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PRIME MINISTER

CARBON DIOXIDE AND CLIMATIC CHANGE

1. I attach a paper prepared by my officials reporting on the work commissioned at the meeting of Ministers on 12th January.

2. Although this notes that there is at present considerable uncertainty about the nature and size of the possible effects of climatic change, it also notes that the potential risks to our environment are also large. In considering any possible responses in the energy sector, we must recognise that our past energy policies have led us to a very heavy dependence on fossil fuels. Our needs for energy are currently met in a way which inevitably leads to the emission of large quantities of carbon dioxide. Our scope for changing this, in the short term, is very limited, and while further work is being done to reduce the scientific uncertainties any attempt by the UK to make radical changes to our energy supply system would inevitably have very large costs. Whatever our aspirations, while we do not know what the real consequences of carbon dioxide emissions are, and in the absence of similar action by other countries, it would not be reasonable unilaterally to inflict such costs on ourselves, and to put ourselves as a consequence at a competitive disadvantage.

3. Global climate change is in any event a truly international issue. The UK is only a very small contributor to the world-wide problem. We emit only 3% of the world's carbon dioxide and this proportion is likely to fall as the developing countries, such as China and India, increase their energy consumption. I believe we must therefore press forward with our existing international initiatives to ensure that all countries recognise the importance of their actions and are encouraged to adopt responsible policies which do not add unnecessarily to the problem. My Department has

been supporting the efforts of the International Programme on Climate Change (IPCC) in this direction.

4. However given the uncertainties and the risks, I believe we should also do our utmost to prevent the UK from adding to the problem. As the note makes clear, our existing energy policies are already directed in a way which should prevent matters becoming worse. The graph included after paragraph 7 of my officials' paper shows that, excluding transport, the energy sector's emissions of carbon dioxide in the UK have declined since 1979 and, if our current policies are pursued, are unlikely to increase significantly above that level through to the year 2005.

5. The key to ensuring this outcome is the vigorous pursuit of our existing policies:-

i. in the electricity sector our privatisation proposals already include commitment to a sustained nuclear power programme through the non-fossil fuel obligation; the framework we shall create for generation will also encourage the use of more efficient electricity generating technologies such as the advanced coal-burning and gas-burning combined cycle technologies which will help keep down carbon dioxide emissions; repeal of the Community directive setting conditions on the use of gas in power stations (for which I and my colleagues have already pressed at the Energy Council) would also facilitate such improvements;

ii. although renewable sources of energy are unlikely to make large inroads into the energy supply system over the next 10-15 years, our R&D programme to develop the technologies and promote their utilisation and their inclusion within the non-fossil fuel obligation will ensure that wherever possible they are able to make a contribution;

iii. we must continue our campaign to increase the level of efficiency of use of energy. I have recently reviewed my Department's programme, much of which had been directed at public awareness and other general activities. I have concluded the right way forward is to focus our efforts on providing information which will allow consumers to see how they can use energy more efficiently. I announced on 7 March the new Best Practice Programme which will provide authoritative and convincing information about the best practice currently available. For domestic consumers, I believe we can build on the contacts between the energy utilities and consumers and in the Electricity Bill I propose laying new duties on the electricity industry to stand alongside those in the gas industry to offer energy efficiency advice to consumers. I am in discussion with the Chief Secretary on proposals for the Public Sector energy efficiency initiative so that we can set a good example in our own energy use; support from colleagues will be essential if we are to achieve the improvements which are possible. I believe that we must also be able to show that we are responding positively to the need to promote energy efficiency amongst low income households, and the difficulties currently faced by Community Insulation Projects. I have recently put proposals on this to the Secretary of State for the Environment. Finally, I also understand that proposals are currently before the Secretary of State for the Environment for the improvement of the energy efficiency aspects of buildings under the Building Regulations. I very much hope that these changes can be made since they offer the real prospect of improvements of energy performance in new and refurbished buildings;

iv. for coal technology I have already noted that our privatisation policies will create a climate favourable to the right kind of new technology; British Coal has recently approached me with a proposal to join with them and a manufacturer of power plant in a programme to demonstrate a new prospect for high efficiency electricity generation - the topping cycle; I am encouraging British Coal to seek greater industrial support, but if necessary to ensure that the new technology can be properly developed, I may need to bring forward a bid at the appropriate time for some governmental support.

6. I invite colleagues to endorse the approach outlined above and in particular:-

i. to support the efforts being made within the IPCC to ensure that other countries recognise the importance of their actions;

ii. to note the changes which will come about as a consequence of electricity privatisation including the arrangements being made for the Non Fossil Fuel Obligation and the requirements on the electricity industry to provide efficiency advice to customers;

iii. to support my efforts to secure repeal of the Community Gas burn Directive;

iv. to support my intention to bring forward the public sector initiative in energy efficiency;

v. to endorse the need for changes to the proposed Home

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Improvement Grant regime to encourage the development of Community Insulation Projects into private sector community insulation business;

vi. to view favourably the proposals for amendment of the building regulations as regards energy efficiency; and

vii. to note that I am pressing British Coal to seek industrial funding for its topping cycle project, although I may need to bring forward a bid for some government support for this in due course.

I am copying this minute to Geoffrey Howe, Nigel Lawson, Nicholas Ridley, David Young, Kenneth Baker, Paul Channon, John Macgregor, Peter Brooke and to Sir Robin Butler.

SECRETARY OF STATE FOR ENERGY
(approved by the Secretary of State
and signed in his absence)

12 April 1989

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CLIMATE CHANGE - A NOTE BY THE DEPARTMENT OF ENERGY

SUMMARY

Scientific understanding of the climate change problem will not be adequate for a clear appraisal until about 2005. The present uncertainties are too large to warrant drastic changes in energy policies now, but the potential risks are also large, and it would be prudent to avoid adding unnecessarily to the problem. Energy policies in hand in the UK will encourage energy efficiency, use of natural gas rather than coal, and increased nuclear power, in such a way as to hold almost level the expected carbon dioxide emissions from the energy users (excluding transport) in the years around 2000. The gathering and burning of methane from landfill sites could significantly reduce the total emission of greenhouse gases.

INTRODUCTION

1. Concern has grown widespread recently about the possible climate change arising from the fact that human activity is creating "greenhouse gases" at a rate faster than natural processes can cope with. There has been much speculation, based on little scientific evidence: and the worst-case scenarios suggest that the problem is already almost insurmountable, even if concerted international action can be agreed.

2. The activities which are creating this threat are processes which are fundamental to the kind of world in which we now live and the lifestyles which have evolved over the last few decades. These benefits are things which the developed world takes for granted: the developing world, too, would like its share of the advantages of technology. But development has been heavily dependent on the exploitation of fossil fuels as the prime energy source - and it is the burning of fossil fuels which is the largest (although by no means the only) contributor to the emerging greenhouse problem.

3. There is no disagreement within the scientific community that the buildup of greenhouse gases will eventually lead to some increase in the average temperature of the Earth's atmosphere. But, at the present state of knowledge, we do not know how much warming there will be, and to what timescale: nor do we know what the consequences of that warming might be, particularly in terms of the regional

climate changes which might have a significant effect on socio-economic life. A variety of initiatives are under way to try to provide some of the answers - but the natural processes involved are complex, and it will be 10-15 years before the picture begins to be clear enough to see the scale of action that is necessary, and to decide how best to implement it (see Annex 1).

4. While we seek firm evidence it is prudent to take what measures we reasonably can to avoid adding unnecessarily to the problem. This paper considers the contribution which the UK energy supply and use sectors (excluding transport) could make towards that objective. The major energy-related contributor to the greenhouse effect is carbon dioxide (CO2); and the largest single source of CO2 in the UK is electricity generation in power stations (about a third). Industrial combustion accounts for about a quarter of CO2 emissions: the balance is accounted for by transport (c. 17%), domestic combustion (c. 15%) and the commercial and public sectors.

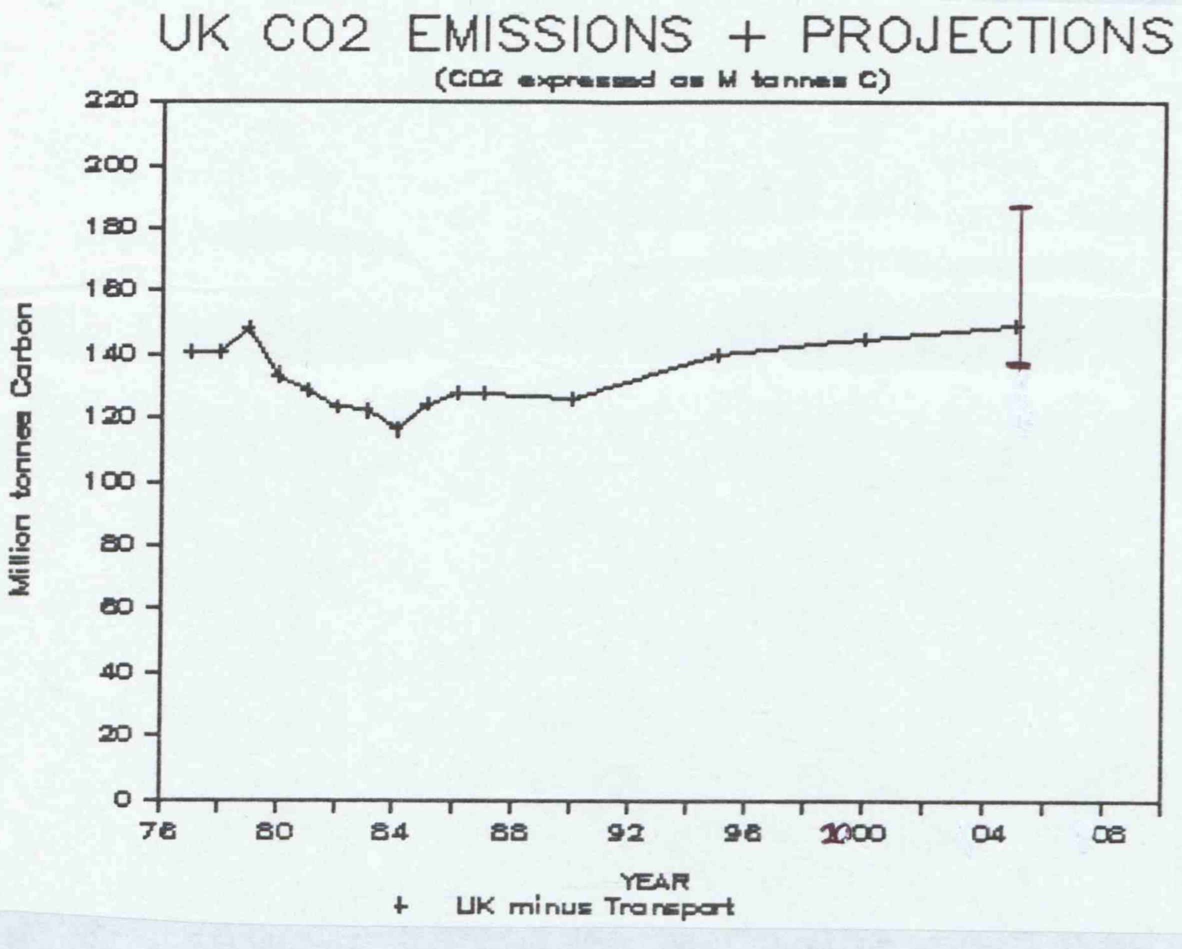
DISCUSSION

5. Contrary to widespread assumption, the UK record on non-transport CO2 emissions has been good in recent years (see Figure 1). From a high of 148M tonnes in 1979, emissions (expressed as Mtonnes of Carbon equivalent) fell to 117 in 1984, and are now beginning to rise again, reaching 128 in 1987. More detailed figures are given in Annex 2. It is prudent, however, to remember that UK total emissions of CO2 are only about 3% of the world total. World CO2 emissions are estimated to have risen some 3-fold between 1950 and 1980, with Western Europe/USA doubling their output; the USSR/Eastern Europe increasing their emissions by a factor of 4; and the developing countries increasing their fossil fuel CO2 emissions, albeit from a low base, by a factor of nearly 7. This pattern of growth can be projected into the future, and some studies have suggested further 3-4 fold increases in CO2 emissions by the year 2050. Much more modest projections have been made, and keen proponents of energy conservation have put forward technical scenarios which halve current CO2 emissions.

6. The important question, of course, is what happens from here on. It is always difficult to predict the future with any accuracy, since the unknown and the unexpected can ruin carefully-crafted scenarios. The simple way to forecast is by linear extrapolation of existing trends; but we know that there are already some factors which will tend to reduce emissions - such as improved energy efficiency, continued

build of nuclear power stations, increased use of natural gas, more efficient coal-burning technology.

7. Energy use generally rises with growth in GDP, but at a lower rate. Many of our energy supply systems in use now will survive till 2005, and there are natural and market forces which place limits on the changes. For any particular mix of supply it is a simple matter to calculate the resulting CO2 emissions; and one hypothetical, but middle ground, estimate of this kind is shown in Figure 1. If this were to be the outcome, we see that the emission levels from all energy use, save transport, in the early 2000s remain almost flat and do not exceed significantly the 1979 peak.



8. The crucial assumptions which led to Figure 1 are: a GDP growth rate of 2.25% till 2005; an energy efficiency improvement of about 0.64% a year, the average since 1973; an electricity supply system which by 2005 includes 14GW generation capacity from natural gas, 4 PWRs, and 1.2GW from renewable energy sources. Annex 2 describes this scenario in more detail. The important point here is that this is

quite feasible under present policies, and it is reasonable to postulate the trend line shown in Figure 1:

- Annex 3 (Energy Efficiency) points out the various initiatives which are ongoing, or about to start - and the public sector campaign will allow the Government, as energy customer, to set a lead;

- Annex 4 (Use of Gas for Electricity Generation) is already beginning to happen - the Minister of State, Mr Morrison, gave consent to gas burn at two power stations (one a new one, at Peterborough; the other a conversion from oil at South Denes) in February 1989;

- Annex 5 (the Nuclear Programme) will be underpinned by the Non-Fossil Fuel Obligation in the privatisation legislation and by the fossil fuel levy: and there will be a renewables element to the NFFO as well.

9. The assumptions which went into the Figure are only one reasonable choice, and some test of variation sensitivity is desirable. If we assume a 1.25% growth in GDP, with only 5GW of gas-fired generation capacity and all else the same, we obtain the low point on the bar line at 2005 in Figure 1. If we have 3.25% growth in GDP, a massive 24 GW of gas-fired generation, but only 1 PWR, we obtain the upper end of the bar line. Again, Annex 2 gives more details.

10. There are also other forces driving in the direction of lower emissions. While electricity privatisation was not planned so as to have a direct impact on the greenhouse effect, a number of polices should have an indirect beneficial effect. The non-fossil-fuel obligation will maintain or slightly increase the amount of electricity generated from nuclear and renewable sources; competition between generators will lead to commercial pressures to improve efficiencies achieved in generation and supply (in particular, many potential independent generators are planning to build combined cycle gas turbine plant with high thermal efficiencies); and the licences which will be issued to public electricity suppliers will contain a requirement to provide guidance to customers on energy efficiency measures. There is scope for greater energy efficiency improvements than those assumed above (Annex 3). It seems unlikely that coal will make a strong comeback in the near future (Annex 6), but, if it does, there will be technologies which can burn it much more efficiently, with consequent reduction in CO2 per unit of energy compared to current plant (Annex 8).

11. Finally, although renewable energy sources are expected to make a useful but small contribution by 2005, in one particular respect they could be significant. Methane from refuse in landfill sites is also a greenhouse gas: molecule for molecule, it is about 30 times more active than CO2, so it is beneficial to burn it before release to the atmosphere. We estimate that about 1 mtce per year of such gas could be collected and burned usefully, with a saving in carbon dioxide equivalent of up to 12 Mtonnes tonnes carbon.

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ANNEXES

1. The scientific timetable
2. Carbon dioxide emissions estimates
3. Climate change and energy efficiency
4. Use of gas in electricity generation
5. UK nuclear programme
6. Likelihood of coal and oil making a comeback
7. Renewable energy sources
8. More efficient coal combustion
9. International Energy Collaboration

ANNEX 1 THE SCIENTIFIC TIMETABLE

1.1 The temperature at the Earth's surface depends on a balance between incoming sunlight and heat being radiated back out to space. It is affected by certain gases in the atmosphere, so called "greenhouse gases", which delay the radiated heat and allow the atmosphere to warm up. The biggest contributor is water vapour, which is controlled by Nature, but other important participants are due to human activities - either by adding to natural biological cycles, as in the carbon dioxide emissions from fossil fuels, or by being wholly artificial, as in emissions of chlorofluorocarbons.

1.2 As the concentrations of such gases rise, they will lead to a rise in average atmospheric temperature and potential long-term effects on wind patterns, ocean behaviour, and rainfall which would be the hallmarks of climate change. How far, and how fast, this might happen is not known. Still less is it known what the effects might be on individual regions of the world. In these circumstances how do we set about improving our understanding?

1.3 Atmospheric temperature measurements have been made for over a hundred years, and it is often claimed that they show a small temperature increase. It is, however, not yet possible to disentangle such an effect with any certainty from climatic variations from other causes. Measurements will clearly continue, but it might need another decade or so of records before the statistics are adequate to decide.

1.4 It is relatively easy to measure the concentration of greenhouse gases in the atmosphere; this is how we know they are rising. But the more chemically active gases (methane, ozone, nitrous oxide) are not fully understood, and there remain questions over their lifetime in the air and their ultimate fate. Even the simpler carbon dioxide raises questions. We know roughly how much extra the burning of fossil fuels is adding, but only about half of this remains in the atmosphere. The rest is swept up in the large natural carbon cycle in a way as yet unclear. Some of these gas processes are slow and complex, others involve natural annual cycles; so, again, one would expect to need measurements over at least several years before the picture clears.

1.5 As the Earth's climate system is unique, the only way of looking ahead in detail is by climate change models. These are sets of elaborate mathematical equations which mimic climate behaviour, and have to be solved on computers.

Detailed understanding of the relevant processes is built into these models, which are compared one against another and validated against what has happened and is happening to the Earth's climate. Computer hardware and methods are developing so quickly that model development per se is unlikely to hold back improvement in our ability to judge the problems. Of greater importance is that crucial parts of the input data have not yet been gathered, and consequently some links in the scientific argument are weak or missing. One such area is cloud formation, where different treatments in the models can cause differences of 50% or more in predicted temperature change. Another is the large scale behaviour of oceans, and recent press discussion of the "El Nino" and "La Nina" ocean currents has pointed up our ignorance.

1.6 Large scale experiments and data gathering on a global scale need to be tackled by collaborative international effort. One vital tool in this is the Earth-observing satellite. There is an outline programme of satellite surveys ranging from Earth Resources Satellite 1(ERS1) to be launched perhaps as early as 1990, through to the proposed US Polar Platform scheduled for the late 1990s, with other possible European and Japanese ventures during that decade. A good deal of this is still tentative. There is as yet no decision on a successor ERS-2 to follow ERS-1, and it appears that the ESA Polar Platform will not now go ahead in its original form. When we consider that satellite launches and performance are in any case risky ventures, it seems unlikely that substantial data could be collected and digested before the early years of next century.

1.7 Satellites are excellent for observing Earth surface phenomena. To understand the oceans, however, there has to be a complementary programme of in-situ observations from ships. Again, there are schemes developing for international programmes. The NERC's Biogeochemical 0ocean Flux Study should begin this year and contribute to a major international programme, the Joint Global Ocean Flux Study. Its data and programmes will eventually be integrated with those from the World Ocean Circulation Experiment whose main effort will occur in the second half of the 1990s.

1.8 Many of these programmes need complex planning and coordination of resources, which just cannot be accelerated by much; and, of course, the programmes themselves have natural time progressions which have to fit with the events being examined. It appears that a detailed scientific assessment of the "climate change problem", and hence definitive, justified advice to policy makers, is unlikely to be available before the early part of next century, perhaps by 2005. This is also the timeframe that bodies such as the IEA have chosen to consider.

ANNEX 2 CO2 EMISSION ESTIMATES

2.1 Warren Spring Laboratory, on behalf of the DoE, have estimated UK emissions of CO_2 retrospectively over the last 10 years. The latest revised figures (expressed as M tonnes carbon) appear in Table 2.1 below. The estimates are made sector by sector, and the sum of the emissions which fall within DEn's remit (basically all energy uses save transport) are also shown in the Table.

2.2 Estimates of emissions of CO_2 in future years are extremely difficult, as so many factors effect their levels, and these factors are unknown and unknowable, eg GDP, fuel price, fuel mix, investment in new plant and ultimate end-use demand. The estimates of future CO_2 emissions (excluding transport) shown in figure 1 of the main paper have therefore been prepared against a number of possible scenarios. The central estimate plotted is based on a moderate to low fuel price increase (with a correspondingly moderate level of price driven efficiency gain). With a GDP growth of 2.25% - within the recent range - changes of structure and demand pattern in 2005 are not going to be great, and the system will generally not be dissimilar to that of today, save possibly for the electricity sector. With its forthcoming restructuring, and with the projected increased use of gas turbines, there will be marked changes to its CO_2 emissions (gas fired plant has lower CO_2 emissions per unit generated). The Non Fossil Fuel Obligation should maintain a sizeable nuclear component up to and beyond the turn of the century; any reduction in nuclear capacity will substantially raise CO_2 emissions. The loss of 1GW of nuclear would possibly require the use of 5-6M tonnes of coal in a fossil station with the emission of 3-3.5M tonnes of CO_2 (expressed as carbon).

2.3 Obviously variations around GDP growth (from a high of 3.25% to a low of 1.25%) will affect demand, the shape of the electricity industry, and resultant CO_2 emissions.

2.4 If in 2005 the final electricity demand is of the order of 350 Twh (cf late 1980s 250 Twh), following GDP growth of 2.25%, and if the electricity system evolved to look like that postulated in Table 2.2 (central) then the UK energy CO_2 emissions (excluding the transport sector) would not be very different from the previous peak energy year of 1979. The pattern suggested shows the introduction of a considerable tranche of heavy duty and combined cycle gas turbines and looks to the completion of the family of four PWRs (Sizewell + 3).

2.5 Lower GDP growth would reduce demand (1.25% leading to 320 TWh), and there would be lower utilisation of existing fossil plant as well as a reduced incentive to invest in new gas powered plant. This is reflected in the line marked "low" in the Table. The CO_2 estimate in this case for the year 2005 is 136M tonnes (carbon) and is shown in figure 1 as the lower limit of the range bar.

2.6 Higher GDP growth (3.25%) would involve much more rapid growth in demand in the electricity sector, perhaps to 420 Twh. This would require much greater investment in new plant - new coal fired plant may have an opportunity and the line in the Table marked "high" shows this. In this case we have also postulated a severe restriction on new nuclear build (only Sizewell B is operated). This would push up CO_2 emissions to 186.5M tonnes (as carbon) and is shown as the upper limit of the range bar in figure 1. Emissions in each case are shown in Table 2.3

Table 2.1 UK CO_2 EMISSIONS Expressed as Mtonnes C

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Total	161.4	162.8	170.7	156	150.4	146.6	145.5	140.7	149.1	154.1	155.1
minus transport	140.6	140.9	148.4	133.5	128.6	124	122.5	116.6	124.6	128	127.9

Table 2.2 ELECTRICITY SYSTEM IN 2005 - Postulated

	Demand Twh	Coal Plant GW	Oil Plant GW	Heavy Load GT&CC	Existing Nuclear	New Nuclear	Renew-ables
Low	320	30	9	5	6.3	4.7	1.2
Central	360	30	9	14	6.3	4.7	1.2
High	420	32	9	24	6.3	1.2	1.2

Table 2.3 PROJECTED CO2 EMISSIONS - UK ENERGY MINUS TRANSPORT

	1990	1995	2000	2005
LOW				136
CENTRAL	126	140	145	149
HIGH				186

ANNEX 3 CLIMATE CHANGE AND ENERGY EFFICIENCY

BACKGROUND

3.1 CO2 emissions from industrial and domestic sources have shown little or no increase in recent years, despite economic growth. At least half of the relative improvement is due to specific energy efficiency measures. Total energy consumed, after rising steadily through the 1960s fell dramatically between 1973 and 1975 with the oil price shock - and despite strong economic growth since 1982 has not yet returned to 1973 levels.

3.2 If the energy to GDP ratio had remained at 1973 levels, the primary energy consumption (ie counting the fuel used to generate electricity rather than the electricity delivered to the user) in 1988 would have been 465 mtce. In fact it was less than 350 mtce. Of this 'saving' we estimate 34 mtce is the incidental outcome of improved technology generally, 21 mtce the changed balance of manufacturing and services in the economy, 12 mtce the result of Gas displacing electricity for space and water heating, and 51 mtce is the outcome of specific energy efficiency measures. (A further reduction of 7 mtce from more efficient fuel conversion is balanced by an <u>increase</u> of 7 mtce in the usage of transport fuels.)

THE POLICY AND ITS ACHIEVEMENTS SO FAR

3.3 Throughout the period, and especially since the creation of the Energy Efficiency Office in 1983, DEn policy has been to stimulate the market for energy efficiency goods and services, by providing reliable and accessible information to energy users about the scope for savings and encouraging the development of the energy efficiency industry without recourse to regulation or general subsidy. The EEO's programme have stimulated savings of over £0.5 billion on the national energy bill.

3.4 We have also raised public awareness of the importance and the potential of energy efficiency, and developed an infrastructure of 'energy managers' in most large companies and a continuing programme of seminars exhibitions and other events. We are now going to build on this foundation with three new initiatives starting this month in April.

NEW INITIATIVES

3.5 The first is a new programme 'BEST PRACTICE', whose aim is to advance and spread good practice in energy efficiency, in collaboration with the leading practitioners. It will inform and stimulate action to bring forward energy efficiency improvements in key sectors and will support the development of new energy efficiency measures. The emphasis is on better information transfer from the best practitioners to the key energy using sectors, end users and decision makers. The programme involves assembling and publishing energy consumption guides which give consumers all the information they need to compare their consumption with what others in their sector are achieving and with what should be technically achievable. Then there are the good practice guides which will show just how the most efficient users get those results. For those already at that level we shall produce new practice case studies presenting the commercial applications of new energy efficient technology, design, management techniques, working practices, training etc. Finally we shall take a share in a number of 'club' R&D projects where several companies are prepared to get together to develop a product or services which are still some way from the market.

3.6 BEST PRACTICE will be tightly targeted on specific groups of users in industry, commerce, buildings, and the domestic sector. The immediate target is to stimulate energy savings with a net present value of at least ten times the cost of the programme.

3.7 The second is a public sector campaign designed to enhance substantially the contribution to overall energy efficiency from this sector, which is responsible for approximately 8% of non transport energy expenditure within the UK. The Secretary of State for Energy has in mind a staged campaign, commencing with energy use by Government Departments, with an initial 5 year programme aiming to improve energy efficiency by 3% per annum. Subsequent stages of the campaign will progressively extend it to the National Health Service and other Non Departmental Government Bodies and to local authorities. Targets for these sectors will be set in the course of 1989/90.

3.8 The third is our regional strategy. The Regional Energy Efficiency Officers, who had been part of the DTI, are now an integral part of DEn. From next month they will have their own delegated budgets for regional promotions, hiring local experts, and marketing. They are themselves undergoing additional training in energy efficiency techniques, marketing, and other business skills. We have set them specific targets for all their marketing, intermediary, and representational work, and emphasised their role as the Department's prime contact with industry, commerce, and local government. They will make a key contribution to BEST PRACTICE and the public sector campaign.

CONTINUING WORK

3.9 Other important work continues, much of it behind the scenes - on promoting Combined Heat and Power, on the Community Insulation Programme, on technical standards (BSI and international), joint policy work with other Government Departments, work with schools, encouraging the energy supply industries to promote efficiency, and nurturing the (still infant) energy efficiency industry. A brief summary is given in the following four paragraphs.

COMMUNITY INSULATION PROGRAMME

3.10 The programme of insulation and draught-proofing for low income householders, using trainees from 'Employment Training' lost some of its impetus during the changeover from the DE's original Community Programme, but the aim is to improve the energy efficiency of 150,000 homes in 1989/90. EEO expenditure of £1m per year harnesses DE Training agency funds of over £40m a year plus outside support (including private sector) for Neighbourhood Energy Action schemes of some £290,000.

COMBINED HEAT AND POWER SCHEMES (CHP)

3.11 CHP, with its inherently greater fuel efficiency over separate heat and electricity generation, gives very significant reductions in atmospheric emissions, for all sizes of plant and all fuel types. The Government has funded a number of studies into various aspects of CHP. It wants CHP schemes to go ahead where economically viable, and believes that their future development should lie with the private sector. It has undertaken to remove the institutional barriers to the implementation of CHP ; for instance, DoE and DEN have agreed that CHP schemes will pay local authority rates on a comparable basis to the main electricity supply industry (e.s.i). In privatising the e.s.i the Government's intention is to provide a 'level playing field' for CHP operators. The new competitive structure of the electricity industry will also present more opportunities for investment in CHP plant.

3.12 Most CHP schemes currently under consideration - whether for buildings, industry or city District Heating - are based on gas firing. There are sound economic as well as environmental reasons for this. Economic advantages include the high efficiencies achievable (typically up to 90%), and the low pollution control costs. On the environmental side, the CO_2 emissions per KWhr from gas-fired electricity generation are less than half those of coal-fired generation. These environmental benefits are further enhanced by the use of CHP technology to displace separate heat and power plants. The low pollution and unobtrusive fuel delivery and storage methods make gas particularly appropriate for urban-sited CHP schemes.

OTHER BEHIND-THE-SCENES WORK

3.13 Beyond these explicit public programmes, the EEO is involved in technical work in establishing codes, standards and regulations which raise the efficiency of plant, appliances and buildings, within Britain and internationally. It works with DoE to enhance the role of energy efficiency in housing and environmental policies, and to enhance the role of energy in education, both generally and for key professional groups. EEO works closely with the major energy suppliers, encouraging them to use their unique access to consumers to provide information and advice. Finally, the EEO in effect sponsors the new energy efficiency industry, providing opportunities for them at home and abroad to develop and market their products and services.

CONCLUSION

3.14 Increased energy efficiency has a very great part to play in reducing demand for energy at any given level of GDP, or level of demand for the services which energy provides. The well established techniques and cost-effective investment which the EEO are promoting enable us to accept and meet the EC target of a 20% energy saving (and concomitant limitation of CO2 emissions) - and greater savings can be achieved by increasingly efficient generation of heat and power in CHP schemes. The EEO's earlier programme of grants and national advertising has already made a substantial contribution to limiting CO2 emissions. Its new programmes, building on this base and on the continuing 'behind the scenes work' in Government and industry, are set to continue this contribution in the years ahead.

ANNEX 4 USE OF GAS IN ELECTRICITY GENERATION - TRENDS AND OBSTACLES

4.1 Gas is increasingly being seen as a potential fuel for electricity generation. This has come about as a result of a combination of circumstances:

- increasing activity in the Southern Basin and improving levels of UKCS gas reserves;

- generally plentiful supplies of gas in Europe, and ready access to gas outside Europe;

- willingness of the oil companies in the post BG privatisation era to consider direct sales of gas to end-users rather than BG itself;

- increased perception by those interested in generation of the benefits of gas generation as a source of fuel - **price, environmental cleanliness** (ease of getting project approvals), **speed** (smaller scale gas fired generating capacity can be put onstream much more quickly than large coal fired or nuclear stations) **efficiency** (combined cycle gas turbines have a significantly higher thermal efficiency than conventional turbines - up to 50% as opposed to 30/35%);

- the opportunities for private generators offered by the privatisation of the electricity supply industry.

4.2 Of the 16 or so proposed major independent power generation projects known to the Department, at least 14 are looking to gas as a fuel source for generation, the others remaining undecided as yet between gas, coal, or oil. It is by no means certain yet how many of these will get off the ground, but together they account for over 6GW of new capacity. If gas substituted for coal in these, it would reduce emissions by 9 million tonnes carbon.

4.3 It is not yet clear to what extent National Power and PowerGen will move into gas fired generation, but we know that they are in the market to buy tranches of available gas. Given the merits of gas burn seen by independent generators it is likely that they will increase their gas burn capability after privatisation.

4.4 The main legal obstacle to the use of gas remains the EC Directive on gas burn in power stations, which seeks to restrict the use of gas on outdated concepts of gas as a 'premium' fuel which should not be used for generating purposes. Whilst lobbying for its removal, the UK has found that projects brought forward can in practice meet the criteria of the Directive, particularly in relation to efficiency and environmental benefits.

4.5 A practical internal obstacle, which is the subject of scrutiny by OFGAS, are the terms on which BG will allow third parties common carrier access to their distribution system. Increased transparency in common carriage, and a demonstration that common carriage arrangements can be set up, would be a helpful stimulus to gas fired projects.

ANNEX 5 THE UK NUCLEAR PROGRAMME

5.1 At present the UK's nuclear power station capacity comprises some 7 GW of plant,including BNFL and UKAEA power stations. In addition,a further 5 GW of AGR capacity still remains to be fully commissioned.

5.2 Electricity generation from nuclear stations in 1987-88 amounted to 45 TWh some 16.5% of total UK electricity requirements. This production reflects low output from the CEGB's AGR's which have been plagued by technical difficulties and which might be expected to increase output over the next few years if the stations reach their full design rating.

5.3 The CEGB's current plans envisage constructing a series of 4 PWRs by the end of the century. Construction on the first of these has already commenced at Sizewell B. The station is expected to be operational by 1994. An application to construct a second PWR at Hinkley Point is subject to a public inquiry and further applications for PWRs are expected in the Spring for Wylfa and Summer for Sizewell C.

5.4 These stations, if built,will add a further 4.8 GW of nuclear capacity by the end of the century, with perhaps a total annual output of around 33 TWh. However this will,to a large extent,be offset by a reduction of around 23 TWh in output from existing Magnox stations (3.5 GW) assuming that the stations close after a life of 30 years. (Berkeley is already scheduled to close this year).

5.5 Whether National Power or other generators decide to construct further nuclear stations after those currently planned will depend on a variety of factors, including the comparative construction and generation cost with conventional stations. Overall there might be a marginally higher nuclear output in 2005 than now, but the difference is unlikely to be significant.

ANNEX 6 LIKELIHOOD OF COAL AND OIL MAKING A COMEBACK (OUTSIDE TRANSPORT SECTOR)

6.1 Since 1960, the amount of coal and oil used outside the transport sector has fluctuated (see figure). But, in practice coal has tended to gain at the expense of oil and vice versa: the proportion of total non transport energy consumption accounted for by the two fuels together has declined consistently since 1960. And the combined level of consumption of the two fuels declined from 1970 until 1983 and has remained approximately constant since then. The question then arises of whether coal and oil can make a comeback.

6.2 It is convenient to look separately at the likelihood of coal and oil making a comeback in electricity generation and in final consumption markets where coal and oil are sold in competition to electricity and gas. By 2005, electricity generation is expected to account for almost 50% of fuel demand outside the transport sector.

6.3 It now looks likely that a high proportion of the new <u>electricity</u> capacity installed up to 2005 will be gas fired Combined Cycle Gas Turbine (CCGT). When fuelled by natural gas, these have lower costs than alternative currently available coal/HFO burning technologies and they also have the advantage of shorter construction times. With the probability that some additional non-fossil capacity is built, this implies that the combined <u>share</u> of coal and oil in electricity generation will decline as that of gas rises. Since electricity demand is expected to continue to grow rapidly, it is nevertheless likely that there will be some increase in the combined <u>level</u> of coal and oil consumption as existing capacity is used more intensively. Continued weakness in the oil price could lead to oil increasing its share at the expense of coal.

6.4 In final consumption markets our expectations are:

- <u>household</u> consumption of coal, other solid fuel and oil will continue to decline. Due to convenience drawbacks, the need for storage space and high capital costs, solid fuel and oil are unattractive fuels for central heating systems except in large old houses outside the gas network;

- on the other hand, we expect industrial consumption of (heavy fuel) oil and possibly coal to increase. Gas is likely to become less competitive for bulk heating than it was in the early 80s, as its price is bid up by demand for gas for electricity generation and the MMC report reduces the potential for price discrimination. The rise of oil and coal in this sector is likely to be limited because of only modest rises in demand for bulk heating - due to factors such as: an increase in industrial (gas-fired) CHP; improvements in energy efficiency; changes in industrial structure (Note: the oil industry do not share our expectation that industrial oil consumption will rise);

- in the commercial sector, there is for similar reasons a possibility that oil will make a comeback. The size of any comeback will be limited by the trend away from large centrally sited boilers (where oil is most competitive) towards small locally sited boilers (where gas is much more competitive). Nevertheless, commercial consumption of oil is on balance likely to increase. Coal consumption will probably continue at its current very low level, which is determined by the political demands of certain local authorities and by the longstanding requirement on Government Departments to show a 5% preference towards coal in evaluating boiler replacements.

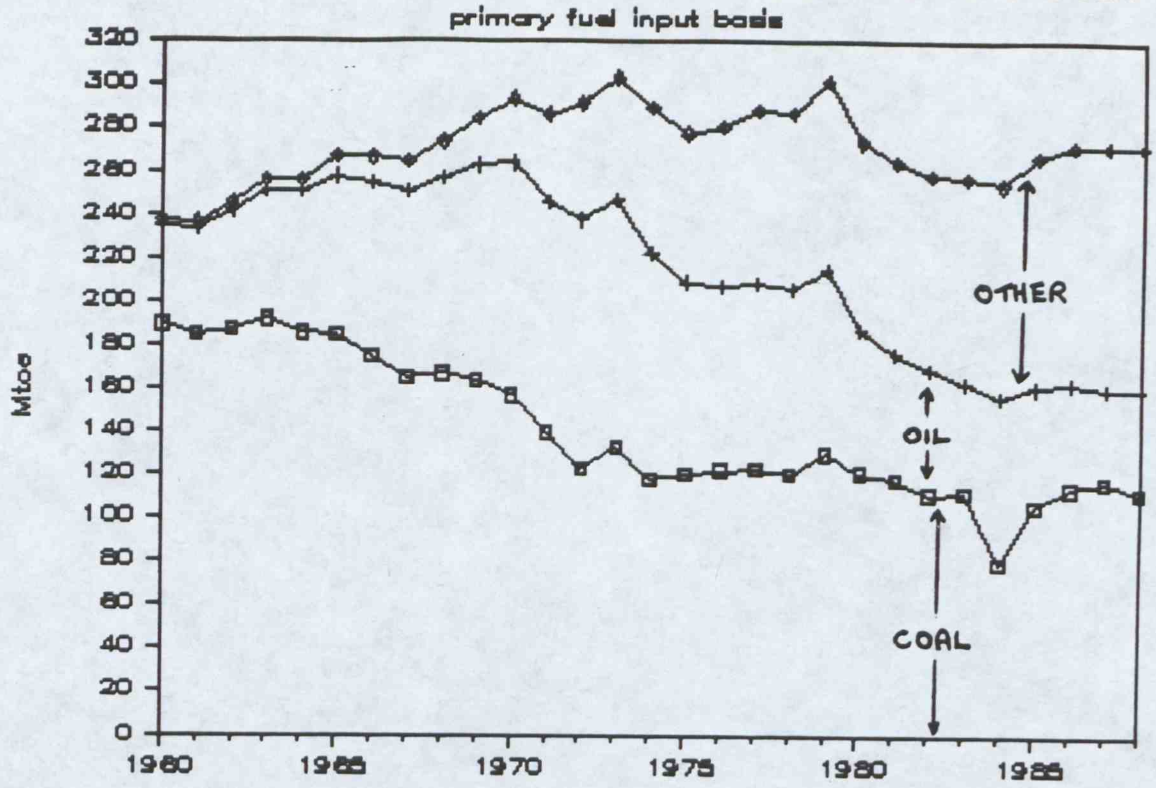
In total, the above suggests there will be some rise in final demand for oil but not coal.

6.5 All this assumes that plentiful supplies of gas are available at reasonable prices from Norway, USSR and elsewhere. The prospects for coal would be much more favourable if OPEC forced up the price and this led to the formation of a cartel of gas producers which pushed up the gas price. It also assumes no major surprises regarding new technology.

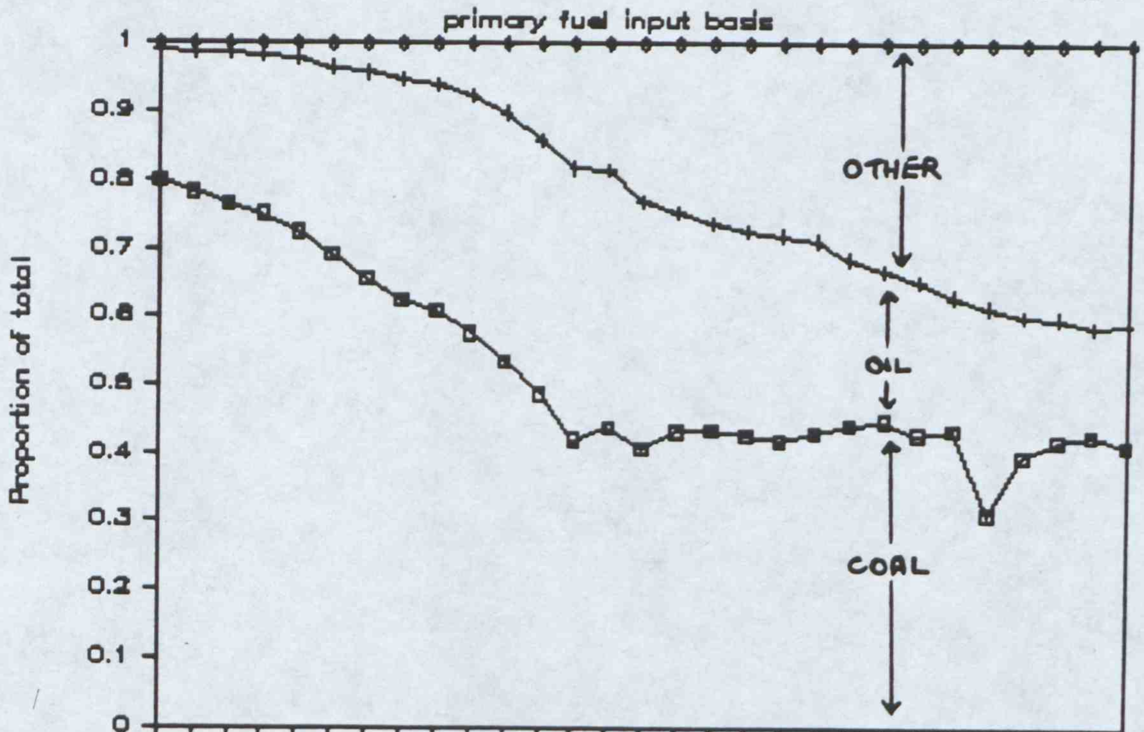
CONCLUSION

6.6 The share of oil and coal in total energy consumption is likely to continue to fall, due mainly to the attractions of gas fired CCGTs for electricity generation. The growth in total energy consumption, and especially electricity consumption, is expected to be sufficient that there is an increase in the amount of oil and coal consumed. This would represent something of a comeback. The increase in oil consumption is likely to be greater than in coal consumption.

ENERGY CONSUMPTION EXCLUDING TRANSPORT



ENERGY CONSUMPTION EXCLUDING TRANSPORT



ANNEX 7 RENEWABLE ENERGY SOURCES

7.1 Only limited use is made of renewable energy at the present time in the United Kingdom. Hydro-electricity provides about 1.5% of the electricity generated, or a little over 0.5% of the 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 wastes provide between one and two million tonnes of coal equivalent, say, 0.5% of the total energy consumption.

7.2 For the future, the position is uncertain, since many of the renewable technologies have not yet been developed to a state where the performance, costs, and the environmental implications can be predicted with any certainty. The Department has, however, been pursuing a programme of research, development and demonstration on renewable energy since the mid-1970s in order to:

- stimulate the full economic exploitation of alternative energy sources in the UK;
- establish and develop options for the future;
- encourage UK industry to develop capabilities for the domestic and export markets.

7.3 It appears likely that renewable energy sources could make a useful and economic contribution to the UK economy beginning in the late 1990s, thereby assisting the diversity of supply. They might also provide some insurance against long lasting, unforseen disturbances in energy supplies in the future. The direct electricity producers such as hydro and wind do not, of course, produce carbon dioxide. Those involving the combustion of biomass such as forest wastes, refuse or landfill gas do, but carbon can be recycled assuming that biomass is replanted.

7.4 One example of the possibilities of development is the combustion of methane, another greenhouse gas inevitably produced from the decay of refuse in landfill sites, for the generation of electricity. This process saves the emission of methane by converting it to CO_2 which is some 30 times less damaging than the methane. It also reduces the need to burn alternative fossil fuels. The Department's earlier R, D & D programmes have shown that the equivalent of 2 Mtce/year could be available for energy production, using existing techniques; the first commercial installations are under way as a result, and a further 30 are in prospect in the near future. Current R & D is expected to lead to a further 1 Mtce/year becoming available.

7.5 The table below shows estimates of the possible contribution from renewables in the UK by the year 2025, at costs which may be competitive with conventional options, and also the technical potential which is ultimately available, though possibly not within today's economic or environmental constraints.

TECHNICAL POTENTIAL, AND ESTIMATED CONTRIBUTION BY 2025 FROM RENEWABLES IN THE UK

Electricity Producers

Technology	Technical Potential TWh/Year	Estimated Contribution TWh/Year
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

Heat Producers

Technology	Mtce/Year	Mtce/Year
Passive Solar	8-14	1-4
Biofuels:		
Wet and Dry Wastes (including Landfill Gas)	22	3-10
Forestry	at least 20	1-5

7.6 If there are pressures, such as environmental considerations, to exploit renewable energy then perhaps it would be possible to exploit the full 70 TWh/y from direct electricity producers and 15 Mtce from combustion as fuels. This would, however, assume complete success in the R & D programme and construction of major projects such as the Severn Barrage, which could itself account for around 14-16 TWh/y of electricity. Lead times are such that this is very unlikely to happen before 2005.

7.7 A more likely scenario is that R & D will only be partially successful, and that financial pressure will force only a small proportion to be exploited. The Non-Fossil

Fuel Obligation within the Bill for the privatisation of the Electricity Industry should, however, provide some stimulus. If initial commercial application begins slowly during the 1990s, then it is possible that between 1 and 3 GW of plant could be built by 2005, producing between 5 and 15 TWh/y of electricity.

ANNEX 8 ADVANCED COAL-BASED POWER GENERATION SYSTEMS

8.1 There are several coal-based power generation systems which have potential for significantly lower emissions of pollutants to the atmosphere than can be achieved with conventional coal-based power stations. These advanced systems are under development, and some are near to full commercial application. Additionally, all of the systems are characterized by higher thermal efficiencies than conventional coal stations. This results in less coal consumption and less carbon dioxide being produced, for each unit of electricity generated.

8.2 A representative listing of these advanced systems is as follows:

Pulverised fuel / flue gas desulphurisation	(PF/FGD)
Circulating atmospheric fluidised bed combustion	(CFBC)
Pressurised fluidised bed combustion	(PFBC)
Integrated gasification combined cycle	(IGCC)
Topping Cycle (British Coal Corp.)	(TC/BCC)

Indicative efficiencies and capital costs of these technologies, as estimated by British Coal, are:

Technology	Efficiency(%)	Capital Cost(*)
PF/FGD	37	1
CFBC	38	0.9
PFBC	39	0.8
IGCC	39	1.1
TC/BCC	44	0.8

* The capital cost figures are the costs per MW relative to those for PF/FGD, assuming that each system generates the same quantity of electricity.

8.3 With the exception of PF/FGD and atmospheric pressure CFBC, power generation based upon each of these advanced technologies would utilize a combined cycle, by which power is generated by a combination of steam turbines and gas turbines. In a conventional power station, electricity is only generated from steam turbines. Brief descriptions of the systems follow.

PF/FGD Currently, all of the major coal based power stations in the UK burn the coal after it has been reduced in size (pulverised) and blown into the furnace. Significant quantities of carbon dioxide and nitrogen oxides (NOx) are produced, and they are discharged to the atmosphere together with virtually all of the sulphur (in the form of sulphur oxides, SOx) associated with the coal. Flue gas desulphurisation is a generic term for several processes by which most of the SOx is removed from the flue gases. The sulphur is discharged from these processes as either solid gypsum, elemental sulphur, or as sulphuric acid, and there are commercial applications of FGD worldwide. Incorporating FGD into a PF plant reduces its thermal efficiency and increases its capital and operating costs. It is possible to reduce the amount of NOx emissions from these plants, by modifying the type and arrangement of burners. The CEGB is currently undertaking this work in some of its stations.

CFBC Instead of burning the coal as small particles in a fireball, fluidised bed combustion burns the coal in a bed of inert material such as sand or coal ash, which has been heated to a high temperature, and which is in turbulent motion because of jets of air passing through it. Most of the sulphur is removed by feeding limestone into this bed, and producing a solid mixture which incorporates gypsum and ash. The amount of NOx produced from fluidised bed combustion is significantly less than that produced by PF/FGD. The CFBC variant of fluidised bed combustion burns the coal and blows the particles of char and bed material out of the large combustion vessel into another vessel which contains the steam raising heat exchangers. This arrangement is designed to reduce the amount of erosion on the heat exchange surfaces. There are examples of this technology, where the coal is burnt at atmospheric pressure, applied commercially overseas. If combustion were to occur at elevated pressure, the gases could pass through a gas turbine and therefore incorporate a combined cycle, with its inherently higher efficiency. This development is still pre-commercial.

PFBC is different from CFBC in that the bed material is coal ash rather than sand, and the solids are not circulated to a different vessel for heat exchange. Instead, the bulk of the solids are retained in the combustion vessel, and heat exchange surfaces are submerged in the bed. Since this vessel is pressurised, the gases can pass through a gas turbine and so generate additional electricity. Emissions from PFBC are broadly similar to those from CFBC. The experimental facility at Grimethorpe has been used to develop PFBC, but it is the Swedish/Swiss company, ABB, which is commercializing the technology.

IGCC With IGCC, the coal is not burnt, but is partially oxidized (gasified) at pressure to yield a fuel gas. This gas is burnt in a gas turbine and because of the higher temperature than that achievable with PFBC, the gas turbine generates more power. There are various competing gasifier technologies available, including those developed by Texaco and British Gas/Lurgi (BGL). The world's first IGCC station uses the Texaco gasifier and is in operation at Cool Water in the USA. The BGL gasifier is being developed at Westfield, Scotland. Emissions of both NOx and SOx from IGCC are equivalent to, or less than those achievable by fluidised bed combustion.

TC/BCC The Topping Cycle is a combination of both IGCC and fluidised bed combustion (either CFBC or PFBC). Coal is fed into a gasifier, but only a portion is reacted to form the fuel gas. The remaining char flows to a combustor, the gases from which are passed through a gas turbine in a similar arrangement to a PFBC combined cycle plant. The temperature of the gas entering the gas turbine is increased by combining it with the fuel gas from the gasifier and burning the resultant mixture. A higher efficiency is therefore achieved, and the total system produces emissions of SOx and NOx similar to those produced from IGCC or PFBC. This technology has not been developed, but is being considered by British Coal and by foreign companies.

Annex 9 International Energy R&D Collaboration

1. The UK is playing an important role in the international consideration of the greenhouse effect being coordinated under the Intergovernmental Panel on Climate Change (IPCC). As well as chairing one of the working groups (on the science of the greenhouse effect), the UK is also participating in the other two working parties on impacts and response strategies. The Department of Energy is taking a lead in the latter's sub-group on Energy, Industry and Transportation, and has played an active role in focussing the work of the group in productive directions.

2. The UK is also participating in International Energy Agency work on climate change and has taken the initiative in steering the work of the IEA and OECD in directions supportive of the IPCC. The UK is seeking the acceptance of the International Energy Agency (IEA) within the Working Party on Response Strategies as the main international source of technical expertise on energy questions. The IEA (OECD countries, less France and 3 others) in conjunction with OECD is holding a seminar on the R&D challenges presented by the greenhouse effect to energy technology on 12-14 April. The UK will be providing the largest number of speakers of any country. The IEA has also organised under the auspices of the IPCC a meeting on 10/11 April on the methodologies for assessing policy options for reducing greenhouse gases; the Department of Energy will be providing a speaker. The results of these meetings will be fed into further work being done by the IEA and OECD on the energy background to the greenhouse effect which will in turn be made available to the IPCC.

3. The European Community also funds programmes concerned with promoting new energy technology which may be relevant to combating the greenhouse effect. In March 1989, the JOULE programme for R&D into energy efficiency, renewables and coal technology was agreed to run for 3 years from 1989-1991 with a total funding of 122 mecu. In addition, the Commission is currently preparing proposals for successors to the Community Energy Demonstration Programme and the Community programme in oil and gas production technology, both of which end in December 1989. Following an evaluation of both programmes, proposals have recently been submitted for a successor programme which will involve, in the case of energy efficiency and renewables, a more targetted approach to secure the dissemination of information more widely to potential users. The UK will be taking an active part in discussions on the new proposals which are expected to begin shortly.