (see Table 7). Given the dominance of oil use in internal combustion engines for road vehicles, there is little scope for inter-fuel substitution. The increase in CO_2 emissions is accounted for by continued expansion in the road vehicle fleet and the associated rise in oil demand (see Table 20). The significance of the transport sector is discussed further elsewhere.[172]

9. The UK Power Station Sector

54. In the power station sector, the proportion of coal used in generation of electricity is higher in the UK than in any other EC country except Denmark, although, in million tonnes of coal equivalent, the coal and lignite burn in West Germany is almost equal to the UK coal burn. This will result in greater CO_2 production since lignite is a fuel which produces more CO_2 per unit of energy. In terms of total fossil fuel use in power stations, again other than Denmark,[173] the UK used the greatest amount of coal equivalent per head of population of any of the EC states. The position of France is particularly noteworthy, and reflects the extensive use of nuclear power in that country.

---

[167] *Ev.* p. 16.

[168] Report in *Financial Times*, 19 May 1989 of Electricity in Asia and the Pacific, by Fereidun Fesharaki and Hossein Razavi, Economist Intelligence Unit.

[169] Q.511.

[170] *Min. of Ev.* p. 159.

[171] Q.509.

[172] See paras 120 to 123.

[173] The Danish figure may be somewhat misleading since a significant proportion of Danish fuel which would otherwise be wasted in the conversion of electricity is converted to hot water.

TABLE 7

UK CO_2 Emissions by Weight

million tones (selected years)

	1977	*1980*	*1983*	*1985*	*1987*	*Per cent of total 1987*
Power stations	238	247	221	217	233	37
Industry (1)	170	136	123	124	125	20
Road transport	73	80	82	88	98	16
Domestic	85	85	81	87	87	14
Commercial/public service	34	33	33	34	32	5
Refineries	25	24	21	20	21	3
Others (2)	28	31	30	29	31	5
Total	654	635	591	601	627	100

(1) Excludes cement and energy industries.
(2) Includes cement, gas production and flaring, and agriculture.
Source: *Digest of Environmental Protection and Water Statistics*, HMSO, 1989 (1985 figure affected by the miners' dispute).

TABLE 8

Shares of UK CO_2 by Fuel

	Proportion of UK CO_2 (per cent)				
Source	*Coal (power)*	*(other)*	*Gas*	*Oil*	*Other fuels*
ACE[164]	42		22	28	8
DoE[165]	44		18	29	9
FoE[166]	36.4	7.4	18.2	28.6	9.4

TABLE 9

UK CO_2 by Type of Fuel

(as MTonnes of carbon)

	1983	*1985*	*1987*	*Per cent of total 1987*
Solids fuels (1)	69.2	65.9	71.9	45.1
Gas (2)	34.5	37.7	40.4	25.4
Oil (3)	45.6	49.7	46.9	29.5
of which,				
Petrol & DERV	22.4	23.9	26.6	16.7

(1) Principally coal, but also includes smokeless fuel.
(2) Natural gas and petroleum gases.
(3) Transport fuels, heating oils and refinery fuel.
[Source: *Min of Ev.* p. 46 (1985 figure affected by the miners' dispute).]

TABLE 10

Relative Production of CO_2 per joule by Fuel

	MT carbon per Exajoule	*Ratio*
Coal	24	1
Oil	19	0.8
Natural gas	14	0.6

[Source: BG *Ev.* p. 22.]

[164] *Ev.* p. 3.
[165] HC Deb. 9 December 1988, cols. 351–352 (extrapolation).
[166] *Ev.* p. 47.

51. These illustrative tables demonstrate that **no one sector of the energy economy, no one fuel and no region of the world is particularly to blame for CO_2 emissions.** As BC said, it would be a "quite misleading perspective to equate the greenhouse effect with coal-fired power stations".[167] As far as world emissions are concerned, most commentators expect the use of fossil fuels to grow most in Asia: electricity demand in Asia has already quadrupled in the last 20 years, and a further doubling by 2000 is expected. At present 39 per cent of Asia's electricity is coal generated: by 2000, 50 per cent will be.[168]. The Secretary of State graphically illustrated this. He told us that with best practice Britain might reduce its CO_2 emission by 50 per cent or approximately 80 million tonnes of carbon by 2020. During the same period, the Chinese would increase theirs by 20 times our savings.[169] In the UK, emissions in the domestic and commercial sectors have remained relatively stable since 1977. Power station emissions have fallen slightly as have industrial emissions. The principal growth has been in the road transport sector, which constituted 11 per cent of the total in 1977, while making up 16 per cent in 1987.

8. Final Energy Demand Sectors in the UK

52. Recent trends in CO_2 emissions from these major end use sectors are summarised in Table 7. The table shows that CO_2 emissions in the domestic and commercial sectors have remained relatively stable over the past 10 years. This is despite growth in primary energy demand, especially in the domestic sector (see Tables 15, 17 and 19). In both sectors this is largely explained by the decline in use of coal for heating and the increased penetration of natural gas (with its lower CO_2 emissions factor). Table 7 also shows that CO_2 emissions from the industrial sector have declined by over a quarter between 1977 and 1987. This trend is explained by a reduction in energy use of a similar magnitude (see Table 18) as a result of the substantial decline in output of the energy-intensive, "smoke stack" industries (such as iron and steel) and structural adjustment towards lighter manufacturing (eg electronics). Given that natural gas consumption in industry has remained relatively constant over the past decade (see Table 18), inter-fuel substitution has been of less significance than in the domestic and commercial sectors. Reductions are also partly the result of energy efficiency measures which have been taken in recent years[170]—the Secretary of State estimated that pressure to use and produce energy more efficiently had resulted in the saving of 122 mtce in the last 15 years.[171]

53. CO_2 emissions in the transport sector have increased rapidly, by over a third, since 1977 (see Table 7). Given the dominance of oil use in internal combustion engines for road vehicles, there is little scope for inter-fuel substitution. The increase in CO_2 emissions is accounted for by continued expansion in the road vehicle fleet and the associated rise in oil demand (see Table 20). The significance of the transport sector is discussed further elsewhere.[172]

9. The UK Power Station Sector

54. In the power station sector, the proportion of coal used in generation of electricity is higher in the UK than in any other EC country except Denmark, although, in million tonnes of coal equivalent, the coal and lignite burn in West Germany is almost equal to the UK coal burn. This will result in greater CO_2 production since lignite is a fuel which produces more CO_2 per unit of energy. In terms of total fossil fuel use in power stations, again other than Denmark,[173] the UK used the greatest amount of coal equivalent per head of population of any of the EC states. The position of France is particularly noteworthy, and reflects the extensive use of nuclear power in that country.

---

[167] *Ev.* p. 16.

[168] Report in *Financial Times*, 19 May 1989 of Electricity in Asia and the Pacific, by Fereidun Fesharaki and Hossein Razavi, Economist Intelligence Unit.

[169] Q.511.

[170] *Min. of Ev.* p. 159.

[171] Q.509.

[172] See paras 120 to 123.

[173] The Danish figure may be somewhat misleading since a significant proportion of Danish fuel which would otherwise be wasted in the conversion of electricity is converted to hot water.

TABLE 11

Consumption of fossil fuels in power generation by country (1987)

Country	*Total Consumption of fossil fuels mtce*	*Consumption per capita tonnes coal equivalent*
Denmark	9.8	1.91
UK	74.8	1.31
Ireland	4.1	1.16
FRG	70.2	1.15
NL	16.3	1.12
Greece	10.3	1.04
Italy	42.8	0.75
Spain	20.4	0.64
Belgium	5.8	0.59
Portugal	3.2	0.31
France	4.7	0.09

[Source: derived from Handbook of Electricity Supply Statistics, 1988]

55. The breakdown of fossil fuel use in England and Wales, Scotland and the whole UK is shown in the following table:

TABLE 12

Electricity Production by Fuel (1988)

(mtce)

	Total	*Coal*	*Oil*	*Natural Gas*	*Nuclear*	*Hydro-Electricity*
England and Wales	98.9	77.6	4.9	—	16.3	0.1
Scotland	13.1	4.5	1.8	—	4.8	2.0
United Kingdom	114.76	82.46	9.10	0.01	21.12	2.06

[Source: Energy Trends, May 1989; *Min. of Ev.* p. 158]

As we saw in Table 10, coal emits more CO_2 per unit of energy than other fossil fuels.[174] Because of this, the largest single source of CO_2 in the UK is the CEGB, and this is also illustrated by the following table:

TABLE 13

UK CO_2 emissions from power producers by source

Producer	*(Millions tonnes CO_2)*	*Power generated*
	(1987)	(TWh) (1986/87)
CEGB	210.1	228
SSEB	17.2	22
NSHEB	1.1	5

[Source: HC Deb 9 December 1988 col. 352]

Scotland has a very high non-fossil fuel content in its electricity industry as a result of its extensive endowment of hydro-electric and nuclear power generation. Only 30–40 per cent of Scottish electricity is produced from fossil fuel sources[175] and, of that, by 1992 a substantial proportion will be generated by natural gas. Indeed the SSEB points out that they and their colleagues in the North of Scotland Hydro-Electric Board (NSHEB) are "substantially in the position which the Toronto Conference sets as a world-wide target for the beginning of the next century.[176] CO_2 emissions from electricity generation in England and Wales are thus a major concern which this Report will address.

[174] Except lignite, which is not burnt extensively in the UK.
[175] *Ev.* p. 87.
[176] *Ibid.*

10. Flue gas decarbonisation

56. An attractive solution to the problem of CO_2 emissions might appear to be the removal of the gas from flue gas exhaust streams. This would not be simple, would be costly and there is no obvious way of disposing of the CO_2 thus extracted. The current environmental concerns over acid rain emissions from flues and vehicle exhausts centre on toxic products arising from impurities present in the fuel (eg sulphur) or on by-products of combustion (eg oxides of nitrogen (NO_x)). These are present in relatively low concentrations, from a few parts per thousand up to a few per cent. In contrast, CO_2 is a primary product of combustion, roughly $3\frac{1}{2}$ tons being produced from each ton of carbon burned. The physical volume of CO_2 to be removed, transported and stored would thus be orders of magnitude greater than in the case of NO_x. The CEGB referred us to the studies carried out in the USA at Brookhaven National Laboratory and concluded that the operation, including storage of the CO_2 removed, would "probably at least double the capital cost of a station and probably double the cost per kWh".[177] The EC Commission states simply that "no economically or technically feasible technologies are available".[178]

57. Since the volume of the resulting CO_2, even when compressed and refrigerated into a liquid state, would, in the case of coal, be several times as great as its precursor fuel, the problem of safe ultimate disposal is a major one, as any significant leakage back into the eco-system would nullify the effects of the separation and could be disastrous. Dispersal in the oceans has been proposed, as has storage at the bottom of the deeper ocean valleys where, because of the temperatures and pressures, the CO_2 would exist in the liquid state. According to present predictions either solution would appear to be safe, but no firm evidence for this is available. BC told us "there is plenty of room in the sea for carbon dioxide; it is very unsaturated".[179] However, in the light of the public opinion difficulties which have faced a number of other industries in disposing of their waste, there must be some doubts about the acceptability of storing immense volumes of CO_2 in this way. Clearly this option is at best a very long-term one which remains to be proved, both technically and economically. In the meantime, **we endorse the proposal of the EC Commission that research in this field should be vigorously pursued.**[180] We were given details of studies planned by the Government in this area.[181] We believe that more work needs to be done, for example by advancing from paper studies alone and by pursuing the question of final disposal options for CO_2 after extraction.

C. CHANGING THE FUEL MIX

1. Introduction

58. Since the removal of CO_2 does not yet appear a practical proposition, our Report will now concentrate upon means by which lower levels of CO_2 can be produced for every unit of useful energy delivered. Given the different CO_2 emission factors of the principal fossil fuels (coal/oil/natural gas = 1.0/0.8/0.6)[182] and the negligible emissions from primary electricity (derived from nuclear or renewable sources, such as hydro-electricity), the first of these is inter-fuel substitution.

59. Over the past four decades, very considerable changes have occurred in the overall national primary energy mix: in principle, at least, similar changes could occur, or be encouraged to occur, over the next four decades. In 1950, coal met some 90 per cent of UK primary energy demand, satisfying direct demands from final consumers in homes, industry and the railways, and indirect demands via electricity generation and coal-based town gas. The remainder of the national energy balance at this time was met by oil and a small quantity of hydro-electric power. By 1960, although the absolute level of coal demand was virtually unchanged from that of 1950, its share of UK primary energy demand had fallen to

[177] *Ev.* p. 27.
[178] COM(88) 656 final, paras. 35 and 39d.
[179] Q.360.
[180] COM(88) 656 final p. 44—also endorsed by the Council of Environment Ministers on 8–9 June 1989.
[181] See HC Deb. 8 June 1989, col. 223 and *Min. Of Ev.* p. 159.
[182] See Table 10.

75 per cent and that of oil had increased to nearly 25 per cent. By 1970, the shares of coal (47 per cent) and oil (45 per cent) were almost equal. Following decisions to launch the Magnox and AGR nuclear power programmes and to exploit rapidly recently discovered offshore gas (and oil) resources, the 1970s witnessed further diversification in the UK primary energy mix. The most striking change over the past twenty years has been the rapid penetration of natural gas in the UK primary energy market (see Table 14). The contribution of gas rose to five per cent in 1970, 17 per cent in 1975, 22 per cent in 1980 and 25 per cent in 1987. Given a shortage of suitable sites, UK hydro-electric output has not changed significantly over the past two decades. As a result, only nuclear power has accounted for the rise in the primary electricity share from four per cent in 1968 to seven per cent in 1988. Despite considerable and consistent government support for nuclear power over this period, it is sobering to compare its slow expansion with the dramatic fuel switches being demanded by some witnesses.

TABLE 14

UK Primary Energy Demand by Fuel

(bn therms)

	Coal	*Petroleum*	*Natural Gas*	*Primary Electricity*	*Total*
1987	28.5	30.3	21.5	6.1	86.4
1986	27.8	30.2	20.9	4.9	84.8
1985	25.7	29.2	20.6	5.6	81.1
1984	19.3	33.9	19.1	5.0	77.4
1983	27.2	27.0	18.7	4.7	77.7
1982	27.0	28.2	17.9	4.2	77.3
1981	28.9	28.1	18.0	3.7	78.7
1980	29.1	30.7	17.8	3.5	81.1
1979	31.3	35.0	17.8	3.7	87.8
1978	29.1	35.1	16.3	3.6	84.0
1977	29.9	34.4	15.7	3.8	83.7
1976	29.8	33.8	14.8	3.4	81.7
1975	29.3	34.3	13.9	3.0	80.4
1974	29.1	38.2	13.3	3.3	83.8
1973	33.0	41.4	11.1	2.8	88.3
1972	30.5	40.8	10.3	2.9	84.4
1971	34.8	38.0	7.2	2.7	82.7
1970	39.3	37.6	4.5	2.7	84.1
1969	41.7	35.1	2.4	2.9	82.0
1968	42.7	32.1	1.2	2.9	78.9
1967	42.7	30.6	0.5	2.7	76.6

Source: Digest of UK Energy Statistics

60. Primary energy demand represents the sum of demands arising from the principal end use sectors (domestic, industry, services and transport) and fuels for conversion. These latter primary to secondary energy conversion processes relate mainly to power stations, refineries and the manufacture of other finished fuels such as coke and town gas. Because the opportunities for inter-fuel substitution differ markedly between the sectors, it is necessary to evaluate them separately. Table 15 shows the relative size of the main consuming sectors and Table 16 the evolution of fuel shares in the principal final energy sectors.

2. Fuel Switches in the Final Demand Sectors

61. The most important fuel switches over the past two decades have been the decline in solid fuels (coal and coke) and the rapid penetration of natural gas (see Tables 17 to 19). These trends are apparent in the domestic, services and industrial sectors. The UK transport sector (Table 20) is almost totally dependent upon oil products. One of the principal constraints on the pace of inter-fuel substitution (and increased energy efficiency) is the rate of rotation of energy-using equipment. Such equipment may have a long life (eg 15–20 years for a domestic boiler, 30–40 years for large industrial boilers, and 10–12 years on average for passenger cars). The scope for fuel subsitution is technologically constrained by this capital stock. Nevertheless, particularly for some types of industrial boiler, it is possible to substitute fuels in existing plant—eg to switch boilers which were originally designed to burn coal or oil to natural gas firing. In the past, Governments have sought to encourage inter-fuel substitution in particular directions, for example, the Coal Firing Scheme provided grants of

TABLE 15
UK Primary Energy Demand by Consuming Sector
(bn therms)

	Service Sector	*Domestic*	*Industry*	*Transport*	*Fuel for Conversion*	*Total*
1987	7.9	17.3	16.6	16.9	27.7	86.4
1986	8.0	17.3	16.2	16.3	26.9	84.8
1985	7.8	16.7	16.5	15.3	24.7	81.1
1984	7.5	15.0	16.3	15.0	23.5	77.4
1983	7.5	15.5	16.7	14.3	23.6	77.7
1982	7.4	15.6	17.4	13.9	23.0	77.3
1981	7.4	15.8	18.1	13.6	23.8	78.7
1980	7.5	15.8	19.1	14.1	24.6	81.1
1979	8.0	16.5	23.2	14.0	26.1	87.8
1978	7.7	15.4	22.5	13.7	24.8	84.0
1977	7.6	15.0	22.8	13.1	25.1	83.7
1976	7.2	14.5	22.8	12.7	24.4	81.7
1975	6.9	14.7	22.0	12.3	24.5	80.4
1974	7.0	15.1	23.8	12.4	25.6	83.8
1973	7.4	14.9	25.8	12.9	27.3	88.3
1972	7.3	14.4	24.3	12.1	26.4	84.4
1971	7.2	14.1	24.1	11.6	25.7	82.7
1970	7.4	14.6	24.7	11.2	26.2	84.1
1969	7.2	14.7	24.1	10.7	25.2	82.0
1968	6.8	14.5	23.5	10.3	24.1	79.3
1967	6.5	14.2	22.8	9.9	23.2	76.6

Source: Digest of UK Energy Statistics

TABLE 16
UK Final Energy Demand by Fuel
(bn therms)

	Electricity	*Gas*	*Oil*	*Coal*	*Total*
1987	8.5	19.7	23.4	7.0	58.7
1986	8.2	18.8	23.5	7.3	57.8
1985	8.0	18.6	22.4	7.4	56.3
1984	7.7	17.4	22.7	6.1	53.9
1983	7.5	17.0	22.4	7.1	54.0
1982	7.4	16.9	22.8	7.2	54.3
1981	7.5	16.9	23.2	7.3	54.9
1980	7.7	16.8	24.8	7.3	56.5
1979	8.0	16.8	27.4	9.5	61.7
1978	7.7	15.4	27.1	9.0	59.2
1977	7.5	14.5	26.8	9.7	58.5
1976	7.4	13.8	26.2	9.9	57.3
1975	7.3	12.7	25.8	10.1	55.9
1974	7.3	12.1	27.1	11.8	58.3
1973	7.5	11.0	29.7	12.8	61.0
1972	7.0	9.6	28.7	12.7	58.0
1971	6.8	9.6	27.7	14.8	57.0
1970	6.6	6.2	27.4	17.8	58.0
1969	6.2	5.4	25.8	19.3	56.8
1968	5.8	4.9	24.3	20.1	55.2
1967	5.4	4.4	22.8	20.7	53.4

Source: Digest of UK Energy Statistics

up to 25 per cent to qualifying industrial plant (boilers and kilns) which switched fuels from oil and natural gas to coal. However, in the main, Governments have allowed market forces to determine the pattern of fuel use in the principal end use sectors, consumers being influenced primarily by fuel availability and relative fuel prices. In addition, the transport sector has been responsible for an increasing proportion of total final energy demand, from 19 per cent in 1970 to 29 per cent in 1987. We deal in more detail with transport in paragraphs 120 to 123. Given the long-term decline in oil use in the other final demand sectors, the transport sector has accounted for a rapidly rising share of total final oil consumption—some 72 per cent in 1987.

TABLE 17
Trends in Domestic Sector Energy Demand
(bn therms)

	1970	*1975*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
Gas	3.5	5.9	8.2	8.4	8.8	8.7	8.9	8.9	9.7	10.2	10.5
Oil	1.3	1.4	1.4	1.1	1.0	0.9	0.9	0.9	0.9	1.0	1.0
Solid Fuels	7.1	4.3	3.8	3.3	3.1	3.1	2.9	2.3	3.1	2.9	2.6
Electricity	2.6	3.0	3.1	2.9	2.9	2.8	2.8	2.9	3.0	3.1	3.2
Total	14.6	14.7	16.5	15.8	15.8	15.6	15.5	15.0	16.7	17.3	17.3
% of total final energy demand	25.3	26.3	26.7	28.0	28.7	28.7	28.6	27.9	29.6	30.0	29.4

Source: Digest of UK Energy Statistics

TABLE 18
Trends in Industrial Energy Demand
(bn therms)

	1970	*1975*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
Electricity	2.5	2.6	3.0	2.7	2.6	2.5	2.5	2.6	2.7	2.7	2.9
Gas	1.9	5.5	6.6	6.3	6.0	6.0	5.8	6.0	6.2	5.7	6.2
Oil	11.4	8.8	8.6	6.7	5.9	5.4	4.8	4.3	3.9	4.1	3.6
Solid Fuels	8.9	5.1	5.0	3.4	3.6	3.5	3.6	3.3	3.7	3.8	3.9
Total	24.7	22.0	23.2	19.1	18.1	17.4	16.7	16.3	16.5	16.2	16.6
Production Index	103.7	105.0	109.5	100.0	94.0	94.2	96.9	100.8	103.8	104.7	108.7
% of total final demand	42.6	39.3	37.6	33.8	30.0	32.1	30.9	30.3	29.3	28.1	28.3

Sources: Digest of UK Energy Statistics, Monthly Digest of Statistics

TABLE 19
Trends in Service Sector Energy Demand
(bn therms)

	1970	*1975*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
Gas	0.8	1.3	2.0	2.1	2.1	2.2	2.3	2.4	2.6	2.9	3.0
Oil	3.0	2.8	2.9	2.5	2.4	2.2	2.1	2.1	2.0	1.9	1.6
Solid Fuels	1.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5
Electricity	1.2	1.4	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.1	2.2
Total	6.7	6.2	7.3	7.0	6.9	6.8	6.9	7.0	7.3	7.4	7.3
% of total final energy demand	11.7	11.1	11.8	12.2	12.5	12.5	12.8	13.0	12.9	12.9	12.5

Source: Digest of UK Energy Statistics

3. Fuel Switches in the Conversion Sectors

62. The two dominant users of fuel for conversion are power stations and refineries. Given that refineries are self-sufficient in fuels required for processing crude oils into refined products (using process waste liquids and tail gases), the scope for fuel substitution within the conversion industries is almost wholly confined to power generation. For many years, the UK has been heavily dependent upon coal in power generation (71 per cent in 1987: see Table 21). The residual fuel requirements have been met by nuclear power and oil. Little natural gas has been used in UK power generation given both its high price relative to coal and policy restrictions on its use.[183]

[183] See para. 64.

TABLE 20

Recent Trends in Transport Fuel Demand

(m therms)

	1975	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
Road									
Oil	9,712	11,042	10,722	11,035	11,372	11,912	12,142	12,944	13,522
Rail									
Solid Fuel	20	16	15	14	6	1	1	1	1
Electricity	92	104	103	91	98	98	101	102	105
Oil	416	365	348	315	337	324	326	321	302
Total	528	485	466	420	441	423	428	424	408
Water									
Solid Fuel	4	2	—	1	1	—	—	—	—
Oil	492	499	437	471	479	527	498	457	438
Air									
Oil	1,675	2,081	1,993	1,982	2,022	2,137	2,216	2,432	2,572
Total Transport	12,411	14,109	13,618	13,909	14,315	14,999	15,284	16,257	16,940
% Road Transport of Total Demand	78.3	78.3	78.7	79.3	79.4	79.4	79.4	79.6	79.8

Source: Digest of UK Energy Statistics

TABLE 21

UK Power Station Fuel Inputs 1983–87

(mt coal equivalent)

						By Utility			
						E&W	*Scotland*	*NIES*	*Other*
	1983	*1984*	*1985*	*1986*	*1987*	*1987*			
Coal	81.4	53.4	73.9	82.7	86.2	79.2	6.4	0.6	—
Oil	8.1	36.2	18.1	10.4	8.2	5.3	0.6	2.2	—
Natural Gas	0.3	0.7	0.8	0.3	0.3	—	—	—	0.3
Nuclear	18.1	19.5	22.1	21.3	19.8	13.9	4.0	—	1.9
Hydro	2.4	2.1	2.1	2.4	2.1	0.1	1.6	—	0.4
Net Imports	—	—	—	1.7	4.7	—	—	—	—
Total (all fuels)	110.3	111.9	117.1	118.8	121.3	103.2	12.6	2.8	2.6

Notes: 1. "Other" includes transport undertakings (eg London Transport) and nuclear plant operated by the UK Atomic Energy Authority
2. 1984 and 1985 data affected by the mining dispute

Source: Digest of UK Energy Statistics

4. Greater use of Natural Gas

63. Witnesses suggested that continued changes in the UK fuel mix could play a significant role in reducing CO_2 emissions. ACE argued that "natural gas emits only 60 per cent of the CO_2 emissions of coal to produce the same amount of energy and only 80 per cent of that from oil. It could thus be substituted in the power station, industrial and transport sectors, as an interim "solution" which will buy more time to switch to non-CO_2 emitting fuels".[184] This view was shared by the UKAEA, BP, BG, CEGB, the Department of Energy, Greenpeace, and others.[185] Gas penetration in the main final demand markets is already considerable and in 1987 accounted for 61 per cent of total fuel use in the domestic sector, 37 per cent in industry and 41 per cent in services. In 1988–89, BG added 350,000 customers, and the underlying trend in its sales (temperature adjusted) was for an increase of 3.8%.[186] It is expected that these trends will continue given lower gas prices, growing environmental pressures and customer preference for clean, convenient fuels. However, there are important constraints upon gas penetration to even higher levels in final energy markets. These include the commercial judgement of BG as to whether to extend the natural

[184] *Ev.* p. 4.

[185] UKAEA, *Ev.* p. 97; BP, *Ev.* p. 12; BG, *Ev.* p. 22; CEGB, *Ev.* pp. 26–27, and p. 32; DEn, *Ev.* p. 37; Greenpeace, *Ev.* pp. 61–62.

[186] BG's announcement of annual results, 8 June 1989.

gas transmission and distribution system in Great Britain (natural gas is not available in Northern Ireland),[187] the limited size of proven gas reserves,[188] the increase in real prices required to bring forward additional gas reserves, and the price relativities between gas and its principal competitors (coal, light and heavy fuel oil and electricity—depending upon end user application).[189]

64. In principle, there is considerable scope for expansion of natural gas use in power generation from its current low base in the UK. As the Department of Energy told us "in the longer term, major substitution could occur, and some small moves in this direction are already mooted for the electricity supply industry post privatisation, eg a number of gas-fired electricity generating schemes are already proposed for early competition within the new privatised industry. The European Directive limiting gas burn for electricity production is an obstacle to such schemes; but, partly as a result of UK prompting, the Directive is currently being reviewed by the Commission."[190] The Secretary of State corroborated this view when he gave oral evidence.[191] The Committee, of course, is aware of the Peterhead contract between the NSHEB and BP which, from 1992, will result in that 1320 MW power station burning gas rather than oil.

65. As BP informed the Committee "gas in power generation wins in two ways. First, emissions from a gas-fired plant are around half of those from a coal plant. Second, gas combined cycle plant electricity generation is more than 45 per cent efficient, compared with around 35 per cent for coal".[192] BG stated that during 1986–87, UK coal-fired power stations operated at "an average efficiency of coal usage to power output of 31.5 per cent",[193] adding that "a modern coal-fired plant with flue gas desulphurisation might have an efficiency of 37.0 per cent. On the other hand current combined cycle gas turbine plant have efficiencies of 42 per cent . . . it appears that turbine plants with 47 per cent efficiencies are well within sight, and it is confidently predicted that gas turbine plants will eventually possess efficiencies of 50 per cent".[194] (See Table 22). BG concluded that "compared with current coal-fired power stations, the introduction of gas-fired combined cycle turbine sets could eventually reduce CO_2 emissions by a factor of around two and a half per unit of electricity produced".[195] Government evidence[196] was somewhat more optimistic than that of BG. According to them, natural gas fuelled combined cycle plants were usually achieving efficiencies in the range 46–49 per cent with the highest efficiency being 50 per cent. Furthermore, work in the USA "indicates efficiencies of 53 per cent may be achievable without the need for major advances in material technology". However, even on BG's figures, the case for gas appears strong.

66. The CEGB noted that simple fuel substitution of gas for coal in a generating cycle of the same efficiency could reduce the CO_2 emitted by 44 per cent but, by utilising natural gas more efficiently in combined cycle plant, CO_2 emissions could be reduced by about 55 per cent.[197] According to the CEGB "it is unlikely that suppliers of natural gas for electricity generation by 2005 would exceed 20 per cent of fossil fuel burn, corresponding to some 10 GW of combined cycle gas turbine plant".[198] The CEGB added that "1 GW of combined cycle plant replacing an equivalent capacity of coal-fired plant saves about 3Mt CO_2 per year".[199] Whilst considerable CO_2 reductions could arise from substituting gas for coal in a

[187] Seventh Report from the Energy Committee, Session 1984–85, *The Development and Depletion of the United Kingdom's Gas Resources*, HC 76-I.
[188] UKAEA, *Ev.* p. 97.
[189] DEn, *Ev.* p. 37.
[190] DEn, *Ev.* p. 37. The most recent position was announced to the House on 23 May 1989, following the meeting of the EC Council of Energy Ministers on May 11: "In an inconclusive discussion of the 1975 directive controlling the use of gas for generating electricity, the United Kingdom strongly urged its repeal particularly on environmental grounds but also in the interests of competition, exploration and efficiency. The Commission was unwilling to propose repeal before the next review of the Community's energy objectives, but would do so if it were shown that the directive restricted the development of the gas industry."
[191] QQ 528, 541.
[192] BP, *Ev.* p. 12.
[193] BG, *Ev.* p. 23.
[194] *Ibid.*
[195] BG, *Ev.* p. 24.
[196] *Min. of Ev.* p. 159.
[197] CEGB, *Ev.* p. 26.
[198] *Ibid.*; see also p. 29 scenario Case 2.
[199] *Ibid.* p. 26.

TABLE 22

Efficiency by plant type

Plant Type	*Efficiency (%)*	*10^6 tonnes carbon per Exa Joule (Electricity)*	*Ratio of CO_2 produced to CO_2 from current UK Power Stations*
Current Coal fired	31.5	76.2	1
New coal fired	37.0	64.9	0.85
Modern combined cycle gas turbines*	42	33.3	0.44
Advanced combined cycle gas turbines*	47	29.8	0.39
Predicted combined cycle gas turbines*	50	28.0	0.37
Gasification combined cycle using advanced gas turbines	40	61.0	0.80

*using natural gas

Source: *Ev.* p. 24, based upon Modern Power Systems, April 1982; Annual Review of Energy, 13, 1988

conventional power station, and from a switch to combined cycle generation, a third route would be CHP.[200]

67. However, the CEGB, amongst others, sounded a note of caution as regards extensive fuel switching to natural gas (and oil), arguing that beyond 2005 gas and oil reserves would be depleting and their prices rising.[201] On a global scale, BC stated that "although gas, for example, contributes less greenhouse gases per unit of heat produced, substitution would have to be carried out on such a large scale to make even a marginal impact on the "greenhouse" effect (our calculations suggest 90 per cent increase in gas usage would be required worldwide to produce a 10 per cent reduction in CO_2 emissions, even with no increase in world energy demand) that such a strategy cannot be seen as a viable policy option".[202] Given that world reserves of coal are 20 times greater than combined oil and gas reserves,[203] BC's case has some merit in world terms.

68. As far as the UK is concerned, we find it difficult to accept BC's scepticism. **The evidence seems irrefutable that increased use of natural gas in the UK energy mix, both in final demand sectors and in power generation (and especially in leading edge technological configurations such as gas-fired combined cycle CHP schemes), would serve to reduce the national CO_2 emissions.** However, UK natural gas reserves are limited,[204] and at current rates of consumption will last some 40 years.[205] Furthermore, whilst imported natural gas from Norway, the Soviet Union, Algeria and Nigeria could become available over the timescales envisaged in this Report, the Committee is also conscious that macro-economic considerations were of great concern to the Treasury in 1985 in deciding to override BG's proposed purchase of gas from the Norwegian Sleipner Field.[206] Balance of payments considerations may be of considerable weight in any future decision to sanction large-scale imports of natural gas. The Secretary of State told us that electricity generators would be

[200] See paras 125 to 129.

[201] CEGB, *Ev.* p. 32.

[202] BC, *Ev.* p. 17.

[203] *Ev.* p. 39, Annex B, Table 1.

[204] Remaining proven natural gas reserves on the UKCS were estimated to be 590 billion m^3 at end 1988 and production was 42 billion m^3 in 1987, giving a proven reserves to production ratio of 13–14 years. This figure could well be conservative in view of the upward trend in estimates. Maximum possible reserves (ie proven, probable and possible reserves) were put at 1765 billion m^3.

[205] *Development of the Oil and Gas Resources of the United Kingdom* (Brown Book), Department of Energy, HMSO, 1989, p. 13.

[206] The announcement was made on 11 February 1985 (see HC Deb 11 February 1985, cc 23ff). See the Committee's Eighth Report (Session 1983–84) *BGC's proposed purchase of gas from the Sleipner Field*, HC 438, passim, and its Seventh Report (Session 1984–85) *The Development and Depletion of the United Kingdom's Gas Resources*, HC 76–I paras 1–2.

entirely free to purchase gas "where they will".[207] We doubt, however, whether they will invest in the necessary pipe-line to import gas from the Continental Grid.

69. **We conclude that gas will have some role to play in reducing the UK's CO_2 emissions, but that its potential should not be overstated. We welcome the Government's stance on the EC directive on the burning of gas for power generation, and we recommend that the Government consider favourably any proposition for joining Great Britain to the European gas grid.**

5. Heavy Oil (HFO) and "Orimulsion"

70. As well as substitution of natural gas in final markets and the power generating sectors, witnesses suggested that oil and a new oil-based fuel, orimulsion, could serve to reduce overall CO_2 emissions if increased use of these fuels occurred. BP suggested that "very significant" reductions in CO_2 emissions could be achieved by switching from coal to "a greater balance of oil and natural gas in existing stations".[208] They added that "given due allowance for supply availability, security and price, much could be done at relatively modest conversion cost and in a relatively short time".[209] The Committee is aware that the CEGB and its privatised successors are contemplating increased use of heavy fuel oil in existing oil-fired power stations and that the CEGB may sanction completion of Unit 5 at the Isle of Grain power station. The CEGB stated in evidence that "some of the projected coal burn could, in principle, be replaced by maximising oil burn in existing oil- and dual-fired power stations. This could amount to a maximum 40 Mtce per year and reduce CO_2 emissions by nearly 16 Mt per year, about nine per cent of the 1987 CO_2 output. The cost would depend on the price differential between the coal and oil supplies available to the privatised industry. At present international prices it [ie the price differential] could amount to nearly £150m/year".[210] However, the CEGB added that "if increased oil burn were widely adopted internationally, oil prices could be expected to rise". The UKAEA also recognised the need to substitute "lower CO_2 emitting fuels for coal (oil and gas)".[211] On the other hand, the Department of Energy drew attention to the role of natural gas as a substitute for coal and oil,[212] and to the relatively limited global reserves of crude oil.[213] Relatively few witnesses advocated an increased role for oil products in the UK energy balance, despite the fact that "for each unit of energy, oil releases about 82 per cent of the CO_2 produced by coal".[214] The Secretary of State also appeared to expect diversification to be into gas rather than into oil.[215]

71. BP drew the Committee's attention to the development of a new fuel, orimulsion, which is a bitumen in water emulsion, principally for use in the power generating sector.[216] It has been developed in conjunction with Petroleos de Venezuela and can be used in place of coal in conventional oil-fired and dual- coal/oil fired thermal power stations, resulting in a 10–15 per cent reduction in CO_2 emissions over coal.[217] BP added that as the Orinoco Basin has "almost limitless" reserves of such heavy oil "it is a very long-term resource".[218] However, as yet, it is a prototype fuel being used only on a trial basis in small quantities[219] and may create its own environmental problems owing to its high sulphur content.

6. Synthetic Fuels and Hydrogen

72. It is of course possible to convert coal (and oil) into gaseous fuels by adding hydrogen atoms. The oil crisis of the 1970s stimulated the technologies and several projects were initiated with the aim of shifting consumption from oil and natural gas to coal-based synthetic fuels. The projected costs were never low enough to be acceptable to commercial

[207] Q.542.
[208] BP, *Ev.* p. 12, see also Appendix to BP, *Min. of Ev.* pp. 64–65.
[209] *Ibid.*
[210] CEGB, *Ev.* p. 27.
[211] UKAEA, *Ev.* p. 100.
[212] DEn, *Ev.* p. 37.
[213] *Ibid. Ev.* p. 39, Annex B, Table 1.
[214] *Ibid. Ev.* p. 39.
[215] Q.543.
[216] *Ev.* p. 12.
[217] Q.252–254.
[218] *Ibid.*
[219] See Secretary of State Q.544.

investors, even in an era of high oil prices and political uncertainties about supplies. Since the processes require a significant heat input the overall reduction of CO_2 production is unlikely to be great. None of the Memoranda submitted to us made proposals for further work and we have not pursued this option further in this Report.

73. The production and use of pure hydrogen as a rocket fuel and in chemical processes is very well established. It is an environmentally benign fuel since it can be produced from water by electrolysis and is re-formed into water when burned. Hydrogen has been successfully tested in many types of engine, in turbines, automobile engines and fuel cells. Nuclear stations and renewable sources of electricity, especially solar cells, have been proposed as producers of the electricity necessary to produce hydrogen. This process would even-out the electricity demand by absorbing off-peak power. The major problems lie in developing safe handling and transportation methods and local storage (in road vehicles, for example) which are suitable for general use by the public. Moreover, "it is not necessarily clean or cheap to produce".[220] We noted with interest that ETSU has made a preliminary assessment of hydrogen as a fuel[221] and that the Chairman of the AEA expressed a wish to continue work in this area,[222] and we would support his aims. Although we recognise the problems inherent in the use of hydrogen as a fuel,[223] we are disappointed that the Department has no plans to undertake new research in this field. We note that the EC and the German and Canadian Governments are supporting a hydrogen energy demonstration project involving the importing of 100,000 tonnes of hydrogen to Germany each year from Canada where it will be produced at a hydrolysis plant powered by hydro-electricity.[224] The Secretary of State promised to investigate the British role in this.[225] It appears to be the sort of project that should be studied seriously, and **we recommend that in the light of greenhouse concerns all research into the potential of hydrogen be urgently reviewed.**

7. Nuclear Power

74. The UKAEA told us that, at the global level, "without existing nuclear generation global warming would now be three per cent (and the energy component seven per cent) higher than it currently is".[226] They argued that nuclear power could make a greater contribution if:

—"a larger share of electricity was generated by nuclear stations displacing fossil fuels (especially coal and oil);

—electricity (nuclear-generated) was substituted for other primary energy sources (eg railway electrification, steel-making) and for heat production".[227]

The Authority added that "non-CO_2 producing technologies, such as nuclear power and the 'renewables', offer the best long-term solution. All have a part to play but, apart from hydro power, nuclear power is the only one that is already in reasonably wide use and at a stage where it could be readily expanded".[228] Were nuclear power to be developed on a large scale internationally, the UKAEA warned that uranium reserves (both proven and speculative) would be exhausted by 2100; hence they regarded "the introduction of fast reactors as essential to the resolution of this problem",[229] "their timing being dependent on the rate at which nuclear power is utilised".[230]

75. In combination with energy efficiency, fuel substitution and renewable energy sources, the Department of Energy also considered that nuclear power could play an important role in curbing CO_2 emissions.[231] The present nuclear capacity in the UK comprises 6.5 GW of plant in full commercial operation, with a further 3 GW in the final

[220] DEn. *Min. of Ev.* p. 50.
[221] *Ev.* p. 100.
[222] Q.442.
[223] Spelt out by the Government in *Min of Ev.* pp. 49–50.
[224] Science and Technology Information Note No. 109/89 from British Embassy, Bonn.
[225] Q.517.
[226] *Ev.* p. 97.
[227] *Ibid.*
[228] UKAEA, *Ev.* p. 97.
[229] *Ibid. Ev.* p. 98.
[230] UKAEA, *Ev.* p. 103.
[231] DEn, *Ev.* pp. 35–37.

stages of commissioning.[232] In 1988, nuclear power stations generated 45 TWh of electricity, some 16 per cent of total electricity generation. With expected improved performance of existing AGRs and the commissioning of the new AGRs at Heysham "B" and Torness, the Department expects nuclear output to rise to 64 TWh or 20 per cent of total electricity generation by the early 1990s. In addition, 13 TWh of electricity (assumed to be nuclear) is provided by the 2000 MW cross-Channel Link with Electricité de France.[233]

76. However, given progressive retirement of the Magnox reactors from the mid-1990s, UK nuclear generation is likely to decline—notwithstanding the commissioning of the Sizewell "B" PWR. Under the terms of the Electricity Bill, the Government is taking powers to require the distribution companies to contract for a minimum of non-fossil fuel output. The total obligation for the year 2000 will not be less than the present level of existing and committed nuclear and renewable capacity. The Secretary of State explained this as "seeking to maintain the level of nuclear power at the level it is now".[234] His Department had earlier told us that "this will require the construction of some 3–3.5 GW of non-fossil plant in addition to the Sizewell 'B' PWR, ie roughly 3 further PWRs".[235] Apart from the possibility of an additional cross-Channel link with France, given the long planning and construction lead times for nuclear plant, the Department thought it was "unlikely that significant further additions to nuclear capacity could be achieved by the year 2000—perhaps one extra station of 1.2 GW is the most that could be expected".[236]

77. The CEGB agreed with this broad judgement that "it is unlikely that more than four PWRs (3.5 GW, excluding Sizewell "B") could be commissioned before 2000, given current planning processes".[237] However, the CEGB considered that "by 2000 the industry will have demonstrated its capacity to build one PWR per year. Thereafter, it is considered that the rate could be increased to two PWRs per year, or possible more".[238] They argued that "by the year 2005 a further 10 PWRs could be commissioned, bringing the total nuclear capacity to about 20 GW".[239] If this rate of commissioning could be achieved, at a cost of about £7 billion,[240] and given that one PWR can be expected to abate about 6 Mt CO_2 per year compared with coal-fired capacity, the CEGB thought that "10 additional PWRs would abate anticipated CO_2 emissions in 2005 by 60 Mt.[241] If 14 PWRs were commissioned by 2005, CO_2 abatement could reach 90 Mt per year. The CEGB thus believed that "the most significant option for CO_2 savings lies in nuclear power".[242] The SSEB agreed with this judgement.

78. BC, BP and the TUC expressed reservations about the ease with which nuclear power capacity could be expanded on safety and environmental grounds.[243] BC noted that at the current Hinkley Point "C" PWR Public Inquiry "the CEGB's case for the station is primarily based on the "non-fossil" fuel requirement, and that the Board is no longer arguing, as it did at the inquiry into Sizewell B, that nuclear power offers the cheapest energy source".[244] Most strikingly, when questioned about the economics of nuclear power and the impending privatisation of the electricity supply industry in Great Britain, the Chairman of the UKAEA said that he did "not believe that in the present situation or climate privatised electricity generating companies would invest in nuclear power, to be absolutely frank".[245] Although the Secretary of State disputed this view[246] and pointed to successful private PWRs in Belgium and West Germany, other witnesses shared the UKAEA Chairman's view of the relatively unattractive economics of nuclear power in Britain at this time. In addition,

[232] *Ibid.* p. 37.
[233] DEn, *Ev.* p. 37.
[234] Q.534.
[235] DEn, *Ev.* p. 37.
[236] *Ibid.*
[237] *Ev.* p. 27.
[238] *Ibid.*
[239] *Ibid.*
[240] FoE estimate the cost of 8 PWRs at £12 billion. *Ev.* p. 49.
[241] *Ev.* p. 27.
[242] CEGB, *Ev.* p. 31; SSEB, *Ev.* p. 88.
[243] BC, *Ev.* pp. 16–17; BP, *Ev.* p. 12; TUC, *Ev.* pp. 94–95.
[244] BC, *Ev.* p. 17.
[245] Q.419.
[246] Q.538.

they were concerned about its wider safety and environmental impacts.[247] Even the CEGB qualified it assessments of the role nuclear power could play by stressing that any expansion would "be subject to political determination and public acceptability and of course to the achievement of mutually acceptable commercial terms to the providers of the plant and the purchasers of its output".[248]

79. One recurrent topic in the evidence was whether investment in nuclear power or energy efficiency was more effective in reducing CO_2 emissions. Many of our witnesses responded to a study by the American researchers Bill Keepin and Gregory Kats of the Rocky Mountain Institute.[249] This concluded that "not only is nuclear power slower and considerably more expensive than efficiency improvement, but its overall potential for displacing CO_2 emissions is also much smaller".[250] This is a strong conclusion, and led to some strong reactions from our witnesses. ACE, BC, FoE, Greenpeace and the Open University[251] all concurred.

80. We asked the Department of Energy and the UKAEA to respond to the study. In oral questioning the UKAEA expressed outrage at the study which they claimed was "misleading" people by putting up nuclear power as a "ridiculous cock-shy".[252] In more reasoned written responses to the study,[253] the UKAEA and the Department both felt that the paper was correct in concluding that nuclear power on its own was not the answer to global warming, and that energy efficiency would be a very important part of any response to the greenhouse effect. However, they believed that the study was weak in several areas. It relied too heavily on US data and circumstances, was dependent on scenarios that were not unanimously agreed, and did not assess nuclear and efficiency investment on the same cost basis. It was also not clear that nuclear and efficiency plans would be competing for the same investment capital in any case. The UKAEA reminded us that not all efficiency investments were cost effective, and the Department stressed that "CO_2 reductions on the scale imagined by the more extreme efficiency proponents are impracticable".

81. We asked Keepin and Kats to respond. They did not retreat from their conclusions,[254] but claimed that enough energy efficiency investment will be more economic than nuclear investment for many years. Much efficiency potential is untapped, though, because of a failure to construct a free market in energy services. They defended their energy scenarios and their cost methodologies as widely used and relatively conservative.

82. It is not our role to judge whether the arguments of Keepin and Kats are sound in economic terms. Others will be able to do that from the evidence which we have taken. We believe that their original paper and the responses to it have at least elicited two facts: that nuclear power is not a solution by itself to global warming, and that energy efficiency is the most important response to the problem. We will return to energy efficiency in the next section of the Report. However, it is also clear that electricity will need to be generated somehow, and that the nuclear power route does not produce CO_2, except to a minimal degree.[255] We therefore believe that nuclear power does have a role to play in a greenhouse-friendly electricity supply industry. Because of the well-known cost and environmemental problems associated with the use and development of present nuclear technologies, this role should not be exaggerated.

83. In this context, we believe that efforts should be redoubled to look at the long-term potential of nuclear power beyond the current technology of the thermal reactors. We have already referred to the UKAEA's view that uranium reserves could be exhausted in little over 100 years. Therefore, as ACE said, "nuclear power's future is . . . dependent on the

[247] eg ACE, *Ev.* p. 5; BG, *Ev.* p. 23; FoE, *Ev.* p. 49; Greenpeace, *Ev.* pp. 60–61.
[248] *Ev.* p. 27.
[249] *Greenhouse Warming: Comparative analysis of nuclear and efficiency abatement strategies*, Bill Keepin and Gregory Kats, *Energy Policy*, Vol. 16 No. 6, pp. 538–561 (December 1988).
[250] *Ibid.* p. 554.
[251] *Ev.* p. 5; pp. 16–17; Q.501; *Ev.* pp. 60–61; p. 127.
[252] QQ. 415–417.
[253] UKAEA, *Min. of Ev.* pp. 99–101; DEn, *Min. of Ev.* p. 49.
[254] *Ev.* pp. 148–149.
[255] Even the environmental witnesses argued that nuclear produced less than 4 per cent of the CO_2 of fossil fuel—QQ.468–473.

plutonium-fuelled fast breeder reactor".[256] The Committee has recently visited Dounreay, and has questioned Baroness Hooper[257] and the Secretary of State about the future of fast breeder research.[258] **Since we are far from convinced that it is sensible for the UK to wind down its contribution to fast reactor research, we have decided that the next major subject for this Committee to investigate will be the future of this research.** We are inclined to agree with the UKAEA that the fast breeder reactor "is . . . a matter for the British Government to foster as a long term option for the generation of electricity in this country",[259] and recommend **that in the interim the Government reassess its position on this new technology in the light of increasing concern about CO_2 emissions and the long term viability of traditional fission.** We regard this as an area which must be pursued by **government** R&D effort, particularly since the privatised electricity industry is highly unlikely to be willing to do so.[260]

84. Whilst the Committee recognises the theoretical potential of nuclear power to curb CO_2 emissions at both the national and global levels, it also recognises that the public's confidence in nuclear power has been reduced by the accidents at Three Mile Island and Chernobyl. In addition, the Committee is conscious that the economics of nuclear power in the UK have been subject to rigorous re-appraisal in the contexts of the Hinkley 'C' PWR Public Inquiry, the fall in international fossil fuel prices, and the impending privatisation of the electricity supply industry in Great Britain. We agree with the Chairman of the UKAEA that, at present, nuclear power would appear unattractive to the privatised generating companies; the Government appears to share this view, too, given the special, market-distorting, non-fossil fuel provisions of the Electricity Bill. For this reason, **we do not believe that further investment in nuclear power beyond the present programme is likely to occur in the current climate. The contribution which nuclear power will make in the next 10 to 20 years to reducing CO_2 emissions should not be overstated** although, as the Secretary of State said, the arguments for nuclear may grow in the future.[261]

8. Renewable Sources of Energy

85. The Department of Energy told us that "only limited use is made of renewable energy at the present time in the UK. Hydro-electricity provides about 1.5 per cent of electricity generated, or a little over 0.5 per cent of total consumption of all fuels. There are no statistics for other renewable sources. However, it is probable that rural use of wood and combustion of forestry, industrial, agricultural and domestic waste provides between one and two million tons coal equivalent—say, 0.5 per cent of the total energy consumption".[262] The Department added that for the future the potential contribution of renewable energy sources is difficult to quantify "since many of the renewable technologies have not been developed yet to a state where the performance, costs and environmental implications can be predicted with any certainty".[263] The Secretary of State added to this:[264] he did not see renewables as a source of base load electricity; though important, they were "peripheral".

86. The Department's latest review of the UK renewable energy programme was published in June 1988.[265] This document outlines the Department's strategy, the major objectives of the programme, and assesses the potential contributions and technological and market constraints facing a wide range of renewable sources. The overall assessment made by the Department is that: "it appears likely that renewable energy sources could make a useful and economic contribution to the UK economy from the late 1990s, thereby assisting diversity of supply. They might also provide some insurance against long-lasting unforeseen disturbances in energy supplies in the future. A contribution of up to 70 TWh/y from those technologies which produce electricity directly and up to 20 Mtce/y from those producing heat may be possible by the year 2025. For comparison, current UK total primary energy

[256] *Ev.* p. 5.
[257] Q.160.
[258] Q.550.
[259] Q.422.
[260] See Third Report from Energy Committee, Session 1987–88, *The Structure, Regulation and Economic Consequences of Electricity Supply in the Private Sector*, HC 307, para 169.
[261] Q.534.
[262] *Ev.* p. 36.
[263] *Ibid.*
[264] Q.545.
[265] *Renewable Energy in the UK: The Way Forward*, Dept of Energy, Energy Paper No. 55, HMSO, London, June 1988.

consumption is 330 Mtce/y of which electricity consumption is 250 TWh/y. The extent of the contribution from renewables will depend upon the success of the R&D".[266]

87. In Energy Paper 55, the Department of Energy provided the following assessments of the technical and estimated economic potential by principal renewable source by the year 2025.[267]

TABLE 23

Technical Potential and Estimated Contribution of Renewables by 2025

(a) Electricity Producers	*Technical Potential TWh/y*	*Estimated Contribution TWh/y*
WIND POWER		
Onshore	45	0–30
Offshore	140	?
TIDAL	54	0–28
GEOTHERMAL HDR	210	0–10
WAVE	50	0–0.2
SMALL SCALE HYDRO	2	0.3–0.7
(b) Heat Producers	*Mtce/y Technical Potential*	*Mtce/y Estimated Contribution*
PASSIVE SOLAR	8–14	1–2
BIOFUELS		
Wet and Dry Wastes	22	3–10
Forestry	at least 20	1–5

88. The CEGB agreed that the long-term potential of the renewable energy sources for power generation was considerable: "if the various renewable energy sources became economic, technically viable and were publicly acceptable, then possibly 18 per cent of the country's electricity demand might be met by such sources in the year 2030".[268] However, by the year 2005, the CEGB argues that the "likely upper limit" to the contributions of the renewable energy sources for power generation was much lower, about eight per cent.[269] The CEGB provided the Committee with the following table:

TABLE 24

Likely Upper Limit of CO_2 Reduction from Renewable Sources by year 2005

	Installed Capacity MW	*TWh/year*	*Mtce*	*% of total Mtce*	*Mt CO_2/year avoided*
Wind	1,100	3	1.2	0.9	2.6
Tidal	9,100	18	7.6	5.4	16.5
Geothermal	200	1.5	0.7	0.5	1.5
Wave	150	0.4	0.2	0.1	0.4
Hydro	10	0.02	—	—	—
Refuse	50	3.3	1.4	1.0	3.0
Totals		26.2	11.1	7.9	24.0

[Source: *Ev.* p. 28]

89. FoE argued that "the long-term potential for renewables is enormous; offshore wind power and wavepower could alone provide all our electricity requirements".[270] FoE identified "a potential contribution of 12 TWh by 2005 (in addition to existing hydro generation)"[271] for England and Wales alone, with substantial additional wind and hydro resources in Scotland. BP took a more cautious view arguing that by the year 2000 it was

[266] *op. cit.*, p. 2.
[267] See also *Ev.* p. 39, Annex B, Table 2.
[268] *Ibid. Ev.* p. 27.
[269] *Op cit.*
[270] FoE, *Ev.* p. 48.
[271] *Op cit.*

unlikely that the UK's consumption or production of power by waves, tide and wind would be more than one per cent.[272] This caution was shared by the SSEB: "assuming the environmental problems are resolved, the electrical system could include one or two large tidal schemes and an uncertain scattering of small wind turbine schemes. It is extremely doubtful whether they will be developed without specific regulatory pressure or financial inducements giving, in effect, a high premium to mitigation of the greenhouse effect. They are capital intensive to the highest degree and would probably be judged unattractive at current commercial rates of return on the investment. It would be well into the next century before very much electricity could be obtained from these sources and they would not dispose of the need for new fossil fuelled and nuclear plant".[273]

90. The non-fossil fuel conditions in the Electricity Bill are not intended to favour nuclear power over renewable sources of energy, assuming that they are equally attractive from a financial perspective. Indeed, the Government has announced—and we very much welcome this—a specific "renewables slice" of the non-fossil-fuel requirement in addition to the basic slice which will principally be met by nuclear power.[274] Thus the need for "specific regulatory pressures or financial inducements" highlighted by the SSEB has already been anticipated by the Government in the Electricity Bill. The Department of Energy recognises that its estimates "all assume that developments are not required which would disturb a conventional economic framework severely. If major costs were found to be incurred by, for example, the need severely to restrict CO_2 emissions, then a further proportion of the very large technical renewables potential might be exploited but at significantly higher cost than under conventional assumptions".[275] **The Committee considers that it would indeed be prudent for the Government to anticipate the need "severely to restrict CO_2 emissions", and recommends that the Department should undertake further thorough analysis of the renewable energy sources which could be deployed over the period to 2025 in the UK, taking into account the advantage of their environmentally benign nature.** With hindsight it is most regrettable that we cannot be any more optimistic about the potential of renewables than our predecessor Committee was over a decade ago.[276] Opportunities must not be lost again. We were told by the Department[277] that the renewables R&D strategy was laid out a year ago, and that "there has been no specific change to that programme on account of recent worries on climate change". **We recommend that funding of renewables R&D should be increased substantially so that the technologies are brought nearer to exploitation.** We accept the Secretary of State's view that it would be a "massive undertaking" to realise the full potential of renewables, but we are concerned that the Government's current target of 600 MW should not be fixed but grow year by year.[278]

9. Coal

91. As we have seen,[279] coal has been in retreat from UK final energy markets for much of the post-war period. Previous inquiries by the Energy Committee have identified the difficult market pressures which coal faces in defending market share in the domestic, industrial and service sectors.[280] Certainly, most independent energy analysts consider it unlikely that direct use of coal will expand significantly in these markets given consumer preference for clean, convenient fuels and the problems posed by stricter environmental regulations. The principal market for coal sales in the UK, by far, is power generation—

[272] Q.261.
[273] *Ev.* p. 88. The Committee finds the views of the SSEB on renewables strikingly similar to those of the Chairman of the UKAEA on nuclear power (see para. 78), as regards their commercial attractiveness in current circumstances.
[274] HL Deb. 15 June 1989, cols. 1531–1537.
[275] *Ev.* p. 37.
[276] See for instance the Third Report from the now defunct Science and Technology Committee, Session 1976–77, *The Development of Alternative Sources of Energy for the United Kingdom*, HC 534.
[277] *Min. of Ev.*, 14 June 1989, HC 435, Q.40.
[278] QQ.513, 545.
[279] See earlier Tables, especially Tables 14 & 16.
[280] First Report from the Energy Committee, Session 1986–87, *The Coal Industry*, HC 165, passim and Third Report from the Energy Committee, Session 1987–88, *The Structure, Regulation and Economic Consequences of Electricity Supply in the Private Sector*, HC 307, paras 129–142.

accounting for 75 per cent of total coal sales in 1987–88.[281] In this market, coal is in competition with nuclear power, oil, orimulsion,[282] renewable energy sources, potential further electricity imports from France, and natural gas. The costs of coal combustion have been increased by the need to retrofit flue gas desulphurisation (FGD) units to meet agreed EC targets for reduction of the gases responsible for acid rain (SO_2, NO_x). In addition, were CO_2 capture to be required, costs of coal combustion in power generation could double.[283]

92. Whilst it would be wholly inappropriate to equate resolution of the global greenhouse problem with the need to curb CO_2 emissions from coal combustion, particularly in power generation, given the size of CO_2 emissions from coal-fired power stations (some 36 per cent of total UK CO_2 emissions in 1987),[284] it is clear that a major contribution to any overall CO_2 emissions reduction in the UK, if required, would need to derive from the power generating sector.

93. BC "regards the adoption of more efficient coal-burning technologies both in the Third World and in the West, as the best way forward to reduce CO_2 emissions from coal burning. British Coal do not believe that large scale inter-fuel substitution would be a viable policy option, on grounds of effectiveness, cost or other environmental considerations".[285] The Department of Energy provided evidence which showed that, on a global basis, coal reserves were some 20 times greater than the combined global reserves of both oil and gas.[286] It is thus difficult to envisage, giving rising global energy consumption—especially in the developing countries—that mankind could survive were coal reserves to be left unexploited. In the case of the UK, **we agree with the Secretary of State that the country cannot afford to turn its back on its largest indigenous source of fuel resources.**[287]

94. The solution to the dilemma would thus appear to reside in technological change, of both an incremental and radical character. The CEGB told us that "since 1950, the amount of CO_2 emitted by the CEGB per unit of electricity production has fallen by 43 per cent from 1.4 kg/kWh to 0.8 kg/kWh. This is due to the increasing thermal efficiency of its plant and to the introduction of nuclear capacity on the system".[288] The CEGB added that "the large improvements in conventional coal-fired efficiency achieved over the past 40 years have brought it very near the practical efficiency limit for this type of cycle".[289] Efforts to curb acid rain emissions have paradoxically led to an increase in CO_2 emissions. According to the CEGB "the loss in plant efficiency resulting from fitting flue gas desulphurisation (FGD) leads to a 1.7 per cent increase in CO_2 emissions per unit supplied. In addition, the limestone-gypsum FGD process itself releases CO_2 during the conversion of calcium carbonate to calcium sulphate. This is likely to add one per cent per unit supplied".[290] The CEGB concluded that "further significant improvements required a new technology".[291]

95. The Committee earlier reviewed the possibilities of inter-fuel substitution and of new generating cycles (eg gas-fired combined cycle plant).[292] However, existing coal-burning technologies could lead to substantial reductions in CO_2 emissions if they were to be widely deployed in the UK. Amongst these is CHP, which could raise overall thermal conversion efficiencies to 70–80 per cent.[293] We will return to CHP in greater detail in the next section of this Report.[294]

96. More advanced technologies are also under development. BC informed the Committee that "the application of combined cycle technology provides the opportunity of improving the efficiency of coal-based power generation and thereby reducing CO_2

[281] *Digest of UK Energy Statistics*, HMSO, 1988.
[282] See para. 71.
[283] See paras. 56–7.
[284] FoE, *Ev.* p. 47.
[285] *Ev.* p. 16.
[286] *Ev.* p. 39, Annex B, Table 1.
[287] Q.529.
[288] *Ev.* p. 26.
[289] *Ibid.*
[290] *Ibid*
[291] *Ibid.*
[292] See paras 61 to 90.
[293] ACE, *Ev.* p. 4; BP, *Ev.* p. 13; BC, *Ev.* p. 18.
[294] See paras 125 to 129.

emissions".[295] Several technologies are at various stages of development. The most highly developed, according to BC, is a combined cycle based upon pressurised fluidised bed combustion (PFBC) with three plants currently under construction worldwide.[296] Such systems "could provide overall efficiency of up to 41 per cent which would represent a reduction in CO_2 emissions of about 10 per cent in comparison to conventional coal-fired power generation plant".[297] BC claimed that electricity generating costs based on PFBC would be about 15 per cent less than for conventional systems.

97. CO_2 emissions could be reduced further, according to BC, by another development in PFBC technology, called "the topping cycle", which is "based on a combined PFBC and gasification system and with an efficiency of 45 per cent offers the prospect of reducing CO_2 emissions by 20 per cent". BC claimed that such a combined coal combustion and gas turbine heat recovery cycle had the potential for reducing coal-fired generating costs by 25 per cent compared with conventional coal-fired power stations fitted with FGD. BC "sees this technology as providing an efficient, cheap and environmentally acceptable means of power generation"[298] and have urged its adoption in the UK.

98. Given the very considerable claims made for PFBC technology, especially when used in conjunction with the topping cycle, the Committee visited BC's Grimethorpe PFBC facility on 8 June. BC told us that the work on the pressurised combustion process was now complete, and that the final phase of the work would be the addition of the topping cycle itself. An independent survey they commissioned had confirmed that the PFBC system with a topping cycle would be 44.3 per cent efficient. They had previously told us that not enough funds were available to continue the project beyond September 1989.[299] At the end of 1987 the CEGB had withdrawn from what until then had been a joint R&D project, on the grounds that the PFBC system would only be of use in relatively small power stations, while they were moving towards much larger stations. In spite of some American funding, BC estimated in October 1988 that £27.5 million would be required to finish the work on the topping cycle. They were able to find £11.5 million of this themselves and asked the government to fund the balance. They were told to find private sponsorship first.[300] On 14 February BC announced that the Finnish Ahlstrom Corporation would provide £5 million of the £16 million required, conditional upon government funding being obtained for the rest of the work.[301] BC returned to the Department to seek the money. The Government wanted further private sector involvement, and said that any more money for Grimethorpe would require a separate PES[302] application, which would delay any firm commitment until September.[303] We were given more information by the Secretary of State when he gave evidence on UK/USSR energy relations on 24 May. He told us that he was "in discussion with a number of people to put together a financial package" and that he was also "very keen" to see the Grimethorpe technology brought into effect.[304]

99. During the Committee's visit to Grimethorpe we heard that BC had been told by the Department that they would argue strongly for another £8 million for Grimethorpe from the Treasury during the next PES round, although, during evidence to us on 14 June from the Permanent Secretary at the Department of Energy, we were surprised to learn that this sum was only "under consideration".[305] BC explained to us that it was also likely that PowerGen could be persuaded to provide another £¾ million in view of their interest in small-scale power stations, and that several thousand pounds would come from the USA. This left £2 million to be found before the project could be saved.

100. BC said they were unable to divert any more money from their own resources in

[295] *Ev*, p. 18.
[296] *Ibid.*
[297] *Ibid.*
[298] *Ev*, p. 26.
[299] Q.311.
[300] Q.306.
[301] *British Coal Corporation/Ahlstrom Pyropower Ltd Joint Press Release*, 14 February 1989.
[302] Public Expenditure Survey.
[303] Q.306.
[304] *UK/USSR Energy Relations*, Q.359.
[305] Fourth Report from the Energy Committee, Session 1988–89, *The Department of Energy's Spending Plans: 1989–90*, HC 435, p. 31.

spite of their confidence in the technology because of the enormous pressure they are under to make an operating profit. R&D, we were told, is regarded as an overhead and is not given the priority it otherwise would be. However, BC did spend £32.6[306] million on R&D in 1988–89. We find it most depressing that all involved—the Government, BC and British industry—have seemed unable to provide the additional funds which will allow the Grimethorpe project, with its clear economic and environmental advantages, to be completed. **This unique technology may be the only acceptable way forward for coal-fired power production. The Government has a responsibility to help bring it to fruition, and we recommend that it should ensure that the next stage of work at Grimethorpe is completed.** We are aware that the research team assembled by BC has dissipated and may dissipate further if a decision on funding is delayed, and we are therefore very worried by the Permanent Secretary's disclosure that a decision may only be reached by the autumn.[307] This may well be too late to save the topping cycle. However, it is evident from what the Secretary of State told us that the Department of Energy at least is determined that the topping cycle should continue.[308] We trust that the Treasury will not be responsible for the death of a vital environmental project.

101. The lack of support for Grimethorpe is thrown into sharp relief by the recent resolution of the EC Council of Ministers[309] that a "high priority" should be given to the "development and introduction in Member States of innovative, commercially viable technologies" to abate greenhouse gases. Grimethorpe is just such a technology, and **we therefore recommend that the Government also press the EC itself to provide funds for Grimethorpe.**

D. ENERGY EFFICIENCY

1. The Potential

102. Fuel substitution and new technologies of fuel use offer only limited and often contentious means of curbing CO_2 emissions. In contrast, **the most striking feature of our Enquiry has been the extent to which improvements in energy efficiency—across all sectors of the economy—are almost universally seen as the most obvious and most effective response to the problem of global warming.** Energy efficiency investments offer multiple attractions: many are inherently economically attractive at present energy prices, whilst others are relatively low cost; they are environmentally benign, and they are capable of speedy introduction, thereby ensuring an early reduction in CO_2 emissions. The Government through the Secretary of State,[310], one of its Ministers[311] and the Department of Energy;[312] the electricity supply industry as represented by the Electricity Council,[313] the CEGB[314] and the UKAEA;[315] other major energy supply interests such as BP,[316] BG[317] and BC;[318]; environmental interests as represented by FoE,[319], Greenpeace[320] and the World Wide Fund for Nature (WWF);[321] and research institutions such as ETSU[322] and the Open University[323] as well as, more predictably, ACE, the pressure group funded by the energy efficiency industry, were in rare agreement, all seeing enormous and inherently attractive scope for a

[306] Net of receipts from third parties.
[307] See Report referred to in footnote 305 Q.49.
[308] Q.533.
[309] Environmental Council 8–9 June 1989.
[310] Q.513.
[311] Q.174.
[312] *Ev.* p. 35.
[313] *Ev.* p. 42; Q.100.
[314] *Ev.* pp. 28–29; Q.88.
[315] *Ev.* p. 98; Q.378.
[316] *Ev.* p. 13; QQ.225 and 228.
[317] *Ev.* p. 22.
[318] *Ev.* p. 16; QQ.329–331.
[319] *Ev.* p. 46; Q.508.
[320] *Ev.* pp. 60–61; Q.474.
[321] *Ev.* p. 113; Q.506.
[322] Paper presented to No. 10 Downing Street Seminar on 26 April, p. 7. (paper submitted to the Committee by HMG, and placed in the Library of the House).
[323] *Ev.* pp. 127–136.

reduction in CO_2 emissions through energy efficiency investments. The EC Commission are similarly persuaded.[324], and have asserted that they "will take urgent action to reinforce and expand efforts in the field of energy savings (and) energy efficiency improvement".[325]. The EC Council of Ministers, in its response to the greenhouse effect,[326] "invites the Commission and Member States to take urgent action to increase energy savings; to improve energy efficiency".

103. Attempts to quantify this potential, however, have produced somewhat different results. The CEGB[327] stressed the contrast between the *potential* for efficiency savings with the likely rate of up-take. The Board took the view that between 1986 and 2005 a 12.5 per cent reduction in electricity demand, below the level that would have occurred without further efficiency improvements, is likely to be achieved. Further savings, however, were "problematic" and would require "direct or indirect intervention by Government across all forms of energy use". BP,[328] on the other hand, predicted that "global CO_2 emissions will increase by about two per cent per annum, doubling by 2025. This growth could be halved on the assumption that policies and behaviour encouraging higher energy efficiency were adopted." FoE were even more optimistic: drawing our attention to their very detailed studies of the electricity sector, they believe there is a technical potential for a 70 per cent reduction in electricity demand through the adoption of existing "state of the art" technologies;[329] they also presented a series of alternative strategies in one of which an increased but not excessive take-up of energy efficiency opportunities contributed significantly to an initial 20 per cent CO_2 savings target. ACE,[330] examining in detail a wider spectrum of potential energy savings over the next 15 or so years, concluded that "a more proactive approach from Government, industry, local government and others, which encourages the rapid take-up of more efficient technologies and removes the market obstacles which currently operate.... could reduce CO_2 emissions by between 18 and 25 per cent from current levels." In a paper to the IEA/OECD Expert Seminar in April 1989, Dr Dale of ETSU, after assessing the various options available to achieve a 50 per cent reduction in CO_2 emissions by the more distant date of 2020, speculated that 40 per cent might come from the more efficient use of energy—by far the largest contribution in his array of possible responses to global warming. Dr Currie of ETSU in his paper to the Prime Minister's seminar put the potential saving up to 2020 from the use of more efficient lighting, motors and appliances at 43 million tonnes of CO_2 per annum.[331]

2. How to achieve the potential

104. There was unanimity between witnesses, however, that only part of this considerable potential will be realised if present circumstances and Government policies in particular remain unchanged. Baroness Hooper explained the Government's commitment to a continuation, and a focussing, of their current measures to encourage a more energy-efficient Britain, including the strengthened programmes that have emerged since the Prime Minister's address to the Royal Society. The Secretary of State also mounted a vigorous defence of his policy towards the Energy Efficiency Office (EEO). He claimed that cuts had fallen on wasteful expenditure, for example on advertising and subsidised studies, while other programmes were being expanded and better targeted.[332] However, the budget of the EEO has been cut drastically, is planned to be cut further,[333] and there seems to be a misplaced complacency that consumers are "now well aware of the case for energy efficiency".[334]. The House of Lords Select Committee on the European Communities has

[324] COM(88) 656 final p. 24.
[325] *Ibid.* p. 53.
[326] Environment Council 8–9 June 1989.
[327] *Ev.* p. 29.
[328] *Ev.* p. 11.
[329] *Ev.* p. 46.
[330] *Min. of Ev.* p. 129.
[331] The second and third most important were fuel switching and nuclear power, offering 12 per cent and 11 per cent of the necessary savings respectively: ACE, p. 143.
[332] Q.514.
[333] See QQ.161–181.
[334] Cm 606 para. 31.

expressed its concern about these matters,[335] and we have dealt with them in a recent Report.[336] There we call for an explanation from Government of the effect which the cuts in funding for the EEO will have on their own targets, expressed by the then Secretary of State as a 20 per cent reduction on 1984 consumption or by the Prime Minister in 1986 as £7 billion per annum. We also make the point that spending less money by itself does nothing to achieve cost-effectiveness. **We believe that the apparent relegation of energy efficiency initiatives in the Department's priorities indicates a misjudgment both of the evidence and of the analysis of this issue.**

105. No country can afford to be complacent. Some of our witnesses argued that, by international standards, our achievements and ambitions in energy efficiency do not appear to rank very highly. The Open University[337] saw it as an organisational rather than a technical problem, and noted that "other countries, such as Sweden, Canada, Denmark and the USA, are pursuing policies of energy and CO_2 reduction with considerable success." ACE told us that "UK building standards are still low compared to other countries",[338] and asserted that "we are still well down the bottom of the energy efficiency league".[339] They took the view that "the UK's poor performance on energy efficiency puts us at an economic disadvantage to such countries as West Germany, Sweden and Japan. [Even the] USA is at a $200 billion disadvantage to Japan as a result of a poorer energy efficiency performance".[340] FoE also observed that "Japan is one of the most energy efficient industrialised nations in the world" and pointed to the fact that Japanese energy intensity (the relationship between GNP and energy consumption) "is about 49 per cent better than ours".[341] The UKAEA[342] similarly noted that "in terms of energy efficiency (expressed as GDP per unit of energy used) the UK is better than the USA but is a little below the European average and well below Japan." As far as Japan is concerned, the Secretary of State reminded us that its energy prices were twice as high as the UK's.[343] The Committee is aware that Japan's energy conservation efforts have indeed produced excellent results. In real terms, energy consumption per unit of GNP has improved by more than 30% since 1973, and notably by over 20 per cent since the second oil crisis in 1979. Our attention was drawn to two remarkable charts published in the 1988 report of Japan's Energy Conservation Centre. These demonstrate that a complex and developed energy conservation policy in Japan has been matched by a well thought out development schedule for conservation R&D.[344] They provide a remarkable illustration of the thinking and policy behind an outstandingly successful example in this field.

106. IEA statistics with which we were provided by the Government demonstrate that the UK has improved its energy intensity since 1973 at a rate higher than all other IEA states except Japan, the USA and the unusual case of Luxembourg. However British energy intensity is only at the European average, and countries like Japan, Denmark, Italy and Switzerland are markedly better. This is demonstrated in Table 25. We were also told by the Government[345] that between 1983 and 1987, UK energy intensity fell by 7 per cent—a rate of improvement twice the EC average. All these figures are extremely useful, but they should be treated with some circumspection both by those who wish to praise and those who wish to condemn the British record. Figures for energy intensity reflect structual changes in economies and fuel substitution as well as improvements in energy efficiency. It is in fact very difficult to make accurate assessments of countries' comparative performance. What is clear from the example of Japan is that it is possible to do much better than the United Kingdom.

---

[335] Eighth Report, Session 1988–89, *Efficiency of Electricity Use*, HL 37.

[336] Fourth Report from the Energy Committee, Session 1988–89, *The Department of Energy's Spending Plans: 1989–90*, HC 435, paras. 22 ff.

[337] *Ev.* pp. 122–127.

[338] ACE, *Min. of Ev.* p. 124; see Figures 5 and 6, pp. 125 and 126.

[339] Q.481.

[340] ACE *Ev.* p. 9.

[341] Q.488.

[342] *Ev.* p. 103.

[343] Q.510.

[344] Copies of these charts are available in the Library. They may also be obtained from The Energy Conservation Center, Japan, 39–3, Nishi-Shinbashi 2-chome, Minato-Ku, Tokyo 105, Japan (Phone (03) 433–0311).

[345] *Min. of Ev.* p. 160 and QQ.510, 520.

TABLE 25

Total Primary Energy Requirement in relation to GDP for all IEA countries[1]

	1973	*1979*	*1985*	*1986*	*1987*	*Average Ann Growth Rates (%) 1973–87*
Canada	0.77	0.74	0.67	0.65	0.64	−1.3
United States	0.59	0.55	0.45	0.44	0.44	−2.1
North America	0.60	0.57	0.47	0.46	0.46	−2.0
Australia	0.52	0.53	0.48	0.48	0.48	−0.6
Japan	0.39	0.35	0.28	0.27	0.26	−2.8
New Zealand	0.48	0.55	0.60	0.59	0.63	1.8
Pacific	0.41	0.37	0.30	0.30	0.29	−2.4
Austria	0.49	0.46	0.43	0.42	0.44	−0.8
Belgium	0.72	0.66	0.54	0.55	0.55	−2.0
Denmark	0.43	0.41	0.34	0.33	0.34	−1.8
Germany	0.53	0.50	0.43	0.43	0.42	−1.6
Greece	0.51	0.54	0.57	0.53	0.57	0.8
Ireland	0.59	0.56	0.49	0.53	0.50	−1.1
Italy	0.42	0.39	0.33	0.33	0.33	−1.7
Luxembourg	1.69	1.31	0.93	0.88	0.85	−4.8
Netherlands	0.62	0.59	0.49	0.50	0.51	−1.5
Norway	0.56	0.52	0.46	0.46	0.46	−1.3
Portugal	0.52	0.61	0.62	0.63	0.62	1.2
Spain	0.42	0.48	0.46	0.45	0.43	0.1
Sweden	0.59	0.57	0.55	0.55	0.54	−0.5
Switzerland	0.28	0.29	0.29	0.29	0.28	0.2
Turkey	0.79	0.77	0.78	0.77	0.80	0.1
United Kingdom	**0.57**	**0.52**	**0.45**	**0.44**	**0.43**	**−2.0**
Europe	0.52	0.49	0.44	0.43	0.43	−1.3
IEA Total	0.55	0.51	0.43	0.42	0.42	−1.9

(1) Measured in toe per $1000 of GDP at 1985 prices and exchange rates: intensities reflect the combined effects of efficiency improvements, structural changes and fuel substitution.

Sources: Energy Balances of OECD Countries:
OECD Main Economic Indicators

107. It would therefore be unfair to dismiss the Government's commitment to the central role of the market in promoting the scale and the type of energy efficiency investments as of no value. There can be no doubt that higher prices after the 1973/74 and 1979/80 oil price shocks stimulated major increments in energy efficiency investment activity, particularly in the case of large energy users such as 'heavy' manufacturing industry. It is equally apparent, however, that there are major imperfections in the markets for energy efficiency goods and services. At the Prime Minister's seminar on 26 April, Dr Currie of ETSU took the view[346] that 'in the absence of further shocks, it is difficult to see how the market by itself, even lubricated by the EEO, will reduce energy consumption.' The director of ACE, with the benefit of a detailed knowledge of the energy efficiency industry's own experience in the market place, told us that 'what appear to be perfectly rational investments showing very swift rates of return are not taking place. The market is unfortunately not working...'.[347] This is not unique to Britain. The Environmental Protection Agency of the United States recently reported to Congress that 'many energy efficiency measures are cost-effective, but a number of institutional barriers and market failures would need to be overcome to facilitate their adoption'.[348] **The evidence received by the Committee overwhelmingly endorses the view that, for a variety of reasons, serious market imperfections persist in the energy efficiency field and, as a consequence, widespread opportunities to invest profitably in cost-effective measures to improve the efficiency of energy conversion and use are being ignored.**

108. The principal reasons for these market imperfections and the barriers to the full exploitation of the economic potential of energy efficiency improvements were listed by

[346] *Op. cit.* p. 7 (see footnote 322).
[347] QQ.454 and 480.
[348] ACE, *Min. of Ev.* p. 133.

ACE.[349] A recent, EC funded report on the potential for energy conservation measures in the North West of England[350] showed that the potential to improve energy efficiency there is not being realised—and concluded that this was the result of the lack of information, the lack of access to investment capital, the lack of advice and the lack of confidence in new technologies.[351] Explanation of the failure to take advantage of cost-effective energy efficiency measures was reduced to four generalisations by Dr Currie:[352] he noted that despite 'the great technical and economic potential for improved efficiency... it is very difficult to make it happen' because:

* it requires a very large number of small and disaggregated actions
* these are peripheral to the (main) interests of most consumers
* the most cost-effective opportunities are limited because of the slow turnover in equipment, and especially in buildings
* all this is exacerbated by a number of market imperfections, such as the lack of specific and unbiased information for users.

109. Many of the observations that we have made in our previous reports concerning the persistent misallocation of capital resources in favour of more energy supply and to the neglect of demand management and contraints remain no less valid today.[353] We stress once again, therefore, that the formation of policies the Government cannot afford to ignore the widespread lack of user information and appropriate technical skills to take advantage of beneficial efficiency investments. The frequent lack of finance for such investments, and the consequences of a general separation of responsibilities for energy supply expenditure on the one hand and conservation investments on the other, are facts of life—and, sadly, they are exemplified by the poor record of the public sector. Moreover, policies must acknowledge the vivid contrast between the multiplicity of independent decision makers that should be responsible for energy conservation investments and the centralised and hierarchical structures that are responsible for assessing and implementing further supply provision.

110. A relatively new obstacle to the improvement of energy efficiency was drawn to the Committee's attention during the course of the inquiry.[354]. This is the tariff structure of BG. Some 1500 customers (no doubt covering many more sites) using between 23101 therms and 25000 therms per annum are all in the quixotic position of finding that if they used more gas they would pay less, while customers using over 25,000 therms have no incentive to reduce their demand below this figure because they would then be paying more. The problem is that there is no taper from the standard tariff to the contract tariff, which begins at 25,000 therms. Although BG is obliged under the Gas Act 1986 and its licence to encourage the efficient use of gas, its tariff structure is currently working against such an objective. Evidence we received from BG[355] explained that there were always problems where there was a price/quantity threshold; that the amount of gas consumption affected was small and that they had no evidence that the tariff structure was causing unnecessary gas burning. However, they were also looking at "what possibilities, if any, there might be to rectify the situation". We believe that the situation needs urgent attention and this should be an early task of both BG and the Director General of Gas Suppy whose responsibilities include the promotion of "the efficient use of gas supplies through pipes".[356] **We recommend that the anomaly in the gas tariff structure be reviewed at the earliest opportunity to eliminate any disincentives to improvements in energy efficiency.**

3. What Government Should Do

111. Baroness Hooper[357] took the view that "the advantages of energy efficiency are so real and manifest that a programme to encourage voluntary compliance is the most

[349] *Ev.* p. 8.
[350] *Energy Study of the North West Region of the UK.* March Consulting Group, December 1987.
[351] Q.479; ACE, *Min. of Ev.* p. 133 and Figure 16, p. 135.
[352] *Op cit.* p. 7 (see footnote 322).
[353] Fifth Report from the Energy Committee, Session 1981–82, *Energy Conservation in Buildings*, HC 401 and Eighth Report, Session 1984–85, *The Energy Efficiency Office*, HC 87.
[354] See Memoranda 23 and 24 from Major Energy Users' Council and British Gas.
[355] *Ev.* pp. 156–157.
[356] 1986 Gas Act, Cl 4(2)(b)
[357] Q.173.

effective". We have to disagree. We have been left in no doubt that, **if the Government is to respond swiftly and effectively to the threat of global warming, it will have to review most carefully its strategy towards the encouragement and promotion of energy efficiency—in both the public and private sectors of the economy—and will have to adopt a much higher profile and pro-active stance.** As the CEGB[358] observed: "significant reductions in (energy) consumption would require direct or indirect intervention by Government across all forms of energy use, whether by regulation, pricing or subsidy". We recognise that these procedures may cause greater difficulties for Government after privatisation.

112. Government must first of all be seen more visibly to be putting its own house in order. As our recent Report on the Department's Spending Plans[359] has argued, any new initiative in the public sector, like that announced by the Secretary of State on 15 January,[360] is to be welcomed, but must consist of more than rhetoric. In our Report we have recommended a number of measures which will give the public sector initiative more teeth. We welcome the Secretary of State's announcement (made after our earlier Report had been agreed) that energy efficiency in Government should be directly coupled with the Public Expenditure Survey round.[361] This parallels our own recommendation that energy savings should be recorded in each Department's volume of the Public Expenditure White Paper. Our observations apply not only to central and local government but also to many public services and public agencies as well. Effective management initiatives are clearly required.

113. With regard to the private sector, we acknowledge that the EEO, administering a carefully designed programme to expose and offset market barriers, could well have achieved better value for money than efforts in many other countries.[362] However, a higher profile and bolder initiatives will be required of the EEO and of the Government more generally in the future. The Secretary of State would clearly like to rely on persuasion to achieve energy efficiency.[363] While persuasion is important we believe the Government needs to go further. **A mixture of regulation, penalties and incentives—all designed to ensure a rising level of energy efficiency in the UK—is clearly required.** The Secretary of State told us that the Government did "lubricate" the market.[364] We favour the application of rather more lubrication than at present.

114. In several areas of energy use, witnesses urged upon the Committee the necessity for Government to define and promulgate new *regulations* or standards as the only means whereby further energy savings might be captured with reasonable certainty. The Secretary of State mentioned the new building regulations which have recently been published and which will have a gradual effect on the energy efficiency of the building stock.[365] They will increase required levels of energy efficiency in new buildings by 20 per cent.[366] However, agreement on these new regulations has taken a considerable time to achieve, and the standards they set are below those used elsewhere, particularly in Scandinavia. For example, the new regulations will not provide for mandatory double or triple glazing in new properties.

115. Mandatory labelling of appliances and domestic buildings was again urged upon us by ACE and FoE.[367] It has been apparent for many years that there is an extreme variation in the energy efficiency of goods. The average electricity consumption of refrigerator/freezers bought in the UK, for example, is 2.5 kWh/litre. This is more than double the consumption figures of the best commercially available fridge/freezer and five times that of prototypes being developed in Denmark.[368] The Committee's attention was drawn to the elaborate and

[358] *Ev.* p. 29.
[359] Fourth Report from the Energy Committee, Session 1988–89, *The Department of Energy's Spending Plans: 1989–90*, HC 435.
[360] *Ev.* p. 36; Q.168.
[361] Q.551.
[362] *Op. cit.* p. 7 (see footnote 322).
[363] Q.512.
[364] Q.519.
[365] Q.521.
[366] Q.173.
[367] *Ev.* pp. 8 and 52; Q.502.
[368] House of Lords Select Committee on the European Communities, Eighth Report, Session 1988–89, *Efficiency of Electricity Use*, HL 37, *Ev.* p. 70.

potentially very influential 1987 National Energy Conservation (Appliances) Act in the United States, which sets down strict minimum energy efficiency standards for a wide range of products—and could well require design changes to between an estimated 70 and 90 per cent of the appliances on sale in that country in 1987.[369] It is also clear that people buy and sell housing with little knowledge of the energy efficiency of the building involved. The EC has been considering draft directives on labelling of appliances and on energy information in buildings for some years.[370] The Secretary of State in his evidence drew our attention to the voluntary appliance labelling scheme which is soon to be implemented throughout the EC, and he outlined his objections to making an energy efficiency survey mandatory before houses could be bought and sold.[371] There has been an unconscionable delay in bringing workable labelling schemes forward either for appliances or buildings—they were being considered by the Department at least as early as 1982.[372] We accept that much can be done voluntarily—by convincing estate agents to make low energy consumption a factor in their advertising, for example. However, a properly designed mandatory system could have more teeth than the voluntary measures so far taken. In effect, an inefficient appliance or house would carry a "health warning". A robust approach to labelling may be one of the simplest methods of achieving energy savings and **we believe that a standard, uniform and mandatory labelling system for appliances and domestic buildings should now be introduced by the EC.**

116. One specific regulatory measure to promote energy efficiency has been inserted into the Electricity Bill by the House of Lords. The new Clause would allow the Secretary of State in consultation with the Director of Electricity Supply to require distribution companies to take specific action to promote energy efficiency and, "if appropriate, may refuse or amend any application for tariff increases or major capital projects". We support the spirit of this Amendment. It is the subject of a separate Report which we are making urgently.[373]

117. We understand the deep-seated reluctance of the Government to promulgate more regulations in our society. The fact remains, however, that in some areas the best interests of the community as a whole can only be served through their existence and firm implementation. Speed limits on roads, safety belts in cars and compulsory tests for older vehicles, are three widely accepted instances. In the energy market, safety regulations are as commonplace as they are essential, and an EC flue gas desulphurisation programme has been imposed upon the electricity supply industry and other large combustion plants. **If the contribution of improved energy efficiency to the reduction of CO_2 emissions is to be seriously and sensibly exploited, Government simply cannot turn its back in principle on the need to establish new energy efficiency standards, and to impose them through appropriate regulatory arrangements.** The alternative route of relying substantially upon voluntary codes of conduct is unlikely to succeed. Greenpeace[374] drew our attention to a telling international comparison of official policies on the greenhouse gas CFC113: in Sweden the gas is being phased out through legislation by 1991; in the UK, in contrast, where a voluntary approach is being used, an electronics magazine recently revealed, according to Greenpeace, that two-thirds of UK manufacturers intend to continue using CFC113 until the end of the century.

118. In the past, the Government has occasionally used financial *incentives* to stimulate investment in energy efficiency measures. Loft insulation grants and financial support for energy surveys are but two. Clearly there are always circumstances in which such public assistance simply helps a private individual or a company to do what they would have done in any case. In other instances, however, there is evidence that incentives bring forward a significant scale of investments that would not otherwise have occurred. The Department itself has acknowledged that £30 of potential savings were achieved for every £1 of government money spent in the energy survey scheme.[375] ACE took the view that, in order to achieve a high level of energy savings and CO_2 reductions, "one has to put out carrots as well

[369] Q.110.
[370] *Ev.* p. 8.
[371] Q.521.
[372] HC Deb. 28 June 1982, col. 603.
[373] Fifth Report from the Energy Committee, Session 1988–89, *Electricity Bill: Lords Amendment on Efficient use of Electricity*, HC 478.
[374] Q.476.
[375] Cm 606 para. 32.

as sticks".[376] Their "technical fix" scenario, for example, assumed *inter alia* that a mixture of improved marketing and (public) incentives would allow gas condensing boilers to capture 90 per cent of the current domestic gas heating market by 2005.[377] Regular opportunities for improvements in energy efficiency will certainly occur as old boilers are replaced, but incentives may be necessary to encourage these opportunities to be grasped. Without incentives, many of the desired energy savings will not in fact be won. The scale of the incentives required in any segment of the energy market will obviously depend upon the rate of turnover of the appliance or building stock, the additional capital costs implied by the more energy efficient equipment, and of course the extent to which energy efficiency regulations pre-empt the need for incentives. **We recommend that the Government consider a package of incentives to encourage the installation of energy efficiency measures.**

119. There may also be scope for fiscal measures to stimulate investments in energy efficiency. We appreciate that the Treasury has endeavoured to neutralise the tax system and to remove tax breaks and concessions.[378] However, the fiscal system is used for socially desirable purposes: personal equity plans encourage investment in British equities, tobacco and alcohol are subject to duties and lead-free petrol is relieved from a proportion of the duty charged on petrol. We will later[379] propose some changes in the taxation of motor cars. A number of other measures might be possible. For example, allowing only, say, 90 per cent of a firm's energy costs to be allowable against tax while a tax allowance of, perhaps, 110 per cent is given for investment in energy efficiency equipment might encourage firms to look more closely at their energy bills. This could be particularly effective in companies where expenditure on energy is not a major part of outgoings and which are therefore less concerned than, say, the aluminium industry to cut demand.

120. Another type of Government action is the removal of measures and *subsidies* that currently and inadvertently encourage relatively high levels of energy use. A particular example is the way in which company car tax policy continues to encourage the purchase and subsidise the use of larger cars with their relatively high emissions of greenhouse gases, a subject with which we deal in the next section.

4. Fuel Use for Transport in the UK

121. Although we are not responsible for transport policy, we believe that high priority should be given to curbing the growth of CO_2 emissions in the transport sector.[380] Greenpeace told us that, on present trends, CO_2 emissions from vehicles will reach the present level of power station emissions by 2044.[381] The Government described for us the co-operation between the Departments of Energy and of Transport:[382] "in practical terms, the Energy Efficiency Office (EEO) provides a central resource of advice and background information which it uses to help other Departments to make informed policy decisions on matters within their areas of responsibility". When questioned, the Secretary of State appeared satisfied by co-ordination between his own Department and the Department of Transport.[383] However, we are by no means convinced that energy efficiency is a major concern of the Department of Transport where it forms a small part of the work of the Vehicle Standards and Engineering Division (which is also responsible for vehicle safety, speed limits and testing requirements). A classic obstacle to energy saving is that potential purchasers of energy efficiency equipment do not regard energy efficiency as the main purpose of their business and therefore tend to neglect it. The Department of Transport is in an analogous position. The fact that its primary concerns are far removed from energy efficiency is graphically illustrated by the recent Roads White Paper[384] which proposes new

[376] Q.479; *Ev.* p. 6.
[377] *Min. of Ev.* p. 124.
[378] QQ.519 and 553.
[379] See para. 123.
[380] We only concern ourselves here with CO_2 emissions. The NO_x and CO emissions can be captured by catalytic converters or ameliorated by lean burn engines. Which method to choose is a subject of political controversy, and one on which we have not taken comprehensive evidence. The Council of Ministers decided, however, on 9 June that catalytic converters should be fitted to all small cars from 1993. See HC Deb. 24 May 1989, cols. 1080–1100.
[381] *Ev.* p. 62.
[382] *Min. of Ev.* p. 46.
[383] Q.554.
[384] Cm 693.

road works costing around £6,600 million to cater for a forecast percentage increase in vehicle miles by 2025 of between 83 and 142 per cent without once mentioning energy efficiency. As the WWF told us, "transport policy does not seem to be looked at in respect to energy use".[385]

122. One approach to curbing transport emissions is to promote the development of new fuels. ETSU's paper for the No. 10 Seminar[386] produced the following analysis of the potential for reduced emissions:

TABLE 26

Potential for Reducing Emissions

Action	*Resulting reduced emissions per vehicle*
Diesel for petrol	up to 30 per cent
Gas for all vehicles	up to 45 per cent
Bio-alcohol for cars	100 per cent
Hydrogen for all vehicles	100 per cent } if electricity from non-fossil sources
Electric vehicles	100 per cent }

However, there are major problems before we see any of these fuels (except diesel) on our roads. BP stressed to us that there would necessarily be a long lead time before the infrastructure for the distribution of any new fuel was in place.[387] Moreover, hydrogen is not being even considered as a fuel by BP at present,[388] nor being researched by the Department of Energy.[389] There are also major outstanding technical problems about storage aboard the vehicle and a safe and publicly acceptable method of charging. As far as electric vehicles are concerned, even the Electricity Council, which has a financial stake in electric vehicles through its co-operation with Chloride Silent Power, only believes that "there are very good chances" of the necessary breakthrough in the next 20 years in battery technology which would allow widespread use of electric vehicles on roads.[390] This would involve the production of a battery capable of offering a 100 mile range. Although the majority of cars and smaller commercial vehicles cover less than this on most of their working days, to be limited to this range would, we suspect, make them generally unacceptable unless their prices were extremely low. The widespread provision of "recharging stations" offering anything like the rapidity of current petrol stations would also require substantial expenditure on reinforcing the electricity supply system. The development of bio-alcohol would also need a long lead time, though the technology is in common use in Brazil. Furthermore, the vegetable matter from which it is derived would need to be replanted or else bio-alcohol use would itself contribute to increasing atmospheric CO_2 concentrations.

123. Curbs on vehicle CO_2 emissions are thus more likely to be achieved by reducing the amount of fuel burnt. This will have the added advantage of reducing other noxious emissions like CO and NO_x. The most obvious way to do this is by increasing engine efficiency. However, in a helpful analysis, the Open University[391] demonstrated that while cars individually had become more efficient, there were more of them on the road, they were on average more powerful and they travelled faster. A range of policy options to reduce vehicle size and use were suggested to us, both by the Open University and WWF.[392] **We recommend that these options are given proper study by the Energy Efficiency Office and those whom they advise in the Department of Transport.** We have not looked at questions like the relative merits of support for public and for private transport or, for example, whether more goods could be moved by rail. However, as we have said elsewhere,[393] we believe that the fiscal system should be used to support environmental policies. For this reason, **we believe that the Government should continue its policy of removing tax incentives for company cars.**

[385] Q.454.
[386] 26 April 1989: paper submitted to the Committee by HMG, and placed in Library of the House.
[387] *Ev.* p. 12.
[388] Q.264.
[389] *Min. of Ev.* p. 50.
[390] Q.108.
[391] *Ev.* pp. 136–142.
[392] *Ev.* p. 113.
[393] See para. 119.

These have tended to increase engine capacities and reduce public transport use while costing the taxpayer perhaps £1,000 million a year.[394] **We also recommend that vehicle taxation be related to energy efficiency**, a proposal supported by the Open University and WWF, and also endorsed by BP.[395]

124. Although we have dealt in the previous paragraphs with road transport, we understand that 2.5 per cent of annual CO_2 emissions result from air transport.[396] There are unresolved questions about the effects on the atmosphere of the burning of aviation fuel at high altitude.[397] **We recommend that the NERC institute a study of this question as a matter of some urgency**, especially since aircraft travel ranks with commuting by car so far as fuel use per passenger kilometre is concerned.[398]

5. Increased Efficiency of Supply—the potential of Combined Heat and Power (CHP)

125. Our remarks to this point have largely been concerned with the efficiency of energy in its end-uses. Other major inefficiencies occur in production and conversion of energy. Road transport apart, practically all the energy demanded by final consumers is in the form of low-temperature heat for space and process heating, or for electricity. Fossil fuelled boilers and power stations are mature technologies whose efficiencies have been improved steadily since around the turn of the century in response to competitors and changing energy prices. We have already referred to the great efficiencies which have been achieved in gas boilers[399] and to the potential for more efficient burning of coal.[400]

126. Unlike the new technologies for gas and coal burning, CHP technologies use well-proven equipment and offer reductions in CO_2 production as great or greater. Figures provided by BP[401] show, for example, that compared with a conventional 5 MW plant, the CHP based alternative would raise overall plant efficiency from 35 per cent to 85 per cent, leading to an annual reduction of CO_2 emissions of more than 20,000 tonnes. The UK lags seriously behind many other countries in the installation of CHP plant and in earlier reports the Committee has repeatedly exhorted the government to take effective action to encourage its wider use. If, in the interests of CO_2 abatement, part of our limited supply of gas is to be diverted for the production of electricity it would make good sense to restrict its use to CHP plants and perhaps prescribe qualifying efficiencies as has been done in the USA for several years.

127. The CEGB informed the Committee that "a gas-fired CHP scheme should have an overall energy utilisation efficiency of about 80 per cent[402] and that "the emission abatement from CHP would occur across several energy sectors, as the heat produced would displace other fossil fuel sources".[403] FoE also highlighted the importance of CHP in achieving reduced CO_2 emission and the additional benefits to be derived from a switch from coal to gas stating that "each GWe of installed coal-fired CHP can be expected to reduce overall CO_2 emissions in the energy sector by around three Mt/annum, while every GWe of gas-fired CHP can be expected to reduce overall emission by around six Mt/annum.[404]

128. Estimates of the feasible savings in CO_2 production up to the year 2020 due to CHP vary widely. Dr Ken Currie of ETSU, in his paper to the Prime Minister's Seminar, suggests up to two per cent of his target of 130 million tonnes, ie 9.5 million tonnes CO_2 per annum could be saved by "more CHP in industry and services". In addition, there could be savings from city-wide CHP applications in combination with district heating (DH). The Electricity Council[405] suggests that the savings of 15–20 million tonnes of CO_2 per annum could be

[394] Q.494; *Ev.* p. 140.
[395] QQ.284–285; *Ev.* pp. 141 and 113.
[396] BP footnote to Q.291.
[397] Q.289.
[398] WWF, *Ev.* p. 112.
[399] See para. 65.
[400] See paras. 94–101.
[401] Supplementary answers Q.266.
[402] *Ev.* p. 28.
[403] *Ibid.*
[404] *Ev.* p. 46.
[405] *Min. of Ev.* p. 32.

saved by 2020 through CHP/DH. FoE quote a Department of Energy figure of a seven GWe saving: this would correspond to a reduction of 20–40 million tonnes of CO_2 per annum depending on the fuel mix.[406] The CHP Association argue that "the total, technically feasible reduction in CO_2 emissions is 30 per cent, though other market influences could reduce this to around a 10–15 per cent contribution".[407]

129. The Committee welcomes the fact that a number of the institutional and political obstacles which for many years have blocked the exploitation of CHP schemes are beginning to fall away.[408] Although progress is being made in the first instance mainly with smaller scale market opportunities, with generation capacities ranging from 4 MWe to 40 MWe, we hope that further progress can soon be made with larger installations as well. The enactment of the 1989 Electricity Bill, together with the Government's moves to ensure rate equalisation for CHP operators and electricity generators, should expedite the more widespread adoption of a technology that can now be seen to have distinct environmental as well as economic advantages. Further helpful measures, as suggested for example by the Open University[409] and the CHP Association[410] should also be given serious consideration by Government.

6. The Economics of Efficiency

130. Whilst we have argued that new regulations and incentives and an end to subsidies that encourage the wasteful use of energy can together lead to a more energy-efficient society, it must not be overlooked that, for a decade or more, most energy efficiency investments are likely to be inherently economic, paying back their capital costs over a matter of only a few years through reduced energy bills. The most comprehensive insights that we received into the enonomics of alternative measures to improve the energy efficiency of buildings were provided by ACE,[411] derived in part from earlier work by the Building Research Establishment (BRE).[412] All of the control systems, lighting and insulation measures recommended by BRE had attractive paybacks. We note with interest the observation of the Environmental Protection Agency in the United States that "in contrast to the common notion that limiting global warming would require great sacrifices we find that many of the policy options that are available for reducing greenhouse gas emissions appear already to be attractive in many respects".[413]

131. Our attention was drawn to the notion of a "Conservation Supply Curve" as a means of assessing the potential of energy efficiency investments at different levels of cost.[414] The curve is derived from data which describe in energy cost terms (£/coal equivalent tonne, or pence/kWh) the cumulative amount of energy that could be saved in an economy through the introduction of energy efficiency measures.[415] Such curves have been developed for the industrial sector of the Ontario economy, and for the electricity sector in the United States. Developed for the UK, they could be of considerable value to the Department of Energy, the Director General of Electricity Supply and the prospective electricity utilities with their statutory obligations to promote the efficient use of electricity. **We recommend that the Department, possibly through ETSU, ensure that the methodology for developing conservation supply curves is advanced, and their potential for guiding energy policies and the utility regulators is fully explored.**

7. Conservation not just Efficiency?

132. The wide spectrum of end uses and the different categories of users and associated

[406] *Ev.* p. 46.
[407] *Ev.* p. 151.
[408] CHPA, *Ev.* p. 151.
[409] *Ev.* pp. 122–127.
[410] *Ev.* pp. 151–152.
[411] *Min. of Ev.* pp. 130 ff.
[412] J. Pezzy, *An Economic Assessment of Some Energy Conservation Measures in Housing and other Buildings*, DOE, 1984.
[413] Q.483.
[414] ACE, *Min. of Ev.* p. 132.
[415] *Ibid.* pp. 139 and 140.

investment appraisal methods (including those of personal taste or prestige) make it difficult for governments to play an effective role as educators or to regulate simply and effectively: this difficulty was recognised during the energy crisis of the 1970s. At that time the sudden shock to consumers given by the rapid escalation of fuel prices and the expectations of insecure future supplies acted as an additional stimulus to increased user efficiency and conservation. In taking timely action to improve end use efficiency in the future, those responsible will need to recognise what could be described as a moral imperative: unless the world produces less pollution it is likely to suffer grave and unpredictable consequences. It is not just a question of economics: conservation of energy is a matter of proper and responsible husbandry of scarce resources. The shock of the greenhouse effect should change the moral climate in favour of energy conservation as the oil shock of the early 1970s changed the economic climate. Every person, to a greater or lesser extent, has an opportunity to contribute by altering the pattern of his or her energy use. This was recognised by the EC Council of Ministers[416] who spoke of "involving the contribution of every citizen" in combatting global warming. We are delighted that this is recognised by the Government, and we warmly endorse the Secretary of State's words: **"these are finite resources we are using up and the more we can conserve them and the less we can waste them, the better."**[417]

E. THE MARKET

133. In the previous two sections we have advocated a number of ways that Government should influence the energy market. There is no such thing as the pure free market or the absolutely level playing field. Every form of taxation or subsidy or special protection disturbs the market: the activities of OPEC, the widespread government support for nuclear power or indigenous energy sources and taxation policies on petroleum products are all examples.

134. Our witnesses were virtually unanimous in conceding that **market mechanisms unaided would not produce an adequate response to global warming.** From the FoE, Greenpeace, WWF and ACE to the CEGB, BP and UKAEA[418] this view was held. As the Electricity Council told us, many of the choices ahead will not be natural ones to follow in the free market.[419] This is not to say that market forces will have no part to play: as we have described, it already makes commercial sense to install equipment which uses energy efficiently. A number of very successful energy management companies have been established to exploit this potential in the industrial and commercial markets. Furthermore, as the "green consciousness" in Britain grows, so producers of goods like refrigerators and freezers will wish to promote their products by showing how much more efficient they are than those of their rivals, while consumers will more often exercise choices on environmental as well as economic grounds. However, as we have explained in the section on energy efficiency, we should like to see these market forces in favour of moderating demand fortified by the fiscal system, regulatory measures and incentives.

135. As far as global warming is concerned, there is a further classic problem for those seeking to rely on simple market forces—the allocation of external costs. How does one quantify the effects of greenhouse emissions and how does one then attribute those costs to the originators of the emissions? The US Environmental Protection Agency has observed that the "current market prices of fossil fuels do not reflect the risk of climatic change and provide no assurance that limiting greenhouse gases will be a consideration in purchase and investment decisions".[420] As one of our witnesses told us "the cost of polluting the environment is not recognised by the market mechanism",[421] or as FoE said "we do not have any system for costing environmental costs", nor any agreed means of deciding how one environmental disbenefit rates against another.[422] For example, how many times worse than

[416] Environment Council 8–9 June 1989.
[417] Q.520.
[418] QQ.480, 27, 217, 267–8, 377, 392.
[419] Q.130.
[420] ACE, *Min. of Ev.* p. 133.
[421] Institution of Electrical Engineers, unpublished evidence.
[422] Q.504.

200 unsightly windmills is the radioactive product of a nuclear power station or the CO_2 emissions of one coal-fired station? We note that one EC-sponsored study[423] suggests that, taking into account their externalities, coal and nuclear electricity costs and prices in West Germany should be increased by 50 to 110 per cent, a move which would improve the relative economics of wind and solar power with their beneficial absence of greenhouse gases.

136. Greenpeace urged us to press the Government to take the external cost of energy options into consideration in planning.[424] We understand that the Government accepts the principle of "polluter pays" and that Lord Caithness told the Toronto conference that there is a need to reflect the external costs of energy production in energy prices.[425] In a recent pamphlet,[426] the Secretary of State for the Environment has said that "it is an essential part of the free market philosophy that regulation by government is necessary to secure the public interest in environmental protection". We were delighted that the Department of Energy's Chief Scientist's Group is exploring ways of taking into account the environmental costs and benefits of renewable technologies. We appreciate that "this is not an easy thing to do",[427] although important academic studies in this area are now being published.[428] However, **we recommend that the environmental costs and benefits of all energy technologies should be at the forefront of the Department's thinking in the future, and we invite the Department to propose methods by which this may be done in their response to this Report.**

137. It will necessarily be the Government's role to impose these environmental considerations upon the energy producers. They will naturally wish to market their product at the greatest profit to themselves and will choose the form of generation which maximises their return rather than securing the greatest reduction in greenhouse gases.[429] They will have the freedom to do so: as the Secretary of State said, "people who want to go into generation will have to choose for themselves their fuels and their technologies".[430] We agree with the Secretary of State that market pressures will encourage electricity generators to behave efficiently,[431] but some fuels burnt very efficiently still produce more CO_2 than other fuels burnt very inefficiently. The Electricity Bill has already demonstrated that the government is prepared to interfere on public policy grounds with the electricity companies' freedom to decide on the means of generation they will use. The non-fossil fuel requirement of the Bill (described by the CEGB as introduced because "the Government perceived that the market mechanism would not bring about the Government-declared policy"[432]) is justified on grounds of the need to secure diversity of supply.[433]

138. **The Committee believes that the public interest now requires the Government to encourage the electricity industry incrementally to invest in all energy production systems which reduce greenhouse gas emissions.** We agree with the SSEB that "any utility's investment in nuclear energy or indeed wind or tidal energy or any other capital intensive project . . . will depend on regulation".[434] **We also believe that the Government should again study the recommendation we made in our earlier Report[435] that energy saving might be included in the non-fossil fuel component of electricity supply.** By this we mean that electricity distribution companies which can demontrate that they have cut demand by the promotion and sale of energy efficiency equipment should be allowed to count the consequent drop in demand towards their non-fossil fuel quota. We also believe that **something akin to the non-fossil fuel requirement must be introduced to secure the full take-up of the potential of CHP:**

---

[423] Olav Hohmeyer, *The Social Costs of Energy Consumption*, Springer-Verlag, 1988.
[424] *Ev.* p. 55.
[425] *Min. of Ev.* p. 133.
[426] *Policies against Pollution*, Centre for Policy Studies, 1989.
[427] Q.204.
[428] See, for example, *Environmental Policy Benefits: Monetary Valuation*, OECD, Paris 1989.
[429] See, for example, CEGB, Q.87; *Min. of Ev.* p. 17 and SSEB, *Ev.* p. 88.
[430] Q.529.
[431] QQ.519, 530.
[432] Q.28.
[433] See Third Special Report from the Energy Committee (Session 1987–88), *Government Observations on the Third Report from the Committee (Session 1987–88) on the Structure, Regulation and Economic Consequences of Electricity Supply in the Private Sector*, HC 701, p. ix.
[434] *Ev.* p. 88.
[435] Third Report from the Energy Committee (Session 1987–88) *The Structure, Regulation and Economic Consequences of Electricity Supply in the Private Sector*, HC 307-I, para. 99.

the CEGB recognised that some interference in the market would be necessary if this is to happen.[436]

139. A further proposal canvassed in evidence to us was the so-called "carbon tax". This might be a 10 or 15 per cent discriminatory tax placed on those forms of primary energy that emit greenhouse gases, in part to mirror their external costs. Such a cost penalty would sensibly differentiate between the several fossil fuels according to the scale of their carbon emissions in use, and would be likely to encourage some fuel switching both between themselves and towards non-fossil sources of energy. The most positive attitude to such a tax came from the CEGB. Their witness believed "it was a matter that ought to be examined"; that "it should be applied across the whole energy piece"; that the money raised should be used "towards the solution of the problem" and that the tax should be looked at "in the total European context".[437] Although BC did not regard a carbon tax as practical, they made a number of similar points, in particular that any tax should be international in scope and that it "has to be even-handed between the fuels".[438]

140. Baroness Hooper told us that the Government had no plans to introduce such a tax.[439] The Secretary of State opposed a unilateral tax, but recognised that an international tax was worth discussing.[440] We appreciate that there are very great difficulties with the idea. First, we agree with the Secretary of State and other witnesses that a tax would need to be international to be effective, and then might be impossible to administer.[441] Even if there were an independent agency to administer it as the TUC suggested,[442] some countries might evade their obligations. Any tax which applied world-wide would also bite particularly hard on developing countries and, even within the EC, would have a lesser effect on rich countries like West Germany compared with, say, Greece and Portugal. Moreover, a tax on carbon alone would unfairly benefit some countries. The Electricity Council[443] warned that "if we are to have such a tax on, say, coal, oil and to a lesser extent gas, in this country, then we are going to have in electrical terms a disadvantage that the French and the Dutch do not have". CO_2 is not the only environmental problem: the nuclear industry brings its own special hazards, and these ought to be reflected in any energy tax also.

141. We believe that, rather than consider a tax on carbon production, **the EC should examine urgently the feasibility of fiscal measures which would reflect the costs of global pollution caused by energy production of all types.** This we regard as one of the most important recommendations of our Report. **We also recommend that the EC consider devoting the revenue from such fiscal measures to energy efficiency investment in the Community.** We would want any measures to reflect the transboundary and global costs of energy production rather than those which are specific to the state where they are levied. Thus, the environmental problems of a scheme like the Severn Barrage would not be subject to any international tax because these problems are domestic in nature. We do not doubt that this type of fiscal measure would be difficult to administer and that while there is some prospect of agreement and implementation within the EC, it would need eventually to apply world-wide. No doubt some nations would be reluctant to impose it. However, we believe that the developed world must take the first step.

F. CONCLUSIONS: THE INSURANCE POLICY—WHAT PREMIUM?

142. Our review of the possible responses to the phenomenon of global warming has revealed an array of energy and non-energy policies that could provide, at different speeds and over different time-scales, significant ameliorative effects. In some cases, notably many energy efficiency investments, these benefits can be achieved without net costs. As the Secretary of State told us, "many of the steps that can be taken to reduce CO_2 emissions are

[436] Q.64.
[437] Q.37.
[438] Q.350.
[439] Q.151.
[440] Q.553.
[441] Q.218.
[442] *Ev*, p. 95.
[443] Q.98.

justifiable in themselves. If they do, as a result, contribute to the reduction in global warming, that is an additional bonus".[444] However, in most cases, the energy policy options would carry a cost. How much should we as a society decide to pay?

143. First, it is unquestionably short-sighted of the UK to neglect those energy efficiency investments which yield a genuine economic return. Such a neglect places our industry and commerce at an unnecessary competitive disadvantage by comparison with many of our key industrial competitors. It diverts into energy production, transport and use financial resources that could better serve alternative economic or social goals. It slows the development of technologies and expertise that could well have a substantial world market potential.[445] And, to the extent that such energy provision relies upon fossil fuels, it exacerbates a number of environmental problems, not least that of global warming. The issue, therefore, is not whether these measures and investments make sense. Rather it is how far concerns about global warming should encourage Government to go beyond whatever actions are justified on broadly economic criteria.

144. We believe that it is clear that a combination of new regulations and incentives need to be deployed to promote with greater vigour the more efficient use of energy and to prevent the waste of relatively scarce resources. Simultaneously any existing Government measures or subsidies that tend to encourage an extravagant and undesirable use of energy should be set aside. The new regulations and incentives would have their immediate costs for Government and others—but these costs would be small by comparison with the economic and social benefits that in due course would flow in return. In addition, of course, a major but as yet unquantified benefit would be won in the form of major reduction in CO_2 emissions.

145. Beyond this, an even greater reduction of greenhouse gases could be secured with yet further, but nevertheless arguably still justifiable, costs to both Government and energy users. Amongst possible policies could be the encouragement of some fuel switching to lower or non-CO_2 emitting fuels. Measures might include a discriminatory tax placed on all forms of primary energy production to reflect their international environmental costs such as we discussed earlier,[446] or a fuller use of measures such as the non-fossil fuel requirement of the Electricity Bill to encourage the provision of more nuclear energy or clean coal technology or renewable sources of energy, such as geothermal, wind or tidal power. Further CO_2 reductions could be bought through the support of those energy efficiency investments that have particularly long pay-back periods, or policies to secure the full capture of methane from landfill sites and measures that would restrain the growth in the consumption of transport fuels. Outside the energy sphere, programmes to ensure the acceleration of both temperate and tropical reforestation could be pursued. All these policies would reflect society's preference for what are judged to be environmentally safer or more attractive sources of energy. They are the necessary cost of reducing the risks of global warming.

146. Over the long-term, even more expensive penalties and subsidies could be formulated and introduced—but there is little point in embarking upon them today when abundant, economically beneficial and low cost responses to global warming are readily available. However, these longer-term possibilities must be given proper study, and steps must be taken now to ensure that they can be implemented on a global scale if the scientific evidence shows them to be necessary. **It would be inexcusable if pusillanimity and the inability of the governments of the world to plan long-term allowed irreversible and disastrous global warming to occur for want of the means or political will to take effective action to curb it.**

147. In effect, we are suggesting a range of insurance premia. The higher the perceived risk of global warming and its adverse consequences that would flow from a continuation of present policies, the higher the premia that in theory should be paid. We believe that, given the present *uncertainties* surrounding the scale, the pace and the consequences of global warming, and given the ready availability of beneficial and extremely low cost measures that would reduce CO_2 emissions in particular, the immediate introduction of expensive and

[444] Q.509.
[445] ACE, *Min. of Ev.* p. 136; Open University, *Ev.* p. 126.
[446] See para. 141.

draconian penalties is not justifiable. **However, action does need to be taken now.** A comprehensive and high-profile Government campaign to improve at modest public cost the efficiency with which energy is used in the UK is urgently required. The extent to which penalties and subsidies might be introduced to reduce CO_2 emissions must depend in part upon the precise nature of the new regulations and standards for energy use which are formulated and the speed with which they are introduced. The public costs will also be affected depending on whether it is judged necessary at this stage to adopt the target reductions in emissions—of 20 per cent or 50 per cent suggested by the Toronto Conference. **We believe that the *risks* of not adopting targets such as these are so great, and the insurance premia required to achieve them so modest, especially when expressed as a percentage of GDP, that it would be irresponsible to avoid the challenge.**

148. Some of the necessary policies will bear fruit sooner than others. It takes very much longer to get planning permission and then to build and commission a nuclear power station than it does to legislate and ensure that all domestic electricity appliances coming on to the market are as energy efficient as are the best on the market today, or to determine that, say, 75 or 80 per cent of all electric lights used in the public estate are of the high efficiency variety. We have already noted the much higher costs of some measures, such as the exploitation of some renewable energy sources or the collection of some landfill gas, than others. It is for Government to explore in detail both the timescale and the costs of alternative policy measures, or insurance premia, and work on these matters needs to be put in hand with real urgency. Given the apparently lethargic response to the recent initiatives to improve energy efficiency in the public sector, this task is of such importance that it will deserve the regular monitoring and review by Parliament which this Select Committee intends to provide.

149. The final selection of policy priorities could take some time. The details of some policy responses cannot be sensibly defined until, for example, a number of EC positions have been agreed and wider international policies put in place. **We hope that the Government, which has been in the forefront of activity in the UN, will also take the lead in the EC. However, there are no good reasons for delaying the early implementation of any policy that can be shown to accelerate the adoption of energy supply and demand measures which are inherently economic and which would reduce CO_2 emissions.** We look to Government for early decisions and action on this matter in particular. Words understandably precede action, but words by themselves achieve nothing.

150. It is quite clear to us that the first priority must be for a vigorous and thorough campaign for energy efficiency and energy conservation. This should be multi-targeted, appealing both to moral and economic sense. It should be fortified by regulation of the suppliers of energy-consuming equipment, the building industry and the motorist. It should also be directed towards the energy producers and those who sell energy, and in particular the gas and electricity industries through their regulators. The potential which the Prime Minister recognised when she opened the Milton Keynes Energy Park in 1986 was of £7 billion savings. This economic benefit for the nation must be realised as soon as possible.

151. The second priority must be for a fresh urgency to be given to the research effort. This will include climatological research to establish what the greenhouse effect is likely to mean and also research into methods of securing our long-term energy needs without devastating pollution of the world's environment. It should also include social science research into the barriers to energy efficient investments. Research breakthroughs by the developed countries will also be of immeasurable benefit to the developing world where the principal sources of greenhouse emissions are likely to occur. Research in areas like the clean use of coal, the development of new nuclear technologies, the renewables and fundamental materials science must be properly funded and vigorously pursued. We have dealt with the issue of the Department of Energy's R&D budget in our recent report.[447] However, we regret that the research budget has fallen in real terms between 1988–89 and 1989–90. The total Department of Energy R&D outturn for 1988–89 is some £219 million, while the provision

[447] Fourth Report from the Energy Committee, Session 1988–89, *The Department of Energy's Spending Plans: 1989–90*, HC 435.

for 1989–90 is £217 million. The Government has a special responsibility for securing long-term R&D as more of the energy industries are returned to the private sector.[448] Energy is a crucial area of R&D. If the defence of the global environment is a failure, there will be no point in defending particular political and social systems within the individual nation states. **For this reason, we believe that the Government must substantially increase its energy R&D budget.**

152. In its R&D work and more generally, the Department of Energy ought to reorganise its priorities. We have frequently criticised it in the past for leaning too far in the direction of support for the supply side of the energy equation. For the future it must devote much greater effort to the improvement of energy efficiency. The reduction in resources and lowering of the profile of the Energy Efficiency Office since 1986 has been unwise and must be reversed.

153. In our recent Report on the Department of Energy's spending plans, we raised the issue of the future of the Department of Energy.[449] Naturally, the Secretary of State was not able to comment on the future of his Department, though he left us in no doubt of the importance of the Department's functions, especially now that global warming has become such a prominent issue.[450] Our enquiry into the energy policy implications of the greenhouse effect has justified our view that the Department of Energy has a vital role to perform. The concerns of resource depletion and energy strategy will be of increasing importance, as will the redressing of the historic and costly imbalance between the provision of energy supplies and management of their use.

154. **A Department of State concerned only with energy policy is vital. Now is not the right time to contemplate the amalgamation of the Department of Energy with any other Department,[451] particularly if the present functions of the Department of Energy were to be split between the already large Departments like the Department of Trade and Industry and of the Environment. However important issues like the privatisation of the gas and electricity industries or the support for the coal industry have been, they are dwarfed by the crucial importance of ensuring that we have a coherent energy policy applying across all sectors to deal with the problems which almost certainly lie ahead. The "massive experiment with the system of this planet itself" which the Prime Minister fears we may unwittingly have begun[452] cannot be countered if we have no body whose principal responsibility is to co-ordinate energy policy and energy R&D.**

G. SUMMARY OF SPECIFIC RECOMMENDATIONS AND CONCLUSIONS

155. Research

- Much more money must be devoted to R&D into global warming. No-one other than governments can realistically be expected to fund or to co-ordinate this basic R&D (paragraph 20)
- The UK and its European partners should devote a sum equivalent to a specified percentage of their gross national product to global warming R&D (paragraph 22)

156. UK and the World

- The Government should exert as much pressure as possible in all international fora to ensure that world-wide action is taken to combat global warming (paragraph 25)
- The UK should set an example to the world by seriously tackling its own emission problems in advance of international understanding: the world response will be the sum of individual countries' responses (paragraph 26)

---

[448] See BC, Q.321; TUC, *Ev.* p. 95.
[449] Fourth Report from the Energy Committee, Session 1988–89, *The Department of Energy's Spending Plans: 1989–90*, HC 435.
[450] QQ.554, 557.
[451] See ACE, Q.508.
[452] Speech to the Royal Society, 27 September 1988.

- Targets for the reduction of emissions will be useful as a measure by which to judge what progress the UK and the rest of the world are making (paragraph 39)

157. Non-CO_2 gases

- Mandatory measures to curb hydrocarbon leaks should be considered unless it becomes clear that the gas and oil industry are making satisfactory progress voluntarily (paragraph 42)
- Further steps should be taken positively to promote the use of methane from landfill sites (paragraph 44)
- There should be a rolling programme enforcing more rigorous NO_x emission standards (paragraph 45)

158. Energy forestry

- The possibilities of energy forestry should be reassessed (paragraph 49)

159. The Role of CO_2

- No one sector of the energy economy, no one fuel and no region of the world is particularly to blame for CO_2 emissions (paragraph 51)
- Research into the possibility of capturing and disposing of CO_2 should be urgently pursued (paragraph 57)

160. Fuel Substitution

- Natural gas will have some role to play in future electricity generation, but its potential should not be overstated. European Community restrictions on burning gas for this purpose should be repealed, and the Government should consider favourably any proposition for joining Great Britain to the European gas grid (paragraph 69)
- Research into hydrogen's potential as a fuel should be urgently reviewed (paragraph 73)
- The Government should reassess its position on the fast reactor (paragraph 83)
- Nuclear power's role in reducing CO_2 emissions in the next 10 to 20 years should not be overstated (paragraph 84)
- Further thorough analysis of the potential which renewable sources of energy offer should be undertaken so that more renewable technologies can be brought nearer exploitation (paragraph 90)

161. Coal

- The country cannot afford to turn its back on coal—its largest indigenous fuel resource (paragraph 93)
- Funding must be found for the next stage of the topping cycle research at Grimethorpe (paragraph 100)

162. Energy Efficiency

- Energy efficiency is the most obvious and most effective response to the problem of global warming (paragraph 102)
- The apparent relegation of energy efficiency initiatives in the Department of Energy's priorities is misjudged (paragraph 104)
- Serious market imperfections persist in the energy efficiency field (paragraph 107)
- British Gas's tariff structure contains disincentives to energy efficiency, and should be reviewed (paragraph 110)
- The Department of Energy should adopt a much higher profile and more pro-active stance on energy efficiency (paragraph 111)
- A mixture of regulations, penalties and incentives is required to promote energy efficiency: the Government should bring these forward (paragraph 113)
- A mandatory labelling system for appliances and domestic buildings should be introduced in the EC (paragraph 115)

163. Transport

- The policy of removing tax incentives for company cars should be continued (paragraph 123)
- Vehicle taxation should be related to energy efficiency (paragraph 124)
- The effects of burning aviation fuel at high altitudes should be studied (paragraph 124)

164. Conservation

- Finite resources are being used up: they should be conserved and not wasted (paragraph 132)

165. The Market and the Government's Role

- Market mechanisms alone will not produce an adequate response to global warming (paragraph 134)
- The environmental costs and benefits of all energy technologies should be at the forefront of the Department's future thinking (paragraph 136)
- The Government should encourage the electricity industry incrementally to invest in all energy production systems which reduce greenhouse emissions (paragraph 138)
- The non-fossil fuel requirement of the Electricity Bill should be expanded to cover energy efficiency and combined heat and power (paragraph 138)
- The European Community should examine urgently the feasibility of fiscal measures which would reflect the costs of global pollution caused by energy production of all types. The revenue could be devoted to energy efficiency investment (paragraph 141)

166. General Conclusions

- It would be inexcusable if pusillanimity and the inability of the governments of the world to plan long-term allowed irreversible and disastrous global warming to occur for want of the means or the political will to take effective action to curb it (paragraph 146)
- It would be irresponsible not to adopt targets for reducing greenhouse emissions, especially when the costs of doing so are modest (paragraph 147)
- There is no good reason for delaying the implementation of any policy that can be shown to accelerate the adoption of energy supply and demand measures which are inherently economic and which would reduce CO_2 emissions (paragraph 150)
- The Government's energy R&D budget must be substantially increased (paragraph 151)
- The existence of an independent Department of Energy is vital if policies to combat global warming are to be properly formulated (paragraph 154)

ANNEX

THE CHANGING ATMOSPHERE: IMPLICATIONS FOR GLOBAL SECURITY

CONFERENCE STATEMENT

Toronto, Ontario, Canada
June 27-30 1988

FOREWORD

At the invitation of the Government of Canada, more than 300 world experts—leaders in science, law and the environment; ministers of government; economists; industrialists; policy analysts; and officials from international agencies assembled in Toronto, Ontario, Canada from June 27–30, 1988 to consider the threats posed by the changing global atmosphere and how they might be addressed. They came from 46 countries and quickly arrived at a consensus that the concerns about the effects of atmospheric change—greenhouse gases, ozone-layer depleting substances, toxics, smog and acid rain—are justified and that the time to act on the problems is now. The Conference was the first direct response to the call for action of the UN's World Commission on Environment and Development. It was also the first comprehensive meeting between specialists on the issues at hand and high-level policy-makers. The significance of the event was underscored by the participation of Prime Ministers Mulroney of Canada and Brundtland of Norway, the participation of Ministers McMillan and Masse (Canada), Salim (Indonesia), Nijpels (Netherlands), Cissokho (Senegal), Luttenbarck Batalha (Brazil), Harilla (Morocco), by Senator Wirth (United States) and by ambassadors from Algeria, Canada, The Maldives, and Sweden.

The message from the Toronto Conference was clear. The Earth's atmosphere is being changed at an unprecedented rate, primarily by humanity's ever-expanding energy consumption, and these changes represent a major threat to global health and security. Sound policies must be quickly developed and implemented to provide for the protection of the planet's atmosphere. That message and an agenda for action are embodied in this Statement of the Conference's conclusions and recommendations. The Statement builds an important preceding conferences and workshops, and draws heavily from ideas and discussion of the Conference's 12 Working Groups. Its careful reading is recommended to all decision-makers seeking solutions to the problems of climate change.

I wish to take this opportunity to thank my colleagues on the Conference Statement Committee. These colleagues, who worked long and difficult hours in drafting the Conference Statement and who also served as advisors on Conference planning over the past two years, are J. P. Bruce, G. Goodman, J. Jaeger, G. A. McKay, J. MacNeill, M. Oppenheimer and P. Usher. Dr. Jaeger also produced the main background paper to the Conference. In addition I must thank the Conference General Chairman, Canada's Ambassador to the United Nations, Stephen Lewis, for his important contributions to the final draft of the Statement.

My thanks also go to the many international experts who wrote the theme papers that provided background to the Conference discussions, to the chairpersons and rapporteurs who so skillfully managed the Working Group sessions, to those who assumed special speaking assignments, and to persons and groups who prepared special reports for Working Group discussions and for general consideration by the Conference. Finally, I extend my deep gratitude to all who participated in the Conference—delegates, observers, media and staff—and thereby contributed to its outstanding success. Their collective efforts constitute a landmark in confronting one of humankind's biggest challenges.

I believe the Conference will prove to have been an important step forward in reconcilling environmental, societal and developmental goals. We still have a long way to go. However, I am confident that the Toronto Conference gave us the right agenda and conviction to act. It also provided an opportunity to share our views with world leaders from many disciplines—scientific, social and political.

H. L. Ferguson
Conference Director

SUMMARY

Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being

changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe.

Far reaching impacts will be caused by global warming and sea-level rise, which are becoming increasingly evident as a result of the continued growth in atmospheric concentrations of carbon dioxide and other greenhouse gases. Other major impacts are occurring from ozone-layer depletion resulting in increased damage from ultra-violet radiation. The best predictions available indicate potentially severe economic and social dislocation for present and future generations, which will worsen international tensions and increase risk of conflicts between and within nations. It is imperative to act now.

These were the major conclusions of the World Conference on the Changing Atmosphere: Implications for Global Security, held in Toronto, Ontario, Canada, June 27–30, 1988. More than 300 scientists and policy makers from 46 countries, United Nations organizations, other international bodies and non-governmental organizations participated in the sessions.

The Conference called upon governments, the United Nations and its specialized agencies, industry, educational institutions, non-governmental organizations and individuals to take specific actions to reduce the impending crisis caused by pollution of the atmosphere. No country can tackle this problem in isolation. International co-operation in the management and monitoring of, and research on, this shared resource is essential.

The Conference called upon governments to work urgently towards an *Action Plan for the Protection of the Atmosphere*. This should include an international framework convention, while encouraging other standard-setting agreements along the way, as well as national legislation to provide for protection of the global atmosphere. The Conference also called upon governments to establish a *World Atmosphere Fund* financed in part by a levy on the fossil fuel consumption of industrialized countries to mobilize a substantial part of the resources needed for these measures.

The Issue

Continuing alteration of the global atmosphere threatens global security, the world economy, and the natural environment through:

- Climate warming, rising sea-level, altered precipitation patterns and changed frequencies of climatic extremes induced by the "heat trap" effects of greenhouse gases;
- Depletion of the ozone layer;
- Long-range transport of toxic chemicals and acidifying substances

These changes will:

- Imperil human health and well-being;
- Diminish global food security, through increases in soil erosion and greater shifts and uncertainties in agricultural production, particularly for many vulnerable regions;
- Change the distribution and seasonal availabiltiy of freshwater resources;
- Increase political instability and the potential for international conflict;
- Jeopardize prospects for sustainable development and the reduction of poverty;
- Accelerate the extinction of animal and plant species upon which human survival depends;
- Alter yield, productivity and biological diversity of natural and managed ecosystems, particularly forests.

If rapid action is not taken now by the countries of the world, these problems will become progressively more serious, more difficult to reverse, and more costly to address.

Scientific Basis for Concern

The Conference calls for urgent work on an *Action Plan for the Protection of the Atmosphere*. This Action Plan, complemented by national action, should address the problems of climatic warming, ozone layer depletion, long-range transport of toxic chemicals and acidification.

Climate Warming

1. There has been an observed increase of globally-averaged temperature of 0.7°C in the past century which is consistent with theoretical greenhouse gas predictions. The accelerating increase in

concentrations of greenhouse gases in the atmosphere, if continued, will probably result in a rise in the mean surface temperature of the Earth of 1.5 to 4.5°C before the middle of the next century.

2. Marked regional variations in the amount of warming are expected. For example at high latitudes the warming may be twice the global average. Also, the warming would be accompanied by changes in the amount and distribution of rainfall and in atmospheric and ocean circulation patterns. The natural variability of the atmosphere and climate will continue and be superimposed on the long-term trend, forced by human activities.

3. If current trends continue, the rates and magnitude of climate change in the next century may substantially exceed those experienced over the last 5000 years. Such high rates of change would be sufficiently disruptive that no country would likely benefit *in toto* from climate change.

4. The climate change will continue so long as the greenhouse gases accumulate in the atmosphere.

5. There can be a time lag of the order of decades between the emission of gases into the atmosphere and their full manifestation in atmospheric and biological consequences. Past emissions have already committed planet Earth to a significant warming.

6. Global warming will accelerate the present sea-level rise. This will probably be of the order of 30 cm but could possibly be as much as 1.5 m by the middle of the next century. This could inundate low-lying coastal lands and islands, and reduce coastal water supplies by increased salt water intrusion. Many densely populated deltas and adjacent agricultural lands would be threatened. The frequency of tropical cyclones may increase and storm tracks may change with consequent devastating impacts on coastal areas and islands by floods and storm surges.

7. Deforestation and bad agricultural practices are contributing to desertification and are reducing the biological storage of carbon dioxide, thereby contributing to the increase of this most important greenhouse gas. Deforestation and poor agricultural practices are also contributing additional greenhouse gases such as nitrous oxide and methane.

Ozone Layer Depletion

1. Increased levels of damaging ultra-violet radiation while the stratospheric ozone shield thins, will cause a significant rise in the occurrence of skin cancer and eye damage, and will be harmful to many biological species. Each 1 per cent decline in ozone is expected to cause a 4 to 6 per cent increase in certain kinds of skin cancer. A particular concern is the possible combined effects on unmanaged ecosystems of both increased ultraviolet radiation and climate changes.

2. Over the last decade, a decline of 3 per cent in the ozone layer has occurred at mid-latitudes in the Southern Hemisphere, possibly accompanying the appearance of the Antarctic ozone hole; although there is more meteorological variability, there are indications that a smaller decline has occurred in the Northern Hemisphere. Changes of the ozone layer will also change the climate and the circulation of the atmosphere.

Acidification

In improving the quality of the air in their cities, many industrialized countries unintentionally sent increasing amounts of pollution across national boundaries in Europe and North America, contributing to the acidification of distant environments. This was manifested by increasing damage to lakes, soils, plants, animals, forests and fisheries. Failure to control automobile pollution in some regions has seriously contributed to the problem. The principal damage agents are oxides of sulphur and nitrogen as well as volatile hydrocarbons. The resulting acids can also corrode buildings and metallic structures causing overall, billions of dollars of damage annually.

The various issues arising from the pollution of Earth's atmosphere by a number of substances are often closely interrelated, both through chemistry and through potential control strategies. For example, chlorofluorocarbons (CFCs) both destroy ozone and are greenhouse gases; conservation of fossil fuels contribute to addressing both acid rain and climate change problems.

SECURITY: ECONOMIC AND SOCIAL CONCERNS

As the *UN Report On The Relationship Between Disarmament And Development* states: "The world can either continue to pursue the arms race with characteristic vigour or move consciously and with deliberate speed toward a more stable and balanced social and economic development within a more sustained international economic and political order. It cannot do both. It must be acknowledged that the arms race and development are in a competitive relationship, particularly in terms of resources,

but also in vital dimension of attitudes and perceptions." The same consideration applies to the vital issue of protecting the global atmospheric commons from the growing peril of climate change and other atmospheric changes. Unanticipated and unplanned change may well become the major non-military threat to international security and the future of the global economy.

There is no concern more fundamental than access to food and water. Currently levels of global food security are inadequate but even those will be most difficult to maintain into the future, given projected agricultural production levels and population and income growth rates. The climate changes envisaged will aggravate the problem of uncertainty in food security. Climate change is being induced by the prosperous, but its effects are suffered most acutely by the poor. It is imperative for governments and the international community to sustain the agricultural and marine resource base and provide development opportunities for the poor in light of this growing environmental threat to global food security.

The countries of the industrially developed world are the main source of greenhouse gases and therefore bear the main responsibility to the world community for ensuring that measures are implemented to address the issues posed by climate change. At the same time, they must see that the developing nations of the world, whose problems are greatly aggravated by population growth, are assisted in and not inhibited from improving their economies and the living conditions of their citizens. This will necessitate a wide range of measures, including significant additional energy use in those countries and compensating reductions in the industrialized countries. The transition to a sustainable future will require investments in energy efficiency and non-fossil energy sources. In order to ensure that these investments occur, the global community must not only halt the current net transfer of resources from developing countries, but actually reverse it. This reversal should embrace the technologies involved, taking into account the implications for industry.

A coalition of reason is required, in particular, a rapid reduction of both North–South inequalities and East-West tensions, if we are to achieve the understanding and agreements needed to secure a sustainable future for planet Earth and its inhabitants.

It takes a long time to develop an international consensus on complex issues such as these, to negotiate, sign, and ratify international environmental instruments and to begin to implement them. It is therefore imperative that serious negotiations start now.

Legal Aspects

The first steps in developing international law and practices to address pollution of the air have already been taken: in the Trail Smelter arbitration of 1935 and 1938; Principle 21 of the 1972 Declaration of the UN Conference on the Environment; the Economic Commission for Europe (ECE) Convention on Long Range Transboundary Air Pollution and its Protocol (Helsinki, 1985) for sulphur reductions, Part XII of the Law of the Sea Convention; and the Vienna Convention for Protection of the Ozone Layer and its Montréal Protocol (1987).

These are important first steps and should be actively implemented and respected by all nations. However, there is no overall convention constituting a comprehensive international framework that can address the interrelated problems of the global atmosphere, or that is directed towards the issues of climate change.

A Call For Action

The Conference urges immediate action by governments, the United Nations and their specialized agencies, other international bodies, non-governmental organizations, industry, educational institutions and individuals to counter the ongoing degradation of the atmosphere.

An *Action for the Protection of the Atmosphere* needs to be developed, which includes an international framework convention, encourages other standard-setting agreements and national legislation to provide for the protection of the global atmosphere. This must be complemented by implementation of national action plans that address the problems posed by atmospheric change (climate warming, ozone layer depletion, acidification and the long-range transport of toxic chemicals) at their roots.

The following actions are mostly designed to slow and eventually reverse deterioration of the atmosphere. There are also a number of strategies for adapting to changes that must be considered. These are dealt with primarily in the recommendations of the Working Groups.

ACTIONS BY GOVERNMENTS AND INDUSTRY

• *Ratify the Montreal Protocol on Substances that Deplete the Ozone Layer.* The Protocol should be revised in 1990 to ensure nearly complete elimination of the emissions of fully halogenated CFC's by the year 2000. Additional measures to limit other ozone-destroying halocarbons should be considered.

• *Set energy policies to reduce the emissions of CO_2 and other trace gases* in order to reduce the risks of future global warming. Stabilizing the atmospheric concentrations of CO_2 is an imperative goal. It is currently estimated to require reductions of more than 50 per cent from present emission levels. Energy research and development budgets must be massively directed to energy options which would eliminate or greatly reduce CO_2 emissions and to studies undertaken to further refine the target reductions.

• *Reduce CO_2 emissions by approximately 20 per cent of 1988 levels by the year 2005 as an initial global goal.* Clearly, the industrialized nations have a responsibility to lead the way, both through their national energy policies and their bilateral and multilateral assistance arrangements. About one-half of this reduction would be sought from enery efficiency and other conservation measures. The other half should be effected by modifications in supplies.

• *Set targets for energy efficiency improvements* that are directly related to reductions CO_2 and other greenhouse gases. A challenging target would be achieve the 10 per cent energy efficiency improvements by 2005. Improving energy energy efficiency is not precisely the same as reducing total carbon emissions and the detailed policies will not all be familiar ones. A detailed study of the systems implications of this target should be made. Equally, targets for *energy supply* should be directly related to reductions in CO_2 and other greenhouse gases. As with efficiency, a challenging target would again be to achieve the 10 per cent energy supply improvements by 2005. A detailed study of the systems implications of this target should also be made. The contributions to achieving this goal will vary from region to region; some countries have already demonstrated a capability for increasing efficiency by more than 2 per cent a year a year for over a decade.

Apart from efficiency measures, the desired reduction will require (i) switching to lower CO_2 emitting fuels, (ii) reviewing strategies for the implementation of renewable energy especially advanced biomass conversion technologies; (iii) revisiting the nuclear power option which lost credibility because of problems related to nuclear safety, radioactive wastes, and nuclear weapons proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could have a role to play in lowering CO_2 emissions.

• *Negotiate now on ways to achieve the above-mentioned reductions.*

• *Initiate management systems* in order to encourage, review and approve major new projects for energy efficiency.

• *Vigorously apply existing technologies*, in addition to gains made through reduction of fossil fuel conbustion, to reduce (i) emissions of acidifying substances to reach the critical load that the environment can bear; (ii) substances which are precursors of the tropospheric ozone; and (iii) other non-CO_2 greenhouse gases.

• *Label products* to allow consumers to judge the extent and nature of the atmospheric contamination that arises from the manufacture and use of the product.

ACTIONS BY MEMBER GOVERNMENTS OF THE UNITED NATIONS, NON-GOVERNMENTAL ORGANIZATIONS AND RELEVANT INTERNATIONAL BODIES

• *Initiate the development of a comprehensive global convention* as a framework for protocols on the protection of the atmosphere. The convention should emphasize such key elements as the free international exchange of information and the support of research and monitoring, and should provide a framework for specific protocols for addressing particular issues, taking into account existing international law. This should be vigorously pursued at the International Workshop on Law and Policy to be held in Ottawa early in 1989, the high-level political conference on Climate Change in the Netherlands in the Fall, 1989, the World Energy Conference in Canada in 1989 and the Second World Climate Conference in Geneva, June 1990, with a view to having the principles and components of such a convention ready for consideration at the Inter-governmental Conference on Sustainable Development in 1992. These activities should in no way impede simultaneous national, bilateral and regional actions and agreements to deal with specific problems such as acidification and greenhouse gas emissions.

• *Establish a World Atmosphere Fund*, financed in part by a levy on fossil fuel consumption of industrialized countries, to mobilize a substantial part of the resources needed for implementation of the *Action Plan for the Protection of the Atmosphere.*

• *Support the work of the Inter-governmental Panel on Climate Change* to conduct continuing assessments of scientific results and to initiate government-to-government discussion of responses and strategies.

• *Devote increasing resources to research and monitoring efforts* within the World Climatic Programme, the International Geosphere Biosphere Programme and Human Response to Global Change Programme. It is particularly important to understand how climate changes on a regional scale are related to an overall global change of climate. Emphasis should also be placed on better determination of the role of oceans in global heat transport and the flux of greenhouse gases.

• *Increase significantly the funding for research, development and transfer of information on renewable energy*, if necessary by the establishment of additional and bridging programmes; extend technology transfer with particular emphasis on the needs of the developing countries; and upgrade efforts to meet obligations for the development and transfer of technology embodied in existing agreements.

• *Expand funding for more extensive technology transfer and technical co-operation projects in coastal zone protection and management.*

• *Reduce deforestation and increase afforestation* making use of proposals such as those in the World Commission on Environment and Development's (WCED) report, "Our Common Future", including the establishment of a trust fund to provide adequate incentives to enable developing nations to manage their tropical forest resources sustainably.

• *Develop and support technical co-operation projects* to allow developing nations to participate in international mitigation efforts, monitoring, research and analysis related to the changing atmosphere.

• *Ensure that this Statement, the Working Group reports and the full Proceedings of the World Conference, "The Changing Atmosphere: Implications for Global Security" are made available* to all nations, to the conferences mentioned above, and to other future meetings dealing with related issues.

• *Increase funding to non-governmental organizations* to allow the establishment and improvement of environmental education programmes and public awareness campaigns related to the changing atmosphere. Such programmes would aim at sharpening perception of the issues, and changing public values and behaviour with respect to the environment.

• *Allocate financial support for environmental education* in primary and secondary schools and universities. Consideration should be given to establishing special groups in university departments for addressing the crucial issues of global climate change.

SPECIFIC RECOMMENDATIONS OF WORKING GROUPS

The recommended actions in the Conference Statement are mostly general in nature and common to a number of Conference Working Groups. The specific recommendations of the working Groups are given in the following section.

Energy

1. Targets for energy supply should be directly related to reductions in CO_2 and other greenhouse gases. A challenging target would be to reduce the annual global CO_2 emissions by 20 per cent by the year 2005 through improved energy efficiency, altered energy supply, and energy conservation.

2. Research and demonstration projects should be undertaken to accelerate the development of advanced biomass conversion technologies.

3. Deforestation should be reduced and reforestation accelerated to significantly reduce the atmospheric concentrations of CO_2 and to replenish the primary fuel supply for the majority of the world's population.

4. There is a need to revisit the nuclear power option. If the problems of safety, waste and nuclear arms proliferation can be solved, nuclear power could have a role to play in lowering CO_2 emissions.

5. It is necessary to internalize externalized costs. Policies should be fashioned to achieve broad, complementary social objectives and to minimize total social, economic and environmental costs.

FOOD SECURITY

1. National governments are urged to reduce the contributions of agricultural activities to the concentration of greenhouse gases in the atmosphere. These contributions arise from the destruction of forests, the inefficient use of inorganic nitrogen fertilizers, the increased conversion of land to paddy rice cultivation and the increased number of ruminant animals.

2. National governments should take the prospect of climate change into account in long-term agricultural and food security planning, particularly with respect to food availability to the most vulnerable groups.

3. National governments and international agencies should give increasing emphasis to a wide array of policy measures to reduce the sensivity of the food supply to climatic variability in order to increase resilience and adaptability to climate change.

4. National governments are urged to increase their efforts to build sub-regional and regional co-operation aimed at achieving food security. International agencies should assist in promoting these regional cooperative efforts.

5. FAO, World Bank, WMO, UNEP, UNDP, CGIAR and other international organizations should encourage research leading to ecologically sound agricultural management systems.

URBANIZATION AND SETTLEMENT

1. Environmental impact statements and land-use management plans should consider future climatic conditions including the local effects of rising sea-level on coastal communities.

2. Urban authorities should undertake risk assessments and develop emergency planning procedures that take into account the effects of climate change, for example, the increased incidence of natural hazards.

3. National governments and the international aid community should develop policies and actions to deal with the likely increased movements of environmental refugees resulting from climate change.

4. Environmental education must be stressed, particularly with respect to the sustainable development of urban areas and human settlements, and should be strongly promoted by local and national authorities and by international bodies such as WMO, UNCHS, UNEP, UNIDO and UNDP.

5. Comprehensive world-wide assessments should be made national and international organizations of the vulnerability of specific geographic regions and urban areas to the increased risk of higher incidence and spread of infectious diseases due to global climate change, including both vector-borne and communicable diseases. In these areas, assessments should be made of health care infrastructures and of their ability to cope with the projected increased risks of the spread of infectious diseases; and steps should be inentified to be taken by local and national authorities and international organizations to improve such capabilities.

6. Assessments should be made of the vulnerability of nuclear facilities, municipal and hazardous waste dumps, and of other waste disposal facilities to the increased hazard of sudden flooding or gradual inundation, and of their potential for the consequent spread of infectious pathogens or toxic chemicals to the surrounding land and sea areas, and appropriate steps should be taken to minimize such risks.

WATER RESOURCES

1. The efficiency of water use and the resilience of existing and planned water resource systems and management processes must be increased to meet the existing climate variability.

2. Existing acid rain conventions must be extended to the global scale and modified to include toxic organic pollutants.

3. Integrated monitoring and research programs are urgently required to improve the methods of assessing the sensitivity of water resource systems, to identify critical regions and river basins where changes in hydrological processes and water demand will cause serious problems, and to understand and model the hydrological, ecological and socio-economic impacts of climate change.

4. To alleviate present and future water problems and to achieve sustainable development, we strongly endorse the global principle of inter-regional and inter-generational equity in all actions.

International co-operation, open technology transfer, meaningful public involvement and effective public information programs are essential.

Land Resources

An international fund should be created specifically for development assistance and research in order to:

1. Maintain the terrestrial reservoirs of carbon through the careful management and protection of tropical and temperate forests and their soils, tundra and wetlands that represent major carbon pools.

2. Encourage the development of varieties of sustainable land-use practices through such activities as agroforestry, reforestation, development of varieties for adaptation to climate change, and develoment of effective management practices for waste treatment and disposal, and through policies for the use, settlement and tenure of land. This requires major changes in the aid policy, commercial practices and policies of related organizations (ITTO, FAO/TFAP and ICRAF) as well as possible "debt swapping" for forest protection and access to a reforestation fund.

3. Identify the most productive agricultural lands so as to be able to implement a land reserve system that can be used to mitigate losses resulting from a more adverse climate and sea-level rise.

4. Increase awareness among the public of issues posed by climate change in relation to the continued wise use of lands in a sustainable manner.

5. Broaden existing programs that address the impact on land resources of acid and other toxic depositions, by taking account of their global dimension.

Coastal and Marine Resources

1. Research is required to understand which natural and human factors determine the productivity and variability of marine and coastal resources.

2. Institutional and legal arrangements for the wise use of common property resources must be greatly improved.

3. The flexibility of marine-dependent industries and coastal communities must be greatly enhanced to respond to climate-induced changes.

4. Site-specific impact studies of the effects of sea-level rise must be undertaken. These should include consideration of the human, economic and environmental risks and should result in local education programs.

5. The implications of climate change for coastal-zone planning must be considered, particularly the risk of sea-level rise and/or the potential need to locate new developments inland.

Futures and Forecasting

1. In order to have any hope of coping with future change, we must acquire and make use of the knowledge of the past and develop the ability to anticipate the possible future. No one model can or should be expected to deal with the uncertainties in forecasting, the details needed for making decisions, and the social, technical and economic implications of change. Hence an array of techniques must be used in order to produce useful results.

2. Not only are continued efforts needed to improve forecasting-methodologies and to integrate cause-and-effect modelling, but also improvements are needed in our ability to communicate and convey their implications for the broader culture so that individual and collective decisions can be made appropriately and with foresight. Attitudinal and institutional changes will be necessary because of the projected serious global consequences. Equally important is the need to take action, in an environmentally sustainable way, on the interrelated issues of population growth, resource use and depletion, and technological inequalities.

Decision-making and Uncertainty

1. The reduction of uncertainties requires advanced understanding of the chemistry of the atmosphere of the implications of climate change for health, agriculture, economies, and other social

concerns, and of the legal, political and other aspects of the possible responses to climate change (prevention, compensation and adaptation).

2. The industrialized nations should begin to restore the integrity of the environment, making atmospheric change the turning point of an ecological innovation of industrial economy.

3. Emission targets ought to be the subject of an international treaty between the nations that take the first step. Those nations should invite all the others to join them in advancing environmentally sustainable economic development.

4. Open decision-making may well provide for decisions that are not easily accepted by the public. We recommend a democratic discussion about possible responses to the atmospheric threat. Non-governmental organizations should play a decisive role in furthering this discourse.

INDUSTRY, TRADE AND INVESTMENT

Proposed as matters for urgent action are:

1. Creation of a World Atmosphere Fund financed by a levy on the fossil fuel consumption of industrialized countries, sufficient to support development and transfer fuel-efficient technologies.

2. Development of mechanisms for incorporating environmental considerations and responsibilities into the internal decision and reporting processes of business and industry.

3. Formation of an international consultative mechanism at the highest level, reporting to heads of government, to assure:

- accelerated research and development efforts
- reduction of institutional barriers to the adoption of appropriate low-emission technologies by industries and households
- improvement of market information to promote the shift of consumption toward ecologically appropriate products.

GEOPOLITICAL ISSUES

1. The particular regions of the world or sectors of the economy that will be damaged first or most strongly by a rapidly changing atmosphere cannot be foreseen today, but the magnitude and variety of the eventual impacts is such that it is in the self-interest of all people to join in prompt action to slow the change and to negotiate toward an international accord on achieving shared responsibility for care of the climate and the atmosphere.

2. Co-ordinated international efforts and an all-encompassing international agreement are required along with prompt action by governmental agencies and non-governmental groups to prevent harmful changes to the atmosphere. Such actions can be based on improvements in energy efficiency, the use of alternative energy sources, and the transfer of technology and resources to the Third World.

LEGAL DIMENSIONS

1. More states should observe the international principles and norms that exist and all should be encouraged to enact or strengthen appropriate national legislation for the protection of the atmosphere.

2. The offer of the Prime Minister of Canada to host a meeting of law and policy experts in early 1989 should be accepted. That meeting should address the question of the progressive development and codification of the principles of international law taking into account the general principles of law set out in the Trail smelter, Lac Lanoux, Corfu Channel cases, Principle 21 of the 1972 Declaration of the United Nations Conference on the Human Environment, the Convention on Long-Range Transboundary Air Pollution and related protocols, Part XII of the Law of the Sea Convention and the Vienna Convention for the Protection of the Ozone Layer and its Montréal Protocol. The meeting should be directed toward the elaboration of the principles to be included in an umbrella/framework Convention on the Protection of the Atmosphere—one that would lend itself to the development of specific agreements/protocols laying down international standards for the protection of the atmosphere, in addition to existing instruments.

INTEGRATED PROGAMS

1. A thorough review is required to establish the institutional needs for co-operation in research, impact assessment and development of public policy options at the international, intergovernmental and non-governmental levels, at regional levels and at national levels. This review should be completed by 1992.

2. Extension and further development is required for a United Nations global monitoring and information system that will incorporate technological advances in measurement, data storage and retrieval, and communications in order to track systematic changes in the physical, chemical, biological and socio-economic parameters that collectively describe the total global human environment. The responsibility for development rests with governments. The monitoring system should be in place by the year 2000.

3. Also required is the development of an educational program to familiarize present and future generations with the importance of addressing issues concerning sustainable development including the actions and integrated, interdisciplinary programs needed.

MINUTES OF PROCEEDINGS RELATING TO THE REPORT

TUESDAY 4 JULY 1988

Members present:

Sir Ian Lloyd, in the Chair

Mr Michael Brown	Mr Geoffrey Lofthouse
Dr Michael Clark	Mr Malcolm Moss
Mr David Clelland	Mr Peter Rost
Mr Ted Leadbitter	

Draft Report (Energy Policy Implications of the Greenhouse Effect) proposed by the Chairman, brought up and read.

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

Paragraphs 1 to 31 read and agreed to.

Paragraphs 32 and 33 read, amended, and agreed to.

Paragraphs 34 and 35 read and agreed to.

Paragraphs 36 and 37 read, amended, and agreed to.

Paragraph 38 read and agreed to.

Paragraph 39 read, amended, and agreed to.

Paragraphs 40 to 50 read and agreed to.

Paragraphs 51 to 53 read, amended, and agreed to.

Paragraphs 54 and 55 read and agreed to.

Paragraph 56 read, amended, and agreed to.

Paragraph 57 read and agreed to.

Paragraphs 58 and 59 read, amended, and agreed to.

Paragraph 60 read and agreed to.

Paragraph 61 read, amended, and agreed to.

Paragraphs 62 to 78 read and agreed to.

Paragraph 79 read, amended, and agreed to.

Paragraphs 80 to 82 read and agreed to.

Paragraphs 83 and 84 read, amended, and agreed to.

Paragraphs 85 to 89 read and agreed to.

Paragraph 90 read, amended, and agreed to.

Paragraphs 91 to 104 read and agreed to.

Paragraph 105 read, amended, divided and agreed to (now paragraphs 105 and 106).

Paragraph 106 to 115 read and agreed to (now paragraphs 107 to 116).

Paragraphs 116 and 117 read, amended, and agreed to (now paragraphs 117 and 118).

Paragraphs 118 to 120 read and agreed to (now paragraphs 119 to 121).

Paragraph 121 read, amended, and agreed to (now paragraph 122).

Paragraphs 122 to 126 read and agreed to (now paragraphs 123 to 127).

Paragraph 127 read, amended, and agreed to (now paragraph 128).

Paragraph 128 read and agreed to (now paragraph 129).

Paragraph 129 read, amended, and agreed to (now paragraph 130).

Paragraphs 130 and 131 read and agreed to (now paragraphs 131 and 132).

Paragraph 132 read, amended, and agreed to (now paragraph 133).

Paragraph 133 read and agreed to (now paragraph 134).

Paragraph 134 read, amended, and agreed to (now paragraph 135).

Paragraphs 135 to 139 read and agreed to (now paragraphs 136 to 140).

Paragraph 140 read, amended, and agreed to (now paragraph 141).

Paragraphs 141 to 144 read and agreed to (now paragraphs 142 to 145).

Paragraph 145 read, amended, and agreed to (now paragraph 146).

Paragraphs 146 to 148 read and agreed to (now paragraphs 147 to 149).

Paragraph 149 read, amended, and agreed to (now paragraph 150).

Paragraph 150 read and agreed to (now paragraph 151).

Paragraph 151 read, amended, and agreed to (now paragraph 152).

Motion made, and Question proposed, That paragraphs 152 and 153 be left out—(*Mr Michael Brown.*)

Motion, by leave, withdrawn.

Paragraphs 152 to 163 read and agreed to (now paragraphs 153 to 164).

Paragraphs 164 and 165 read, amended, and agreed to (now paragraphs 165 and 166).

Ordered, That the following paper be appended to the Report: Toronto Conference Statement—*The Changing Atmosphere: Implications for Global Security.*

Resolved, That the Report, as amended, be the Sixth Report of the Committee to the House.

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

Ordered, That the provisions of Standing Order No 116 (Select Committees (Reports)) be applied to the Report.

[Adjourned till Wednesday 12 July at half-past Ten o'clock.

Printed in the United Kingdom for Her Majesty's Stationery Office
Dd 0502833 7/89 C10 3382 4235 65889 Job No. 891823P

HMSO publications are available from:

HMSO Publications Centre
(Mail and telephone orders only)
PO Box 276, London SW8 5DT
Telephone orders 01-873 9090
General enquiries 01-873 0011
(queuing system in operation for both numbers)

HMSO Bookshops
49 High Holborn, London, WC1V 6HB 01-873 0011 (Counter service only)
258 Broad Street, Birmingham, B1 2HE 021-643 3740
Southey House, 33 Wine Street, Bristol, BS1 2BQ (0272) 264306
9–21 Princess Street, Manchester, M60 8AS 061-834 7201
80 Chichester Street, Belfast, BT1 4JY (0232) 238451
71 Lothian Road, Edinburgh, EH3 9AZ 031-228 4181

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

ISBN 0 10 296989 2