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cc Mr Wilson
Mr Monger

MR MORRIS

GLOBAL CLIMATE SEMINAR

I attach draft minutes of the Prime Minister's seminar on 26 April.

2. As agreed after the seminar, I have produced a fairly full record, attributing views to the various contributors rather than attempting to draw the points together into a set of common themes. Given the nature of the event, I think this must be the better approach.

3. The only major contribution for which I have not produced a full precis is Dr Holdgate's introduction to the afternoon session, both because it was a summary of the morning's discussion, and because he has produced his own written version. I suggest that when his final text arrives it should form Annex A to the record.

ANDREW WELLS

4 May 1989

Geo
DTI
Energy

RECORD OF THE PRIME MINISTER'S SEMINAR ON THE GLOBAL CLIMATE

12 Downing Street, Wednesday 26 April 1989

THE PRIME MINISTER welcomed the participants to the seminar, the purpose of which was to provide herself and other Ministers with a better understanding of the scientific facts of global climatic change, and the implications which followed from them.

She recognised that the state of knowledge was still developing, and that firm conclusions might not yet be available in many areas. Nevertheless there were areas where empirical lessons were already clear. The advance of scientific knowledge had allowed the growth of much larger human populations than at any previous time. This and industrial development were interacting with the atmosphere in ways which seemed likely to give rise to global warming. It was essential to tackle this problem, to ensure that we handed on a decent environment to our descendants. To do that it would be necessary to identify routes to sustainable economic development.

It was vital that participants in the seminar should be able to speak freely. The seminar would therefore be conducted according to Chatham House rules: that is each person would be free to say to the Press or in public what he had contributed to the seminar, but should not attribute views or statements to others who had participated.

I. Scientific assessment of climate change and its impact

PROFESSOR TOM WIGLEY, said that he aimed to summarise existing knowledge on climatic change, and the uncertainties which affected it. The prediction of global warming was based on the knowledge that the concentrations of a number of greenhouse gases in the atmosphere were increasing as a result of man's

activities. The most important were carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs).

Over the last few hundred years the concentration of carbon dioxide had increased by about 25%, that of nitrous oxide by about 10%, that of methane had doubled and the concentration of CFCs had risen from zero to measurable levels. The prospect was for further substantial increases in carbon dioxide as less developed countries (LDCs) became more industrialised and as deforestation continued; and in methane as agriculture became more intensive to support larger populations. On the other hand the Montreal Protocol would, if successful, lead to a substantial slowing of the increase in CFC concentrations in the atmosphere. The net effect of these changes could be expressed in terms of the equivalent concentration of carbon dioxide. The prospect on a "business as usual" basis appeared to be for a doubling of the pre-industrial level of greenhouse gases by the later 2020's, although there were considerable uncertainties which meant that this level could be reached much earlier or later.

To estimate the increase in temperature which was likely to arise from a given increase in the concentration of greenhouse gases it was necessary to use models of the global climate. Existing models suggested that a doubling compared to the pre-industrial level would in time lead to a new equilibrium with global mean temperatures between 1.5°C and 4.5°C above the historical level. But there would be a time lag before this equilibrium was reached: if the greenhouse gases doubled by the late 2020's the full effect might not be felt until around 2075.

One test of these models was the extent to which they were consistent with past changes in global temperatures. There had been a rise in average temperatures of about 0.5°C over the last century and this was broadly in line with the lower bound of the predicted changes in temperature. So the output of the models was not inconsistent with measurements of actual climatic changes

to date. But it was too early to claim that global warming due to the greenhouse effect was an established fact.

The detailed implications of the greenhouse effect for the global climate were likely to be very complex. There would be different effects as between different regions, as between different seasons and so on. Increases in sea levels could be expected, whose implications would vary depending on local geographic and geological factors. Existing global climate models were not sufficiently developed to provide any reliable predictions of these effects.

Finally, it was clear that exceptional measures would be required from the international community if the increase in the concentration of greenhouse gases was to be contained. Even to limit the increase to twice the pre-industrial level would require substantial reductions in existing emissions from the developed countries, and severe constraints on the increases in emissions from less developed countries.

DR JOHN HOUGHTON said that the international scientific effort on the global climate was being coordinated through the International Panel on Climate Change (IPCC) under the United Nations Environment Programme (UNEP). He chaired the group on the basic science. This provided the mechanism to involve the 200 or so scientists world-wide who had real expertise in this field. It was clear that two things were needed to allow better predictions of climatic changes: more observations of existing climatic processes as an input to models; and better models to turn those observations into predictions of the future. The work in his group was concentrating on five areas: transient responses; the estimation of uncertainties; regional effects; extreme climatic processes; and the timetable on which improved predictions could be made available. The hope was that the group's work would achieve some convergence between the different global climate models in use throughout the world, leading to

agreed predictions in which the scientific community could have some confidence.

PROFESSOR MARTIN PARRY said that it was necessary to consider the likely effects of climatic change on the economy and on society. Three questions needed to be answered: what and where the impacts would be; where they would be significant; and what were the costs of adapting to change as proposed to preventing it. It was already possible to provide preliminary answers in relation to some aspects of the greenhouse effect. For example, a rising sea level would lead to loss of land for rural settlement and agriculture in many parts of the world. In the UK it had been estimated that around £5 billion would need to be spent on improved sea defences. Even with that level of spending there would be some land loss, and some salt penetration of groundwaters currently used for abstraction. As far as agriculture was concerned, the major effects on the United Kingdom (UK) might be indirect: the loss of land and of potential agricultural production in some LDCs could destabilise the international food system, with implications for the UK. But as against this, there could be beneficial effects on agriculture in some areas as a result of higher temperatures and the direct fertilizer effect of higher carbon dioxide concentrations in the atmosphere. Climatic change was also likely to affect forests. On some estimates, the margin of cultivation for some species of trees might move northwards by 50-90 kilometres per decade. However the ability of forests to shift their boundaries might be limited to something like 10 kilometres per decade. The result might be a progressive reduction in the area of forestation. Finally, increased evaporation and changes in rain fall might effect water supplies, leading to real shortages for domestic, industrial and other uses in certain areas.

PROFESSOR JAMES LOVELOCK said that the increase in global average temperatures on some estimates could be as large as twice the difference in temperature between the present day and the most

recent ice-age. The speed and magnitude of the change would be unprecedented, and there could be major surprises in store, which would not be predicted in any model. One possible source of such surprises could be the interaction between cloud cover and the growth of organisms in the oceans. The possible feedback effects in this linked system needed further research. A second possible area was deforestation in the tropics, which would become complete during the next century, just as the greenhouse effect was taking off. This could affect both the climate and the economics of many tropical countries.

DR DAVID DREWRY said that research into the earth's polar regions was linked with concerns about the global climate in a number of ways. First, the polar ice sheet provided a historical record of changes in the atmosphere, in the form of gases locked up in successive layers of ice. Second, there was an amplification of global temperature changes in the polar regions: warming in these areas might be two to four times the global average. Temperatures at the poles could therefore be used as an early warning system for global warming. Finally, the Antarctic Peninsula was one of the areas which was likely to be affected most acutely by climatic change, and this might result in some retreat of the ice sheet. Effects of this sort could add a few tens of centimetres to the increase in sea levels, although more information was needed before the timescale for such changes could be estimated.

SIR JOHN MASON said that there were shortcomings with all the existing models of the global climate. The key question was what we could do to reduce the uncertainties and provide a firmer base for policy. It was not yet possible to attribute observable climatic changes to the greenhouse effect. There had been an increase in average global temperatures of 0.5°C over the last century. But it was noticeable that the largest increase in temperature had taken place up to the 1940's, when the increase in carbon dioxide concentrations in the atmosphere was relatively

modest. The subsequent increase in temperature was much lower, despite the fact that carbon dioxide concentrations had increased more substantially. In the absence of direct, measurable effects on the climate, we were reliant on models for predictions of what might happen in future. But the uncertainties in current predictions were too wide to provide a sensible basis for formulating policy. The crucial need was to improve the models, and to expand them to include effects associated with the oceans, the ice sheets, the cloud system and so on. To do this it was essential to have better observations, which would be the expensive part of the necessary research effort. Nevertheless there was a strong case for a sufficient UK contribution to ensure that we had a voice in the international scientific community, and that we could get access to all the data. That would allow the UK to remain in the forefront of climatic modelling, as the only country outside the USA with that sort of capability. The expenditure required represented a very small insurance premium against the risk that the worse predictions of climatic change proved to be true.

PROFESSOR M H UNSWORTH said that if climatic change was to be modelled accurately it was essential to take into account the effects of eco-systems, and particularly plants. Historical records at a typical agricultural research station showed natural variations in annual average temperatures of plus or minus 1°C. So it was clear that an increase in global temperatures of 1.5-4.5°C was substantial, and could have effects which went well beyond historical experience. But vegetation would also react to other factors, such as changes in rainfall and the increase in carbon dioxide concentrations in the air. It was clear that global climatic change could result in major changes in eco-systems both in the UK and abroad. It was important to try to build such effects into the models of these processes.

PROFESSOR C R W SPEDDING said that global warming could pose very substantial problems for agriculture world-wide. But much would depend on how various factors interacted, particularly temperature changes and changes in rainfall. As far as the UK was concerned there would be changes in our agricultural production potential, but adaptation should be possible. Some changes in crops might be necessary, for example the growth of maize which was currently grown in Southern Europe. But many existing species should be able to adapt to a warmer climate, depending on factors like rainfall. Growth rates of many species might increase at a higher temperature, but this would not necessarily increase agricultural production. That would depend on the sort of plant: determinate plants such as wheat which grew until it produced grain could become less productive if growth was faster; on the other hand indeterminate growth plants, such as those grown for animal feeds, could be expected to be more productive. All the main domesticated species of animals were farmed in both hotter and colder climates, and there should be few serious problems of adaptation.

[The seminar broke for coffee at this point.]

PROFESSOR BRIAN HOSKINS said that it was essential to know what the regional changes in climate were likely to be before we could make a proper assessment of the impact of global warming. For example, it was possible that the UK might actually become colder because of shifts in winds and ocean currents. In areas like the Indian sub-continent there might be changes in the monsoon which would be crucial to agriculture there.

DR JOHN WOODS said that an understanding of the oceans was essential for models of climatic change. The biology of the oceans controlled the magnitude of climatic change, through the amount of carbon dioxide absorbed by plankton. Research suggested that reduced carbon dioxide take up by plankton had been a major factor in the ending of the last ice-age. It also

appeared that storage of heat in the oceans had preceded previous changes in climate, and acted as a controlling factor. Ocean currents redistributed heat energy on an enormous scale, and this was a major factor in the climates of different regions. Heat was taken up over the whole of the southern ocean and released elsewhere, particularly in the North Atlantic. There was evidence of fluctuations in this effect between the 1950s and the 1970s, with an increase in the temperature of the southern ocean and a reduction in temperature in the North Atlantic. It was essential to understand the reasons for these fluctuations, and that would require new and better observations.

MR MICHAEL OPPENHEIM said that despite the uncertainties which affected our knowledge, it was clear that we were entering a period of continuous changes in the climate at record rates. These effects were subject to substantial time lags: emissions of greenhouse gases which had already taken place would affect the climate in future. So there was an emphasis on acting now rather than waiting until climatic changes were upon us. In this respect the greenhouse effect was unlike any previous environmental problem.

MR E W J MITCHELL said that he had not been involved in modelling the climate, but he did have experience of modelling fluids. From this independent point of view, his impression was that existing models of the global climate were not seriously predictive in any scientific sense. They could be improved, but this would need an enormous amount of work. More observations would be essential to strengthen confidence in their results, so that they could be used for policy formulation. Observations from a number of satellites which were due to be launched during the 1990's would be particularly important.

II. Measures to mitigate the greenhouse effect

DR KEN CURRIE said that he wished to concentrate on the options which were available for mitigating the greenhouse effect. He

started from the assumption that the scientific consensus, described by Professor Wigley, was correct. Furthermore he assumed that an international agreement had been reached which required developed countries such as UK to halve their emissions of carbon dioxide compared to current levels by the year 2020. Thus Britain was required to reduce its emissions from 160 million tonnes of carbon now to 80 million tonnes in 2020. However on the assumption of growth at 2.25% per annum and in the absence of any special measures emissions could be expected to rise to 210 million tonnes. The reduction required compared to what would otherwise happen was therefore 130 million tonnes. He proposed to consider how a package could be put together which might achieve that target.

Option 1 was reforestation. About 10% of the UK was wooded, and studies suggested that this could be increased to 25%. That would absorb 3 million tonnes of carbon per annum, contributing 2% of the target.

Option 2 was the burning of wastes to produce energy. If half of all suitable wastes were used in this way carbon dioxide emissions would be reduced by 7 million tonnes, contributing 6% of the target.

Option 3 was the adoption of all cost-effective improvements in energy efficiency. This could halt the upward trend in energy usage in buildings, industry and transport, and indeed result in a slight fall by 2020. This would achieve 40% of the target.

Option 4 was the adoption of alternative fuels in the transport sector, the area with the highest growth in consumption. The use of gas in vehicles was a realistic alternative, which could reduce emissions by 15 million tonnes, equivalent to 12% of the target.

Option 5 was the removal of carbon dioxide from power station flues. This was thought to be technically feasible, but would probably double the cost of electricity production. He therefore assumed no more than one demonstration plant by 2020, contributing 2% of the target.

Option 6 was the generation of electricity from renewable energy sources. The technical potential was very large, but not all the options were economic. On optimistic assumptions he assumed that about 14% of current supply could be provided by renewables in 2020, contributing 7% of the target.

Option 7 was the increase of nuclear electricity generation. This had substantial technical potential, but suffered from debateable economic potential, some practical problems and considerable controversy. Nevertheless he assumed that nuclear power stations might provide the baseload of about 50% of our generation capacity. That would be equivalent to 24 Pressurised Water Reactors (PWRs), reducing carbon emissions by 30 million tonnes, representing 23% of the target.

Option 8 was the use of alternative fossil fuels with lower carbon emissions than coal. If 40% of the maximum technical potential could be realised that would reduce carbon emissions by 19 million tonnes, representing 15% of the target.

The savings quoted for these 8 options added to more than 100%. However there were interactions between them, and together they would just meet the target. So in technical terms a 50% reduction in present carbon emissions might be achievable. But there would be many practical and political problems. Many of the options would require a doubling in energy prices to make them attractive economically. Consumers would be required to act in new ways. And the slow turnover in buildings and equipment and other market imperfections would represent a brake on what could be achieved. The Energy Efficiency Office had a well

thought out approach designed to tackle these barriers. But in the absence of further price shocks, it was difficult to see any prospect of the market reducing energy consumption to the extent he had assumed.

The other developed countries would all be in much the same position he had outlined for the UK. The position in developing countries would be different. It was clear that they would need to increase their energy consumption if they were to meet their plans for economic development, even if they adopted measures of the sort he had considered.

He drew a number of conclusions from this analysis. First, no single option could achieve the desired results, and a multi-pronged approach would be required. Second, even on the most optimistic assumptions a target of the sort he had considered would be very difficult to achieve. Third, the most promising options appeared to lie in the areas of energy efficiency, the generation of electricity by nuclear power and the use of alternative fossil fuels. Finally, there was considerable scope for further work in this area, and particularly a careful economic analysis of the various options.

THE LORD MARSHALL OF GORING said that it was clear that nuclear electricity generation had a major contribution to make to mitigating the greenhouse effect. But first it would be necessary to restore public confidence following the Chernobyl disaster. A number of countries, including the Soviet Union, were working together to achieve this, and he hoped that it would be effective. But he recognised that until it was achieved it would be difficult for politicians to give unreserved support for nuclear options. It was instructive to relate the environmental effects of nuclear energy to that of other sources. The burning of fossil fuels had already had a measurable effect on the environment, with increased concentrations of carbon dioxide in the atmosphere. By contrast, even if all our electricity world-

wide was produced by nuclear plant, and if the resulting nuclear waste was distributed across the whole surface of the globe, the increase in radiation would be unmeasurably small compared to the natural background. So there was a striking imbalance in the environmental effects of the two sources of electricity, quite opposite to the position as perceived by the public. He accepted that there were other concerns, such as nuclear proliferation. But proliferation would be stopped only if the spread of information could be prevented, and not by restricting the use of nuclear power stations. In broad terms it was easy to make nuclear bombs, but difficult to make nuclear power stations. Finally, he accepted that there was a strong case for action on energy efficiency, alongside greater use of nuclear power.

PROFESSOR IAN FELLS said that it was necessary carefully to consider the implications of various options for mitigating the greenhouse effect. For example, gas was a valuable resource and it was questionable whether it was best used for electricity generation. Use at the rate suggested by Dr Currie could deplete our gas reserves by 40% over 20 years. More generally, market-led policies on energy had been successful in the past in encouraging energy efficiency. But it was very unlikely that they would be sufficient as a reaction to the greenhouse effect. It seemed likely that Governments would need to set targets and standards if businesses were to make sufficient efforts to reduce carbon emissions. There was also room for fiscal incentives to energy efficiency, which had been used successfully in France. One option was an Energy Added Tax. There was also scope for setting targets for the vehicle industry, as was being done in California. The motor industry was very conservative, and it was unlikely that it would make a sufficient effort to cut emissions solely as a result of market forces. There was much scope for the development of electric vehicles, which already provided a practical alternative for the great majority of journeys. However both higher energy prices and the setting of targets would be counter-productive if the effect was to make industry in

the UK uncompetitive. It would therefore be essential to proceed by international agreement.

MR DAVID COPE said that it was difficult to persuade businesses and consumers to take action on problems like global warming with a 40-year timetable attached to them. However many of the options would also have other attractive environmental or economic benefits. Examples included the burning of waste and of methane from landfill sites, and agricultural changes such as set-aside and reforestation. There was a strong case for preferring these options, where the electorate would see substantial immediate benefits. More generally, the policies which had been advocated following the oil price shocks in the 1970's had involved a mixture of coal, conservation and nuclear energy. The greenhouse effect required a modification of this mix, to no coal, conservation and nuclear power. The use of coal involved many environmental problems. Although China had ambitious plans for industrialisation based on coal, it seemed likely that it would pay a shocking price in terms of air pollution, acid rain and so on. There was therefore a strong case for nuclear electricity generation, and much to be said for investigating new designs of nuclear reactor, such as the so called "ever-safe" design.

MR ARNOLD GRAYSON said that action on forests had a valuable part to play in mitigating the greenhouse effect. The great virtue of trees was that they fixed carbon from the atmosphere and stored it for a substantial period of time. Provided there was new planting, forests could lock up a substantial store of carbon. The longer trees were left before harvesting the greater the benefit, and there was a good case for trying to increase the period before timber was cut, perhaps by as much as 20 to 40 years. Some uses of harvested timber, such as paper, resulted in the release of carbon back to the atmosphere in as little as one year on average. But uses such as particle board or solid wood could continue to lock-up carbon for many decades. There was

scope for substituting wood for the products of carbon dioxide-intensive industries, such as steel and cement, in buildings. The use of wood from a well managed forest for fuel could also be beneficial if it reduced the use of fossil fuels. However deforestation was continuing at a very rapid rate in the less developed countries, and there was a strong case for action to reverse this trend. International initiatives had been taken in this area, which the UK was supporting.

MR ROBIN PAUL said that the Confederation of British Industry were taking the greenhouse effect very seriously. New industrial plant built now would be a source of emissions for the next 20 to 30 years. It was essential to make investment decisions in the light of the long-term problems, and to avoid expensive remedial action later. Industry would therefore be strong supporters of action on energy efficiency, and also of the greater use of nuclear power for electricity generation. But it would be counter-productive to take action in the UK which made out industry uncompetitive internationally. A better approach would be to develop technology which would minimise carbon emissions, giving us products which could be sold around the world as recognition of the need for action spread.

MR GERALD LEACH said that there was a case for regulation to act as a spur for the changes necessary to mitigate the greenhouse effect. For example, the car industry had the capability to produce 80-100 mile per gallon vehicles, but no incentive to do so under market forces at present. There was no prospect of countries like China or India approaching our level of economic development unless they used indigenous fuel resources, which would mean much increased carbon dioxide emissions. The important thing was to help them to achieve a much higher level of energy efficiency, and the best mix of fuels. It was important for the UK to take the lead here, to avoid other developed countries getting the majority of the economic benefit from the new markets which would open up.

MR MICHAEL OPPENHEIM said that it was necessary to exercise some caution over the nuclear options, which needed to be weighed against other attractive options, such as improved energy efficiency. There were problems with nuclear waste precisely because it was not evenly spread throughout the environment but very highly concentrated. There were also proliferation risks. The privatisation of the electricity industry in the UK provided the country with a unique opportunity to build a regulatory framework which created the right incentives in favour of energy efficiency. There was much to be learnt from experience in the United States where the regulatory framework did not benefit efficiency.

III. Responses in the international context

SIR CRISPIN TICKELL said that, when considering international responses to the greenhouse effect, it was wrong to make an artificial distinction between developed and developing countries. There was in fact a spectrum of countries, with the major industrial nations at one end, the poorest countries at the other, and in between countries like India and China who were developing fast. All experienced different mixes of the three main sources of greenhouse gases: those associated with land use (deforestation, methane from agriculture); those associated with energy policy (fossil fuel burning, use of wood for fuel); and those associated with industrial policy (eg CFCs). In the temperate areas there was a broad balance between population and resources. But elsewhere there was enormous pressure from population growth, unmatched in many cases by natural resources, and this made responses to the greenhouse effect even more difficult.

Most non-industrial countries had not yet given serious thought to the problem of global climatic change. However the Brundtland Report had acted as a catalyst, and the leaders of countries such as India, Zimbabwe and the Maldives were becoming involved. What interested them most was the likely regional effects of

global warming, and it was crucial to improve the models of the global climate to provide reliable predictions at this level. What these countries needed was practical help from the developed world, to help them take action which was both in their own interest and in the international interest. The aim should be to encourage developing countries to adopt a different route towards industrialisation, which was less damaging to the global environment. It would also help if the developed countries adopted equivalent measures within their own borders so as to lead by example. As far as energy was concerned, the developing countries needed cheaper options, often on a small scale, which would help them to reduce the use of coal. There was also scope for action on forests, both through aid and through debt for nature swaps. There might also be a case for tighter environmental conditionality on aid.

If effective action were to be taken to tackle the greenhouse effect it would have to be done by international agreement. The protracted negotiations over the Law of the Sea showed what could go wrong with attempts to negotiate all-embracing agreements in such areas. It would be important to avoid those dangers. A better option would be to seek a very loose framework Convention on the global climate, building on the previous year's United Nations resolution which the UK had co-sponsored. Such a Convention could be backed by an advisory Code of Good Practice covering areas such as energy pricing, efficiency, etc. Detailed protocols on particular issues, similar to the Montreal Protocol on CFCs, could then be negotiated when scientific knowledge was sufficiently advanced.

As far as institutional arrangements were concerned, there were already many international organisations with an interest in the global climate. But some of them were weak or had limited remits, and several different initiatives were being pursued without proper coordination. This was an area where the UK could take a useful lead. At the working level, we could propose the

strengthening of the United Nations Environment Programme, building on the increase in the UK's financial contribution to it; any necessary strengthening of the World Meteorological Organisation (WMO); and an extension of the life of the World Climate Programme and the International Panel on Climate Change (IPCC). But there was also a strong need for a political institution at the top level. An attractive option was to propose that the UN Security Council should have a role here. This would appeal to the Soviet Union, who were looking for ideas in this area, to the United States, who had not yet developed their own policy, and to China who were all permanent members. However the Security Council could not itself give day-to-day oversight on the subject. One possibility would be to set up a Commission under the Council, perhaps building on the precedent of the Baruch Commission of 1946.

Finally there was the question of financial aid for developing countries. There was a case for a stronger environmental role for the World Bank, and also for the Regional Development Banks. Proposals were also being put forward for a new environmental facility or fund which would assist developing countries to respond to global environmental problems, such as the greenhouse effect and the threat to the ozone layer.

If the UK Government did decide to launch an initiative on the greenhouse effect, it would be important to move quickly in view of the other developments which were taking place internationally. It would be necessary to speak to the Governments of the United States and the Soviet Union, and also to other Governments who were active in this area. One possibility would be to launch a new UK initiative in a major speech by the Prime Minister herself.

SIR JAMES GOLDSMITH said that he had experienced the problems of seeking to reverse deforestation in Mexico, where he had established a trust to preserve the remaining areas of forest.

He had been giving consideration to how the developed world could help in this area. Any attempt to take over the ownership of forests would cause resentment and concerns about loss of sovereignty. It would be better to act on a market basis, with contracts for the preservation of particular areas of forest. What he proposed was that there should be a new international body which would enter into free negotiations with developing countries and pay rent for the preservation and management of forests. But rather than pay these rents in cash it would be attractive to create a link with the problem of third world debt. The new international body would buy debt on the international market: there would be no element of subsidy to commercial banks because the debt would be purchased at the current discount on its face value, reflecting the market's assessment of its real value. The international body would then seek to separate the interest stream from the capital element of the debt, which would be sold on. It would then pay developing countries for the protection of forests by forgiving the interest on the debt, which was what most concerned local politicians.

Such a new international body would of course need to be financed by the developing countries, as part of their aid programmes. But preliminary calculations suggested that the amount of money involved could be found by redirection of existing aid, and was by no means out of proportion to the importance of reversing deforestation. The proposal would build on past debt for nature swaps. He anticipated that many developing countries would find it an attractive approach, building on their own concern about deforestation. He therefore felt that the proposal could make a valuable contribution to solving two problems: deforestation and third world debt.

PROFESSOR DAVID PEARCE said that there was considerable scope for conservation of energy and greater energy efficiency in developing countries. The developed world could do a great deal to help, using bilateral and multilateral aid programmes. There

was also scope for encouraging reforestation and agro-forestry. We needed to look at the causes of deforestation in different countries. This was not always the result of clearance by poor farmers. In some countries there were perverse fiscal incentives which made forest clearance a tax haven for the rich. We should draw attention to these mistaken economic policies. It was also important to ensure that prices gave the right signals. In many countries agricultural prices were too low to encourage sensible farming measures, and lack of tenure or of resource rights could also encourage a wasteful approach to natural resources like trees. Finally, there was scope for action in the Commonwealth on these issues as well as in other international organisations.

DR JOHN HOUGHTON said that deforestation could be harmful not only in terms of its effects on carbon dioxide emissions but also more directly. In many areas forests were an important influence on climate, and their removal could substantially reduce rainfall, with serious implications for agriculture.

DR BOB WATSON said that it was true that the United Nations Environment Programme was not strong. Experience in trying to coordinate global action on CFCs showed some of the dangers in this area. India and China had not yet been persuaded to collaborate, and were insisting on the transfer of substitute technologies from the developed countries. If it was not possible to resolve these issues in relation to CFCs, it would be impossible to persuade them to collaborate in the much more difficult area of the greenhouse effect. They were very suspicious of the developed countries' aims, and considerable efforts would be necessary to get their full cooperation.

[At this point the seminar broke for lunch.]

IV. Summary of morning session and general discussion

DR MARTIN HOLDGATE gave a summary of the morning session. In conclusion, he said that the seminar had demonstrated a high

degree of consensus that global warming was a real threat, resulting from the many human activities which generated greenhouse gases. Further work was necessary to improve our knowledge of the basic science, to gather more data about climatic processes, and to improve the predictive abilities of our models. The UK had a major role to play here. But it was also right to attempt to identify policies which could mitigate the greenhouse effect in the most cost-effective fashion. There might be a case for taking some action in advance of greater certainty, on the ground that prevention was often better and cheaper than cure. There was also scope for helping developing countries to respond to the greenhouse effect, through aid and perhaps a link with the problem of third world debt. Finally, there could be a case for international initiatives, in cooperation with other like-minded nations, perhaps leading to a framework Convention on the global climate.

[Dr Holdgate's own full note of his summary of the morning session is attached at Annex A.]

SIR JAMES GOLDSMITH said that the seminar had heard a diagnosis of the problem of climatic change which recognised that the base of scientific knowledge was changing constantly. But all the solutions which had been discussed were based on conventional approaches. It should be remembered that we were in the middle of a dynamic new industrial revolution, and that new ways of tackling the problem were likely to be developed in the future.

SIR JOHN MASON said that it was not necessary to wait for the last degree of scientific certainty before developing responses to the problem of climatic change. We should be developing the tools and techniques to counter the problem. On the scientific front there probably were sufficient international institutions in place. What was required was for all nations to make available the necessary resources to do the work. In the early 1990's scientists would be receiving truly global observations of

climatic processes for the first time. These would need to be incorporated in improved models, a job for which the UK was well placed with a disproportionate number of the 200 or so scientists world-wide who had real expertise in this area. There was no need for extra bureaucracy, just for the resources needed for the scientific work to go ahead.

DR KEN CURRIE said that there were some options which would help with the greenhouse effect and which were also attractive for other reasons. A good example was the burning of waste and of methane from landfill, which would have other benefits. But we should not count on scientific breakthroughs to provide entirely new options. The road from any breakthrough to commercial use was always long and hard. We should therefore seek, for the foreseeable future, to build policy on existing options.

DR FRED TAYLOR said that we still needed to understand some of the basic processes underlying the global climate, and work on this was continuing. We needed to bear in mind that the greenhouse effect was essential for life on earth, maintaining the temperature at the surface at a level some 33°C above what it would otherwise be. The main greenhouse gas was not one of those discussed during the seminar but water vapour in the atmosphere. There was a complex interaction between evaporation, clouds and precipitation, which was not yet fully understood. We needed more measurements to be sure what was happening, and to be sure that we could identify global warming attributable to the greenhouse effect as soon as it became apparent. The programme proposed by the United States in this area was very impressive, and we needed to collaborate as far as we were able.

DR TONY FISH said that we needed to incorporate more biology into our models of the global climate, recognising the interaction between atmospheric effects and the biosphere. This would be complex: for example it would need to take account of differing

levels of irrigation, which were much higher in the United States, the Soviet Union and Japan than in the UK.

MR MICHAEL OPPENHEIM said that the UK was well placed to play an important role internationally, which could be critical if the greenhouse effect was to get the time and notice it deserved. In contrast, the United States Government was not yet giving serious consideration to the problem at the highest political level.

DR DAVID DREWRY said that the issue of CFCs demonstrated the difficulties of getting international agreement on environmental issues. It was not so long ago that some countries in the European Community had refused to accept any link between CFCs and depletion of the ozone layer. It was therefore necessary to persuade people in other countries, and particularly in the developing countries, that the threat of global climatic change needed to be taken seriously. The UK was well placed to take a lead here, and there was also a crucial role for British scientists to play with their counterparts elsewhere.

THE MINISTER FOR OVERSEAS DEVELOPMENT (MR CHRISTOPHER PATTEN MP) said that the UK's bilateral aid programme played a considerable part in meeting environmental problems. Potential aid projects were considered carefully for their environmental impacts. Action on forestry played an important part in the overall programme. Looking ahead it was possible to envisage that the UK might be funding as much as 10% of the Tropical Forestry Action Programme in 4-5 years time. There was also scope for more debt for nature swaps to generate additional funds to halt and reverse deforestation. Proposals for a more formal link between the problems of deforestation and third world debt were interesting, but also raised a number of problems. There was not always a good match between a country's indebtedness and its problem with deforestation; it would be undesirable to enter into any programme which involved Governments in the developing countries

bailing out commercial banks; and unless new money could be found to fund the programme the developing countries might not be particularly interested. But general measures to solve the debt problem could help by strengthening the economies of developing countries. There was also a strong case for helping them improve their energy efficiency, and this was another area where aid could be useful.

SIR JAMES GOLDSMITH said that he accepted that there was not always a perfect match between a country's debt and the extent of its forestry problem. Nevertheless the great majority of the South American countries with tropical forests did have debt problems. His proposals did not involve bailing out commercial banks: they would have to take their losses, by selling their debt at the discounted market price. Finally, the money involved would be a fairly modest proportion, perhaps around 15%, of existing international aid budgets, and it should not be impossible to redirect sums of this magnitude.

THE PRIME MINISTER, summing up the seminar, thanked the three speakers for introducing the morning sessions of the seminar. She thanked Dr Holdgate for his brilliant summing up at the start of the afternoon session. She also thanked all the other participants for their contributions to a valuable and enjoyable day.

The seminar had given all the Ministers present a lot to think about. The Government recognised the need to strive to identify the right answers to the problem of global warming. It was clear that further work was needed to achieve a greater degree of certainty in predictions of climatic changes, both at the global level and particularly in respect of regional effects. That would require an international programme to collect new observations, and the further development of models of climatic processes. The UK had a major part to play in both respects.

But the lack of scientific certainty did not remove the case for action where it was obvious what needed to be done. One example was the clear need to halt and reverse the trend to deforestation. The UK should seek coordinated international action in such areas, recognising our strong obligation to preserve the global environment which we bequeathed to our descendants.

CABINET OFFICE

May 1989

GLOBAL CLIMATE CHANGE

The purpose of this Seminar was defined by the Prime Minister in her opening remarks as the establishment of facts, so that policy was based on sound science.

The first session accordingly reviewed the state of knowledge of the greenhouse gases, their sources and their effects. It established that carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, tropospheric ozone and water vapour do affect the radiative balance of the atmosphere, to differing degrees. It indicated the wide range of sources of the greenhouse gases, but also demonstrated that carbon dioxide, methane and nitrous oxide arose from activities fundamental to human civilization - agriculture, and the burning of fuels to generate energy. The reduction in emissions of these gases would consequently be a good deal more difficult than the elimination of chlorofluorocarbons, for which adequate substitutes existed, as the recent Conference in London on Saving the Ozone Layer had established.

The concentrations of the greenhouse gases have fluctuated substantially in the past, as a result of natural processes, but are now increasing through human agency. Carbon dioxide has the most significant effect on radiation balance, accounting for about half the calculated greenhouse effect, with methane accounting for 18 percent, CFCs for 14 percent, and nitrous oxide for 6 percent. If CFCs are eliminated, the relative importance of carbon dioxide will increase.

Eighty percent of the carbon dioxide added to the atmosphere as the result of human activities comes from the burning of fossil fuels, and 20 percent from deforestation, especially in the tropics. While therefore the latter process is important on a world scale, halting tropical deforestation will clearly not cure the problem.

At present the developed countries are the dominant sources of carbon dioxide. However the rapid growth in energy generation in the developing world means that they are likely to catch up the present industrialized countries in about 30 years.

Implications

The Seminar demonstrated that there is a near consensus that these increases in greenhouse gases will raise the mean temperature of the earth. An increase of approximately 0.5°C has occurred over the past century, and this fits the hypothesis that the greenhouse effect has already begun although it does not prove it. The evidence of rapid ice retreat in various parts of the world including the Antarctic peninsula also fits but does not establish the hypothesis.

Present calculations suggest that by 2030 AD the increase in world temperature is likely to lie in the range +0.5°C to +2.5°C. More important than the gross increase is the fact that the rate of increase will be between two and eight times that over the past century. The implication is that changes are taking place on a larger scale, in a shorter period, than the ecological systems of the earth have been

exposed to at any time in the past 150,000 years, and this takes us into new territory when we seek to deduce how these systems will respond. Another feature of the phenomenon is the existence of substantial lags between cause and effect, so that today's impacts commit us to long drawn-out changes, lasting decades or even centuries before mean temperature and global sea level come to equilibrium.

There is some indication that global sea level has risen by of the order of 8 to 10 cm in the past century, and it is expected that there will be a significant and rapid increase in future, perhaps of the order of 10 and 20 cm by 2030 AD. This increase is expected to arise especially from the thermal expansion of the warmer seas and the melting of mountain glaciers, but its magnitude in the longer term depends critically on the response of the polar ice sheets. Again, the combination of rate and duration is critical. The rapid rise in sea level, prolonged over several thousands of years at the time of the melting of the ice sheets from the last glaciation exceeded the capacity of response of many coral islands and has led to well over a hundred known "drowned" atolls. However if the changes induced by current human actions last only for a century or so, the majority of coral reef systems should be able to keep up.

Present models and analyses make it extremely difficult to break the effects down regionally. Figures presented to the Seminar suggest however that the United Kingdom could be 4°C warmer in summer and between 4 and 5°C warmer in winter if atmospheric carbon dioxide doubled. Even larger temperature changes are likely in the polar regions. However changes in the magnitude and distribution of precipitation are likely to be of even greater environmental significance, and while some calculations suggest that the present wet areas will get wetter while the arid tropics may get drier there is no reliable basis for prediction.

Factors to be considered

The Seminar left no doubt of the complexity of the system with which we are dealing, and the considerable uncertainties in present models and analyses. A better understanding of the interactions between ocean and atmosphere and between living organisms and their habitat is especially necessary. It appears that carbon dioxide levels in the atmosphere may be governed especially by the plant life (phytoplankton) in the surface waters of the sea. There is a great need for better actual observations of what is going on in the world, to feed into the better models that are also needed if uncertainty is to be reduced and regional effects are to be predicted better.

In the further elaboration of the science, it is necessary to consider the likelihood of extreme events as well as mean situations. There is a possibility that the intensity of tropical storms and their frequency will change. It is also important that allowance be made for surprises. The "ozone hole" over Antarctica in springtime was not expected, and nature may well have other surprises in store. For example, the effects of clouds on global and local temperature balance have not been well analysed, and more needs to be known about the impact of deforestation in the humid tropics. The Seminar was told that one analysis suggested that

the United Kingdom might get colder even if the world generally became hotter, should the ocean current system that currently transfers vast quantities of heat into the North Atlantic, drawn from the other oceans of the world including those of the southern hemisphere, was altered. Another area of uncertainty lay in the responses of plant life to higher carbon dioxide concentrations in a warmer world. Carbon dioxide itself might be expected to boost plant growth, as would warmer temperatures, but water supplies are likely to be limiting in many circumstances, and there are numerous interactions which are not properly understood. It was also important to bear in mind that even if crop growth were increased, it would not necessarily mean increases in yields.

Social impacts

It is evident that the social impacts of these changes could be large. The Seminar was told of one calculation of an increased expenditure required on the east coast of the United Kingdom of £5 billion, even if some areas were abandoned to the sea. Similarly, even if United Kingdom agriculture had the resources and flexibility to adjust to the changes, over the world as a whole there was likely to be substantial stress on the food-producing system. Many crop species were currently grown near the limits of their range, and changes in temperature and water availability would have a major impact in many regions, especially of the developing world.

Similarly, the impacts on natural environmental systems could be substantial. A 1°C rise in average temperature, in crude terms, could be compensated for by a movement of around 100 to 150 km towards the Poles or 150 m vertically, assuming that soil and other habitat conditions were comparable over these distances which they are unlikely to be. Evidence was presented that forest trees were unlikely to be able to respond by moving more than 10 km per decade, so that if in fact the limits of their growth were being shifted 50 km a decade, as some scenarios indicated, they would be in danger of being left behind, with consequent changes in ecological systems.

The Seminar was told of the substantial scientific effort in progress to reduce these uncertainties. However it was stated that there were only about 200 real experts capable of making a fundamental contribution to understanding. Given the existence of a much larger multitude of people making pronouncements in this field, the noise:signal ratio can clearly be expected to be massive and potentially misleading of public opinion. A plea was made for a reduction in the number of conferences debating the issue, while the competent scientists concentrated their efforts on amassing the knowledge that would make such conferences meaningful.

The potential for action

From the evidence presented to the Seminar, it is clear that exceptional measures would be required if the system was to be brought to stability with less than a doubling of carbon dioxide above pre-industrial levels.

Against this background, a policy of waiting and seeing clearly emerged as unwise, even if there were uncertainties in the situation. It would be prudent to plan on the basis of the reality of the phenomenon and the desirability of social action to limit its impacts and eventually reverse it.

It was suggested that the response might come under the heading of "four As":

- avoidance;
- adaptation;
- abatement;
- assistance.

These needed to be based on national action, but within an international context.

The analysis presented by the Energy Technology Support Unit, and valid for other OECD countries as well as the United Kingdom, demonstrated that it would be technically feasible to halve carbon dioxide emissions by the year 2020. Some eight alternative types of action were presented, ranging through reforestation and the generation of energy from waste through increases in the efficiency with which fossil fuel was burned, more effective energy use in transport, carbon dioxide removal at power stations, the development of renewable energy sources, the expansion of nuclear power and the substitution of alternative fossil fuels to coal.

Of these, the most promising in technical terms was clearly the increase in energy efficiency, but it is difficult in practice because it demands the disaggregated action by a vast number of consumers, and is hampered by the slow turnover of the building stock within which much conservation has to be concentrated. The development of nuclear power is a second most promising contribution, provided that public opinion can be influenced to accept it. Fuel substitution could make a contribution in theory, but it was pointed out in discussion that there were limited amounts of natural gas that could be substituted for coal. Certain measures, such as reforestation and the use of wastes as fuel, only contributed at the margins but would nonetheless be popular with the public and worth pursuing for that reason. Taking all the options together it is clear that it is technically possible to achieve the abatement target, if practical policies can be established to deliver the various savings.

How to achieve these savings

One key to the achievement of policies to limit carbon dioxide emissions clearly lies in the field of public understanding. Public opinion needs to be influenced first so that consumers vigorously pursue goals of energy conservation. Public opinion likewise needs to be influenced if they are to accept a future nuclear power strategy that is safe and disposes of its wastes in an environmentally acceptable way. Public understanding could also play a positive part in the creation of new markets for energy efficient products, like more efficient cars.

A second key to the future was the establishment of a clear strategy with appropriate incentives, which might include a mix of fiscal measures, pricing policies, taxation incentives and technical targets.

The establishment of such a strategy and such targets was important because they provided signals to industry and assuming that the strategy was sustained, a clear context for the substantial industrial investment that would be needed. Given a clarity in the definition of strategy, and an effective approach to public information, market opportunities could be created, both within the United Kingdom and internationally, so that the situation should not be looked on in industrial terms as wholly negative: it provided opportunities as well as constraints.

A different approach was needed however between developed and developing countries. Some of the measures listed, such for example as a massive expansion of nuclear energy generation, would not be practicable in the developing world. There was nonetheless great scope, through the provision of appropriate assistance, for a more energy-efficient growth pattern in the developing countries than they are currently pursuing, and it would be important to provide such assistance.

The world context

This brought the Seminar toward a consideration of the international field. It is clear that the greenhouse phenomenon is a truly global one, contributed to by the actions of all nations and affecting all regions of the globe. It is accordingly both essential and inevitable that the actions taken in response must be concerted internationally.

The nations of the world should not be grouped arbitrarily into two blocks: developed and developing (or "north" and "south"). They form a continuous spectrum in terms of their industrialization and economic strength. They display widely varying population pressures, which however constitute one of the most serious impediments to effective development, pose grave threats to environmental stability in many parts of the world, and could hamper the achievement of any strategies to stop climatic perturbation. Industrial growth is an imperative for developing countries, and in itself, by raising standards of living, provides the best hope of bringing about population stabilization. The developing countries are for the most part committed to paths of industrialization, and will not take kindly to being requested to adopt policies that inhibit it, especially in a circumstance where some 20 percent of the world's population is using over 100% of the safe dispersal capacity of the atmosphere! They are likely to look to the wealthy industrialized countries to take the measures that will release atmospheric capacity to disperse the carbon dioxide emitted from their growing commercial energy sector.

There is a major economic problem, at the world scale, because whereas a dear energy policy might be advantageous in promoting energy conservation in the developed countries, it would severely inhibit the process of industrialization and development in the third world.

While these were intractable problems, it was clear that there would be a considerable need for assistance to the developing countries in order to establish patterns of activity which would be of global benefit. One area for such assistance lay in land use. It would be valuable to demonstrate that the sustainable use of forests, and stable systems of agroforestry are economically more beneficial to many tropical countries than the clear-felling of their forests, replacing them by impoverished pastures and erosion. Aid should also allow longer-term sustainable management patterns to be substituted for short-term destructive use of natural resources which could not readily be renewed. Debt for nature swaps could make a significant contribution in these circumstances.

Two other areas of action that might be considered involved adapting the global commercial system to favour the products derived from sustainable land-use policies in the third world, and assistance to help transfer sound modern technology (like, for example, the substitutes for chlorofluorocarbon that many countries have made clear at the recent London Conference they would like to introduce if they were helped to bear the costs of doing so).

Cooperation and coordination would also be vital between nations. One area for such cooperation lay in science. There is already a substantial international scientific research effort, which is cooperating in the use of satellite and other environmental data and the construction of models. The Intergovernmental Panel on Climatic Change is one component of that cooperation, and others are to be found within the International Council of Scientific Unions.

Another area for cooperation lies in the development of an international Convention, providing a framework for the coordinated action the world will require. Such a Framework Convention would be likely to include a commitment to cooperate in research, in the evaluation of results, in the construction and interpretation of models and in monitoring. It would be able to lay down a code of conduct at international level. It might include some provisions for international assistance. It would also contain commitments to discuss and eventually adopt protocols on particular areas of action like those agreed under the Montreal Protocol for reduction of chlorofluorocarbons (this protocol could equally well have been negotiated under a Convention on the regulation of human interference with the climate).

A third area for international action was institutional. There is already a substantial global institutional effort, in the United Nations and elsewhere, which needs to be made more coherent and effective.

It was suggested that this institutional machinery might include the following components:

- a) a new role for the United Nations Security Council, which could be required periodically to review major environmental issues of global concern, which undoubtedly do increasingly threaten the peace and stability of nations;

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- b) a coherent role for the UN Agencies Coordinating Committee (ACC) which does bring the major UN agencies together, under the aegis of the UN Environment Programme, but at the present time lacks the power to force the conjunction of plans or the adjustment of budgets to mutually agreed ends;
- c) a revitalized UN Environment Programme, potentially as the lead agency for the UN in these matters (although it will always be hard for UNEP to undertake the leadership of political discussions in New York when it is based in Nairobi);
- d) an enduring role for the international scientific effort, for example by prolonging the Intergovernmental Panel on Climatic Change as a committee with a defined role in the UN system.

A further international institutional measure that could be considered is the establishment of a fund for environmental problems, to be disbursed via the multilateral development banks, including the World Bank. Such banks could enter into commercial agreements for the rental of areas for sustainable management, payments being made when monitoring showed that the agreed policies were in fact being carried out.

Finally, it was suggested that there was a role in the institutional machinery for non-governmental organizations. Much of international science has been coordinated through the non-governmental machinery of ICSU. The International Union for Conservation of Nature and Natural Resources linked in membership 62 States, 130 government agencies and over 300 non-governmental organizations including all the major conservation bodies in the world, and this could provide a valuable forum for stimulating action which reinforced that agreed by Governments.

Conclusions

The Seminar demonstrated a virtually universal acceptance of the need to treat human perturbation of the climate, through the release of greenhouse gases, as a real threat to many socially important actions.

It was concluded that it was right to evaluate policies that could lead to the limitation of the impacts of this phenomenon, and its ultimate stabilization, in the most cost effective fashion, and this should be done in parallel with science that would improve understanding of the phenomenon and especially give a better basis for the regional assessment of its impacts.

It was agreed that there were real opportunities in this area for the United Kingdom, in partnership with scientists and policy-makers in other countries. In particular, the United Kingdom could contribute significantly to science, it could develop its own energy policies and other domestic activities so as to be ahead of the problem, on the basis that prevention was commonly better and cheaper than cure. It could contribute through helping to form public opinion and to create new demands and markets for products that would improve energy efficiency and reduce greenhouse gas emission. It could contribute in international policies, through aid, debt management, and the development of an

appropriate Framework Convention. Above all, it could contribute, with other like-minded nations, in promoting the development of an international institutional machinery that worked.

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