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PRESENTATIONS

"Scientific Assessment of Climate Change and its Impacts"

by

Professor T M L Wigley, Climatic Research Unit,
University of East Anglia

"Options for mitigating the Greenhouse Effect"

by

Dr K Currie, Energy Technology Support Unit

DEPARTMENT OF THE ENVIRONMENT

OPTIONS FOR MITIGATING THE GREENHOUSE EFFECT

by Ken Currie
Energy Technology Support Unit

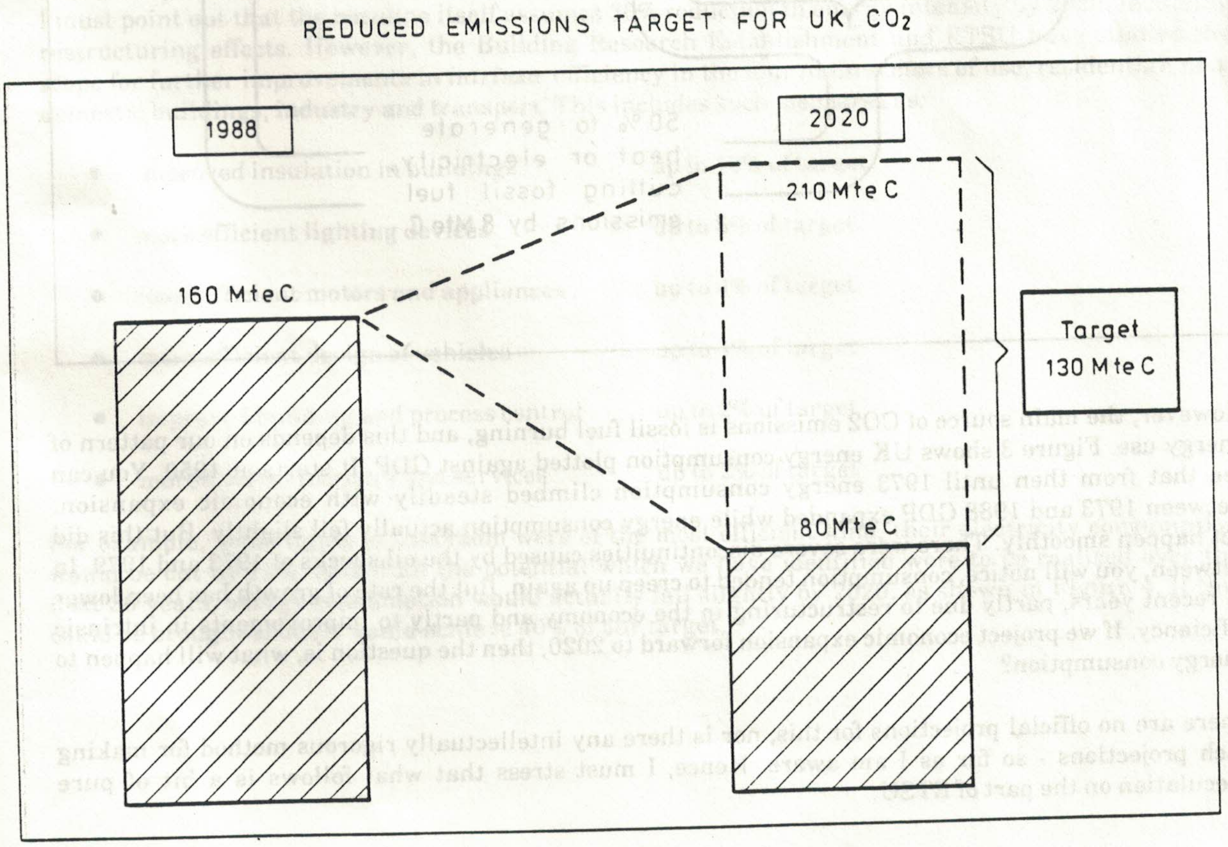
Introduction

Professor Wigley has given us a global perspective on the greenhouse gases and climate change. I thought it might be helpful if I were to focus down on the more parochial question of what we in the UK might actually *do* to reduce emissions. I shall not consider adaptative measures or changes in lifestyle.

First of all some assumptions. Let us assume that the current scientific consensus is confirmed. So we have a real problem to deal with. Second, I shall take it that there is international agreement on concerted action, along the lines of the Toronto Conference, where it was suggested that it would be necessary to cut emissions by 50% or more. For simplicity, let us concentrate today on CO_2, which accounts for a little over half the present warming. Fourth, for the purposes of exposition, I shall assume a hypothetical target of 50% reduction in CO_2 by 2020. Finally, let us suppose that Britain must contribute pro rata to that goal, and that our economic growth rate is $2\frac{1}{4}$% per annum.

What all this boils down to is that, under these hypothetical circumstances, we would have to cut our emissions of CO_2 from 160 million tonnes of carbon per annum today, to 80 million in 2020 (Figure 1). Without action the emissions would go up to 210 million or more; instead, we have got to reduce them from that by 130 million tonnes per annum. That is our target! What then are the practical prospects for bringing about such a reduction? I am now going to list eight options and speculate about what each, *in isolation*, might contribute to this target.

Figure 1

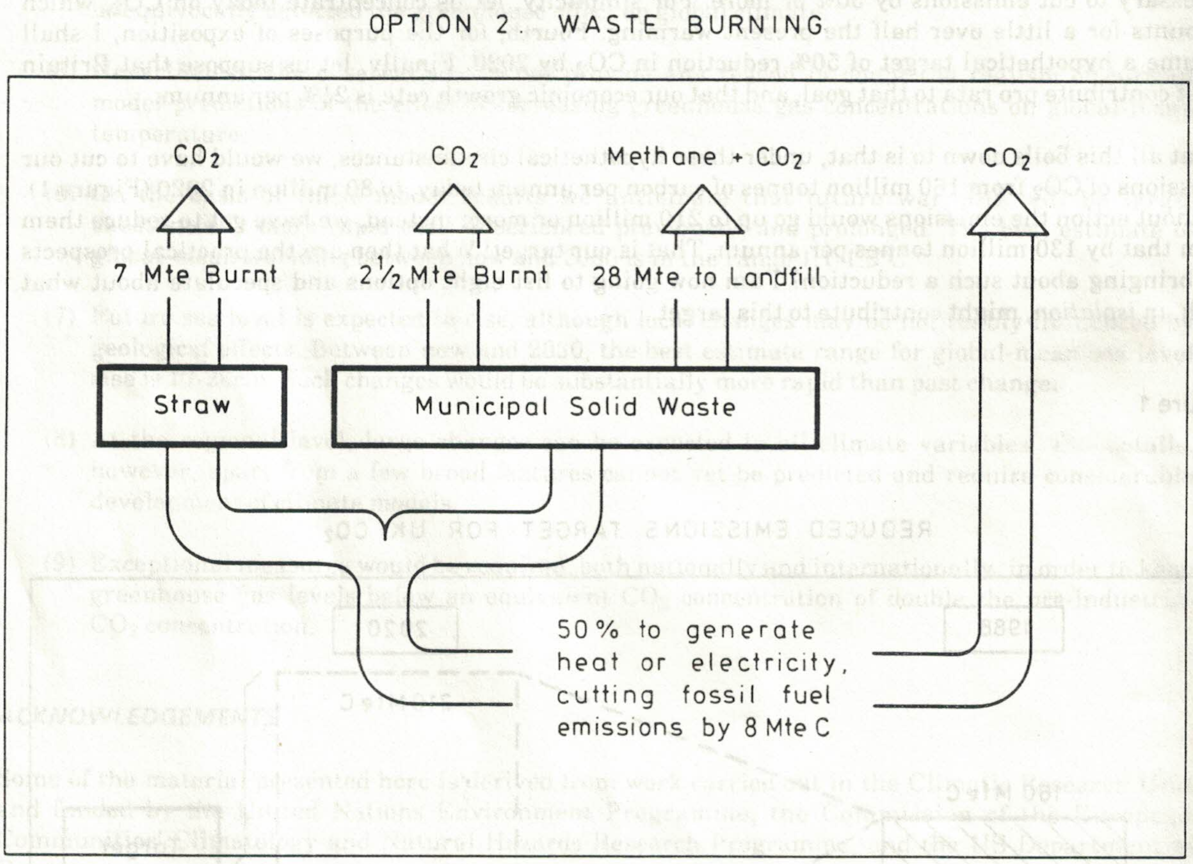


The Options

Option 1 is reforestation. This could help by absorbing some of the CO_2. About 10% of the UK is wooded, and studies done for ETSU suggest that this could be expanded to 25%. If the area were doubled, and the extra land devoted to broadleaf species, 3 million tonnes of carbon could be absorbed per annum, and that would contribute 2% of our target.

One of the renewable options is energy from waste. Seven million tonnes of straw are burnt annually and 2.5 million tonnes of waste, while another 28 million tonnes of waste is put to landfill, where it also emits methane, a more potent greenhouse gas than CO_2. If the proposals for waste management outlined in the recent report by HM Inspectorate of Pollution are implemented, that will cut methane emissions. If, in addition, half of all these wastes were used to generate heat and electricity, that would reduce emissions by the equivalent of 8 million tonnes of carbon and contribute 6% to our target (see Figure 2).

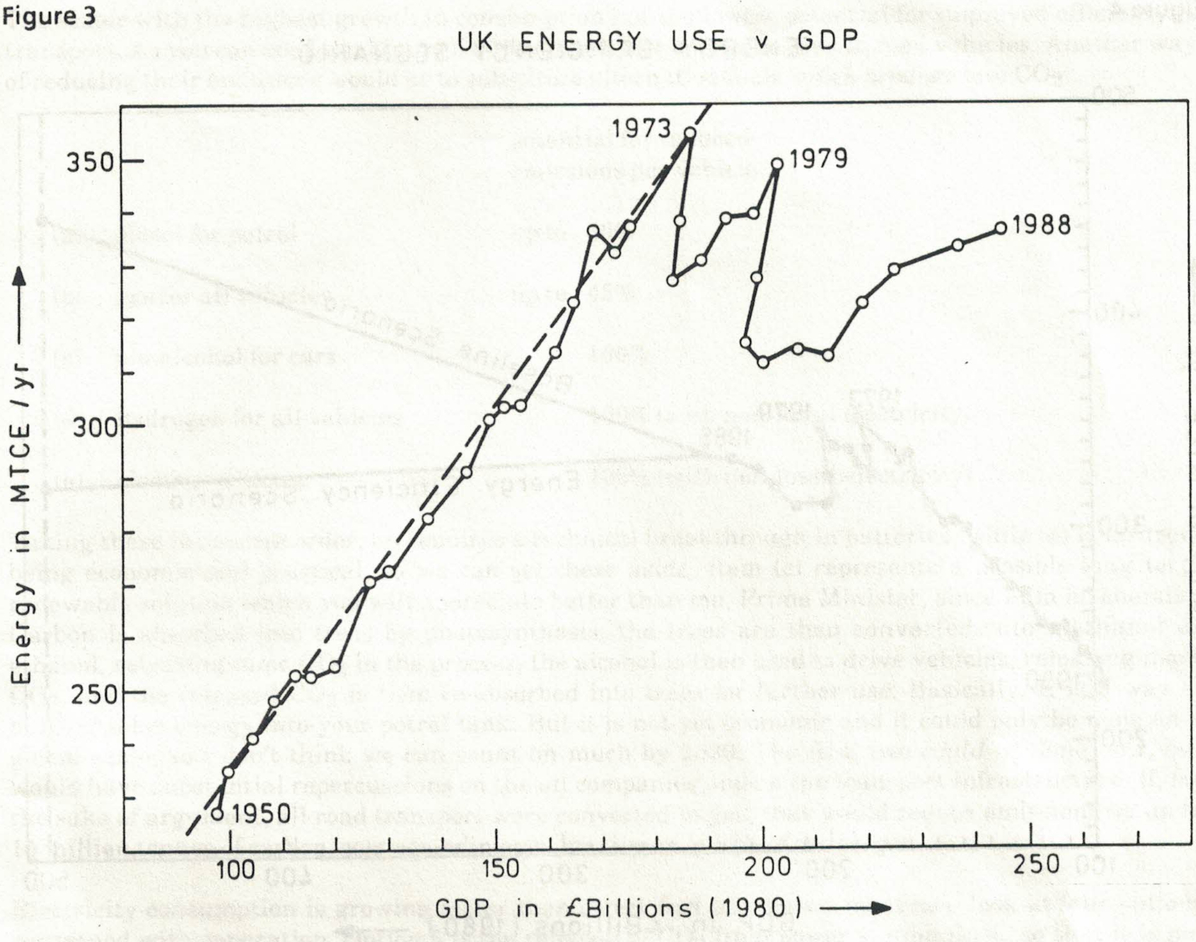
Figure 2



However, the main source of CO2 emissions is fossil fuel burning, and this depends on our pattern of energy use. Figure 3 shows UK energy consumption plotted against GDP. It starts at 1950. You can see that from then until 1973 energy consumption climbed steadily with economic expansion. Between 1973 and 1988 GDP expanded while energy consumption actually fell slightly. But this did not happen smoothly. There were severe discontinuities caused by the oil shocks of 1973 and 1979. In between, you will notice, consumption tended to creep up again. But the rate of growth has been lower in recent years, partly due to restructuring in the economy and partly to improvements in intrinsic efficiency. If we project economic expansion forward to 2020, then the question is, what will happen to energy consumption?

There are no official projections for this, nor is there any intellectually rigorous method for making such projections - so far as I am aware. Hence, I must stress that what follows is a bit of pure speculation on the part of ETSU.

Figure 3



My baseline assumption is that, in the absence of further oil shocks, energy consumption will continue up on its present trend, as shown in Figure 4. *All my numbers are related to this baseline*, and I must point out that the baseline itself assumes 30% reduction in energy intensity by 2020, including restructuring effects. However, the Building Research Establishment and ETSU have studied the scope for further improvements in *intrinsic* efficiency in the four main sectors of use, residential, non-domestic buildings, industry and transport. This includes such measures as:

- improved insulation in buildings — up to 10% of target
- more efficient lighting devices — up to 5% of target
- more efficient motors and appliances — up to 4% of target
- more efficient design of vehicles — up to 4% of target
- improved building and process control — up to 2% of target
- more CHP in industry and services — up to 2% of target

For example, if the lights in this room were of the most efficient kind, their electricity consumption would be cut by 75%. And if all the potential which we have identified were to be realised over the next 30 years, energy consumption would actually fall slightly by 2020, as shown in Figure 4. If this could be brought about it would achieve 40% of our target.

Figure 4

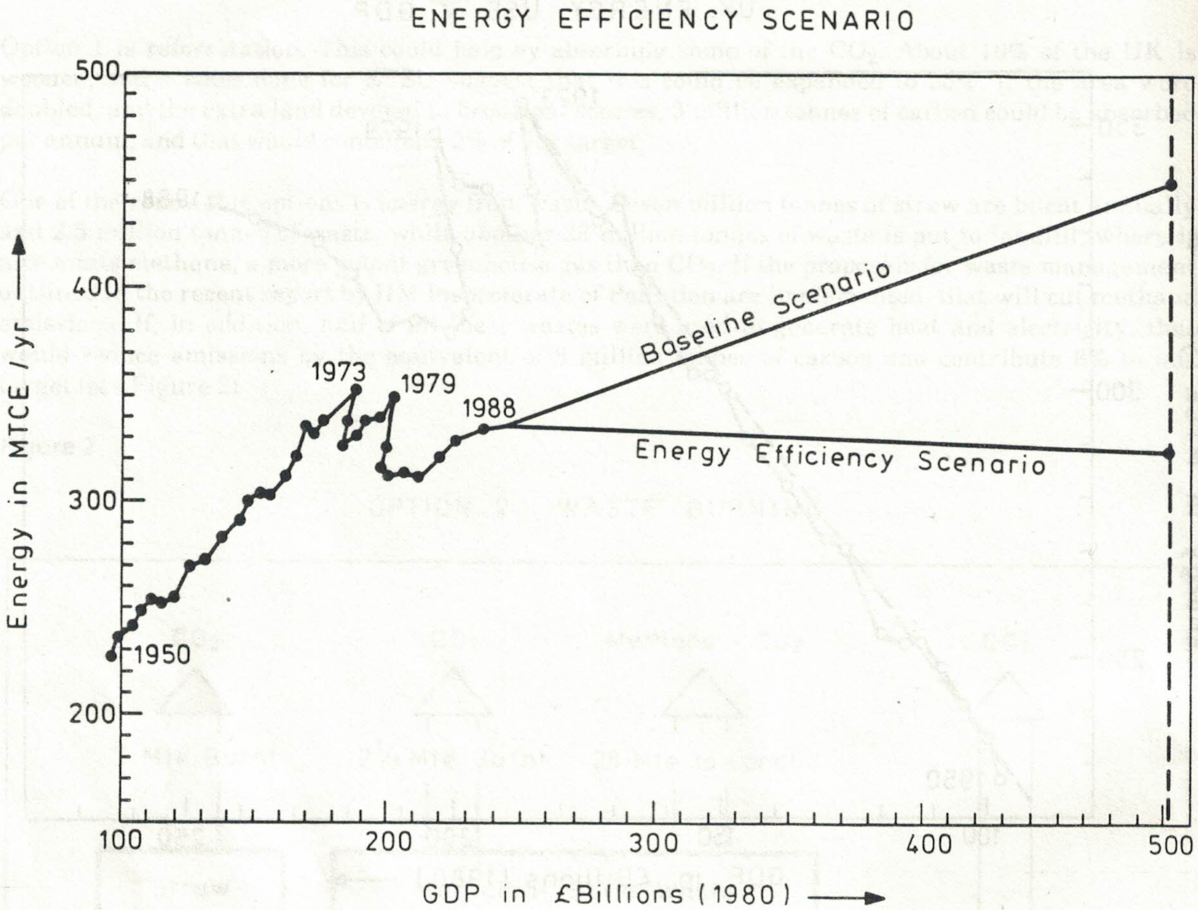
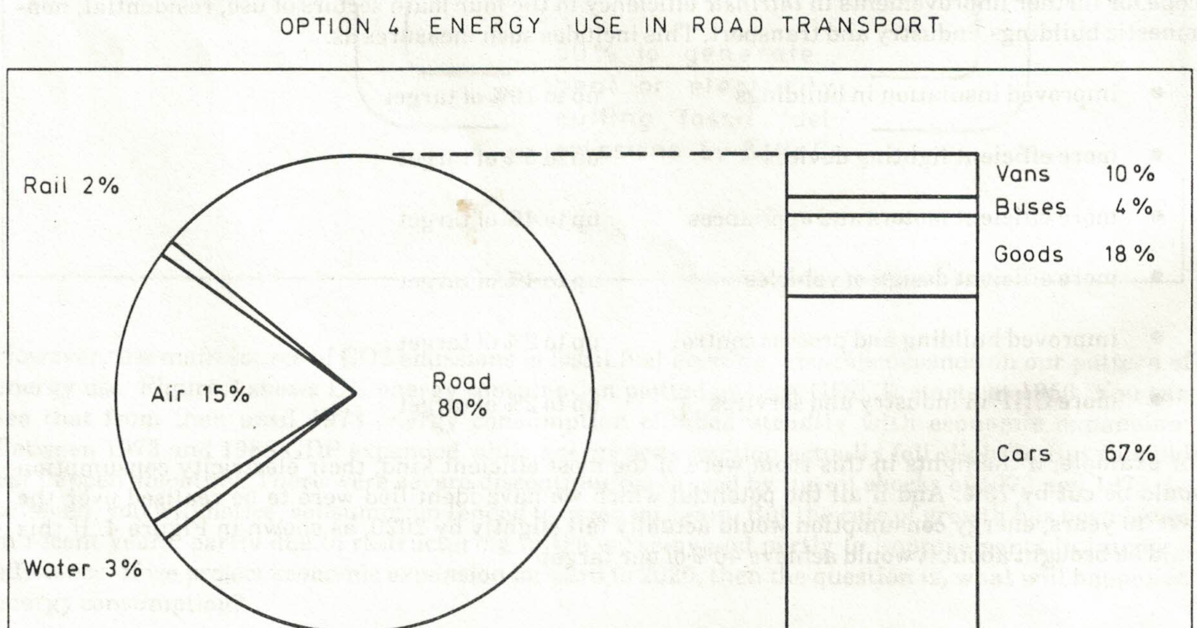


Figure 5



The sector with the highest growth in consumption but the lowest potential for improved efficiency is transport. As you can see from Figure 5 80% of transport energy is used in road vehicles. Another way of reducing their emissions would be to substitute alternative fuels which produce less CO_2:

		potential for reduced emissions per vehicle
(a)	diesel for petrol	up to 30%
(b)	gas for all vehicles	up to 45%
(c)	bio-alcohol for cars	100%
(d)	hydrogen for all vehicles	100% (with non-fossil electricity)
(e)	electric vehicles	100% (with non-fossil electricity)

Taking these in reverse order, (e) requires a technical breakthrough in batteries, while (d) is far from being economic and practical, so we can set these aside. Item (c) represents a possible long term renewable solution which you will appreciate better than me, Prime Minister, since I am no chemist. Carbon is absorbed into trees by photosynthesis; the trees are then converted into methanol or ethanol, releasing some CO_2 in the process; the alcohol is then used to drive vehicles, releasing more CO_2, and the released CO_2 is then re-absorbed into trees for further use. Basically, it is a way of putting solar energy into your petrol tank. But it is not yet economic and it could only be done on a global scale, so I don't think we can count on much by 2020. The first two *could* be done now, but would have substantial repercussions on the oil companies and on the transport infrastructure. If, for the sake of argument, all road transport were converted to gas, that would reduce emissions by up to 15 million tonnes of carbon, corresponding to a maximum of 12% of the target.

Electricity consumption is growing faster than direct fuel use. So we must now look at four options concerned with generation. Option 5 is the removal of CO_2 from power station flues, so that it is not emitted into the atmosphere. This is thought to be technically feasible, and the CO_2 could be pumped down oil wells for enhanced oil recovery. But, it would probably double the cost of electricity production, and it is not yet proven, so I have assumed that there will be no more than perhaps one commercial demonstration by 2020, contributing 2% of our target.

Option 6 is electricity generation from one or more of the following renewable energy sources:

(a) Biofuels (including some waste)

(b) Onshore wind

(c) Small-scale hydro

(d) Tidal energy

(e) Geothermal hot dry rocks

(f) Wavepower

The technical potential for these is very large, but the basic issue is one of economics. Being optimistic, we might assume that by 2020 renewable sources contribute 40 TWh/y. That is about 14% of current supply and would contribute 7% of the target.

Next we have nuclear power with a large technical potential, but also facing a number of problems. Who can say what the level of nuclear generation might be in 2020? For the purposes of this presentation, let us assume that all planned baseload power is nuclear, so that the economic returns are most favourable. Nuclear would then contribute 50% of the electricity supplied; that would require 24 new PWRs; it would cut emissions by 30 million tonnes per annum; and it would contribute 23% of the target.

The last option is alternative methods of fossil fuel generation, where there are a number of sub-options. These help in two ways, by substituting gas for coal, and by using more efficient systems of generation:

		potential reduction in emissions per kWh
(a)	substitution of gas for coal	45%
(b)	combined cycle, using gas	57%
(c)	district heating/CHP (coal based)	14%
(d)	combined cycle, using coal	7%
(e)	fluidised bed combustion of coal	7%
(f)	generation by fuel cell (gas)	67%

Item (f) is not technically proven and (a) is not terribly attractive by itself on a large scale for new plant, but in ETSU's view, 40% of the maximum technical potential might be realised through some combination of the sub-options (b) to (e), contributing 15% of our target.

Projected Results

These eight options are summarised in the following table. The first column indicates the technical potential, the second the economic potential, the third the practicability and the fourth the degree of political controversy. Green indicates 25% or more of the target, and/or no problems; amber is 5-25% of the target, and/or significant problems; while red indicates less than 5%, and/or serious problems. The last column lists the speculative contributions which I have given earlier.

OPTION	TECHNICAL POT.	NEAR ECONOMIC POT.	PRACTICABILITY	CONTROVERSY	SPECULATIVE CONTRIBUTION
1. Reforestation	RED	RED	AMBER	AMBER	2%
2. Waste burning	AMBER	AMBER	AMBER	AMBER	6%
3. Energy efficiency	GREEN	GREEN	AMBER	AMBER	40%
4. Alt transport fuels	GREEN	AMBER	RED	RED	12%
5. Removal of CO2	GREEN	RED	RED	AMBER	2%
6. Renewable electricity	GREEN	AMBER	AMBER	AMBER	7%
7. More nuclear power	GREEN	AMBER	AMBER	RED	23%
8. Alt F F generation	GREEN	AMBER	AMBER	AMBER	15%

Now, some of you may have added up the final column of numbers and felt a sense of relief because it comes to more than 100%! But that's not allowed, because these numbers are for each option in isolation, whereas there are complex interactions between the various options. So let me be quite clear about what the table says. Technically it could be done. But many of the technologies are not economically attractive. And in all cases there are practical obstacles and controversial issues to be overcome. So it is difficult to see how we could halve our emissions by 2020.

To put the economic aspect into perspective, it would need at least a doubling of the price of energy to make some of the supply options attractive to investors.

To illustrate the practical difficulties, let me go back to the energy efficiency option (Figure 4) because, on paper, this offers the greatest scope. Despite great technical and economic potential for improved efficiency, however, it is very difficult to make it happen. This is because:

- it requires a very large number of small and disaggregated actions
- these are peripheral to the 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.

The energy Efficiency Office has a well thought out approach designed to tackle these barriers. It has probably achieved better value for money than the efforts of most other countries, where the emphasis has been more on subsidies and regulation. Nevertheless, 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 much below the baseline.

Developed and Developing Countries

Before I conclude, a brief word about the developed and developing countries. The picture which I have presented will not be fundamentally different for any of the OBCD countries. Different countries would give different weights to the options, of course, but they would mostly be looking at the same list of options.

The position, in the developing countries is fundamentally different. At present, many of them could not meet even the basic necessities without increasing their energy consumption, and they do not have the finance or the expertise to pursue many of the options which I have just described. Hence, it would be extremely difficult for them to cut emissions without arresting economic development.

To put our own situation into the global context, the following table summarises world energy data for 1986. It shows how small our own energy component is on a world scale and also how the energy per capita of the industrialised countries is an order of magnitude higher than that of the developing countries.

	UK	Other OECD	CPEs	3rd World	World
Energy (Mtoe/y)	208	3,575	2,658	1,158	7,598
Population (M)	57	729	1,466	2,664	4,917
Energy/Capita	3.6	4.9	1.8	0.4	1.5

Conclusions

I would now like to draw a few tentative conclusions from this admittedly over-simplified analysis. First, there is no single option which could achieve the desired results; a multi-pronged approach would be required. We probably need a complex solution to this complex problem.

Second, even if the options were pursued in the optimistic manner which I have described, it would be difficult to reach the target.

Third, the three most promising areas for the UK in the short to medium term would seem to be energy efficiency, nuclear power and the substitution of gas for coal and oil.

Finally, a note of caution. It is relatively easy to identify technical options and work out their potential effect on emissions, as I have done. Lots of people have been doing this recently. It is much more difficult to form a judgement about which options offer the best economic prospects, and not so many people have been doing that. Yet that is what really matters at the end of the day. Hence, the formulation of policy might be more robust if it were underpinned by some careful economic analyses, and I am sure that a number of companies would be happy to assist with this.

I trust that this brief outline of the options provides a useful basis for discussion.