PROFESSORS AND PARLIAMENTARIANS

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INTRODUCTION

I shall try to discuss three related issues :

- The general relationship between scientists and the Government.
- The particular case of that relationship in regard to the Greenhouse issue.
- The actions which scientists should presently advise with regard to Greenhouse.

Parliamentarians cannot generally be expected to understand all the scientific details which should determine policy - they must rely upon the advices given them by scientists. On the other hand scientists cannot generally be expected to understand the political questions involved, and may lose perspective. It is clearly the role of scientists to advise, and the role of parliamentarians to act on advice, and every effort should be made to avoid mistakes occurring through the knowledge gap. One way of closing this gap would be to encourage scientists to make factual statements in simple non-scientific terms, directing such statements particularly to those aspects which should determine practical policies.

But the closing of the gap is not so simple as might at first appear. In a democracy, major policy changes cannot be implemented without public consent, and this means that the public, as well as parliamentarians, must be made aware of the factors involved. Both scientists and politicians have a responsibility to see that the public is kept informed.

It is just here that a problem arises. Organised factions (themselves sometimes primarily interested in getting political clout for its own sake rather than in the cause they publicly espouse) can get in on the act, and parliamentarians (to whom votes are the stuff of life) will go to great lengths to buy the support of these factions. From

this point of view, the conduct of all political parties, bidding for the Greenies' vote at the recent Federal Election, left a lot to be desired.

Nor were the scientists altogether innocent. Dwellers in ivory towers may be inclined to look with envy on the real world outside, and to seize opportunities for publicity. With the Media anxious to get a good story at any price, some scientists have the habit of making newsworthy statements (not only about Greenhouse) which their knowledge would not justify - even worse, some have been deliberately making sensational statements with the reservation that they should be considered hypothetical, knowing full well that the Media would run them without the reservation. The combination of uninhibited Greenies and consenting scientists can be specially damaging.

On our present knowledge there is real reason for Greenhouse apprehension, and there are some measures which should be urgently undertaken. It would be a pity if a reaction against ill-founded public hysteria about hypothetical dangers were allowed to prejudice this urgent action.

In order to maintain our perspective we should distinguish between what we know, and what we surmise, indicating the probability we attach to our deductions and relating this to the world effects of the hypothetical scenarios we envisage. This will provide the basis for a proper policy.

At present our Greenhouse observations make us sure of two things :

(i) In recent years there has been a substantial depletion of the ozone layer in the upper atmosphere.

(ii) In the last century or so there has been a significant change in the proportion of certain gases in the atmosphere - a proportion which had been relatively constant for many previous millennia.

In consequence of these observed changes two serious effects are conjectured :

- **The radiation effect.**
- **The warming effect.**

These two effects should be considered separately, because the need for urgent action which they pose may be different.

THE RADIATION EFFECT

Depletion of the ozone layer has only been observed for a decade or so - but no serious attempt was made to observe it much before then. We cannot, therefore, be certain whether it has occurred previously, i.e. whether it is due to recent human activities or whether it is a natural phenomenon (in that case probably a cyclic phenomenon). As against this, there is a good reason to link it with the observed increase of man-made C.F.C.'s in the atmosphere, since the way in which these C.F.C.'s could deplete ozone is quite certain, and since they have only been produced for a couple of decades.

The consequence of a major depletion of the ozone layer would almost certainly be catastrophic, because the layer acts to shield the earth from ultra-violet radiation. A great increase in this radiation at the surface could have critical effects on the atmosphere, not only leading to cancer in humans but to the disruption of the food chain.

C.F.C.'s are almost certainly long-lasting in the atmosphere, and the probability that they are responsible for this depletion is sufficiently strong to justify immediate action against their production, especially since such action (provided a substitute refrigerant gas is available) would entail little loss. Unless and until a reversal of ozone depletion is observed, or its depletion is reasonably proved to be due to natural causes, *such action, world-wide, should be considered urgent, and scientists should be advising Governments accordingly.* Since ozone emissions would appear to

be equally damaging from whatever location they originate, effective action would need to be on an international basis.

Meanwhile :

- The possible effects of ozone depletion should be studied.
- Observations of the ozone layer over the whole earth (not only the Poles) should be very substantially extended.
- There should be a crash programme on refrigerant gases alternative to C.F.C.'s.
- The possibility of measures to enhance the ozone layer should be examined.

THE WARMING EFFECT

In the last century or so human activities have certainly increased the proportion in the atmosphere of certain gases which are more opaque to outgoing long radiation than to the incoming short radiation. Accordingly these gases tend to constitute a 'trap' for solar heat - which is the warming generally referred to as the Greenhouse effect.

However, the extent to which this warming might be reduced by greater reflectivity of any increased cloud cover is still uncertain, although the calculations made by some scientists in regard to the so-called 'nuclear winter', arising from the dust of atomic explosions, may throw some light on this. We cannot as yet say for certain whether or not there has been any global warming in the last couple of decades.

Projections may be made of the extra emissions of 'Greenhouse gases' into the atmosphere on the basis of various scenarios, the chief variable assumptions being our gross production of energy, the proportion of that energy derived from combustion and the net amount of forest clearing. When a hypothetical choice of scenario has been made, it is still uncertain how much of those extra gases will be retained in the

atmosphere, since the behaviour of the "sinks" (principally the ocean) cannot as yet be accurately predicted.

On present knowledge the rapidity of warming consequent upon specified rates of emission of these gases is still uncertain. This is unfortunate, since the potential damage caused by Greenhouse warming is almost entirely dependent upon the rapidity of its onset.

Damage from global warming can come either through a *rise in sea level* or from *climatic change.* The second of these would appear to be by far the more important, at least for a century or so.

WARMING AND SEA LEVEL

Global warming may affect the sea level in two separate ways.

- By warming the ocean it would increase its volume.
- By causing the residual Ice Sheets to melt it would divert extra water into the ocean.

So far as thermal expansion from a given degree of global warming is concerned, there are again substantial uncertainties. What would be the delay in transferring atmospheric warming to the ocean? How would this be affected by horizontal and vertical currents? In a pond the surface layer can be considerably warmed without raising the temperature of the deeper water - would the saline waters of the ocean behave like this? Would increased evaporation cool the surface? Would there be increased snowfall in the Antartic, which would reduce sea level? There are many such complex issues, but it seems clear that the net thermal effect would be quite minor for the coming century.

So far as the melting of the ice sheets in Antartica and Greenland is concerned, it would appear on inspection, that the extra discharge occasioned by one or two

degrees of warming would not be sufficient to raise ocean levels perceptibly in the coming century or so, unless (which seems improbable), they were to cause a major slippage of ice into the ocean.

So far there are no reliable observations of a present rise in sea levels. Gauges are subject to rises or falls of the land on which they are situated, and the global network of gauges is miserably inadequate. Biological depositional markers can be useful, but their interpretation is often subject to argument. It is, in fact, still uncertain whether sea level over the last decade or so has risen or fallen.

All these uncertainties as to the effects of warming, superimposed upon the uncertainties of the degree of warming itself, would indicate that, *on present knowledge*, there is no justification for substantial expenditure against a possible rise in sea level due to the Greenhouse effect.

This does not mean that further expenditure upon research would be unjustified. We need to know more about the physics of the process, and much more about currents and temperatures in the ocean at various locations and at various depths. We need many more gauges to check any changes in levels actually occurring.

In the meantime it would be prudent to see that new shoreline construction should envisage a sea level rise of a metre or two within the expected life of the work concerned. Such precautions need not be expensive. At present, however, there would not seem any Greenhouse justification for costly alterations to existing structures.

Of course we should always keep in mind the possibility that new knowledge would call for a new policy.

WARMING AND CLIMATE

If the global temperature were to rise, significant climatic changes would be likely to follow.

Atmospheric circulation is linked to oceanic circulation, but whereas the latter has a momentum which makes it relatively stable, the former is obviously highly

unstable. The feed-back between them must be taken into account in any attempt to predict climatic variations, which are inherently atmospheric.

Simplistically an atmospheric warming should shift the latitude of climatic zones, but real developments are likely to be much more complex. It is probable that the general pattern of atmospheric circulation (both vertical and horizontal) could be affected, with consequences hard to predict. It is not easy to see why the present general pattern should be uniquely determined : perhaps one radically different would be equally sustainable.

Indeed, some would argue that such patterns could be considered quantized (like electron rings), so that one mode might 'flip over' into another with little delay. There is reason to believe, for example, that with the Younger Dryas a change of mode took place in less then twenty years (for Northern Europe at least). With the more recent Little Ice Age, the 'flip over' appears to have been rather more gradual, but it was not longer than a few decades. Even without a 'flip over', climatic zones can change substantially in a few hundred years (as would appear, for example, to have occurred in North Africa).

So, if global temperatures increase by a couple of degrees, it may be that zones will gradually shift towards the Equator, or it may be that there will be radical re-arrangements, perhaps over a century or so; or it may be that there will be a 'flip-over' covering a couple of decades. In the present state of knowledge we may be able to assign probabilities to these various scenarios, but we cannot be certain. Nor do current observations help us much. It is said that in the last two decades the world has been experiencing 'unusual' weather, and that this is the first manifestation of the Greenhouse effect. But, ephemeral weather patterns are always variable, and at present observations may well be recording only a normal variability.

It is still too early to tell - perhaps the picture will become clearer with new developments in a year or two or in a decade or two : or perhaps our climatologists will become more perceptive with increased knowledge and better observations.

As of now, we cannot be certain as to what a given number of degrees of global warming would do to the weather - and this on top of the uncertainty of how much global warming and assumed emission of global gases would cause. At best, we can assign probabilities - no more.

EFFECTS OF CLIMATIC CHANGE

If Greenhouse causes any climatic change, its *long-term agricultural effects* will probably be favourable, whereas its *short-term effects* (depending upon their speed) are likely to be unfavourable and may even be disastrous.

Increases in global temperature may alter the distribution of rainfall, but they should increase its total; also increases in atmospheric carbon dioxide will tend to quicken plant metabolism, especially if natural mutation is assisted by genetic engineering. These long-term advantages from Greenhouse warming would be outweighed over the shorter term by disruption of established production.

Farmers are slow to adjust, and if a basic climatic shift were to occur, it would be interpreted for many years as a passing seasonal vagary which could be ignored. When it becomes too persistent to be disregarded, corrective action is likely to be postponed, even if it only involves a change of crop. If it involves abandonment of a holding, it will be longer delayed and will occasion real capital losses when it occurs since most agricultural improvements are fixed, as also are farmers' houses.

A fundamental climatic change could cause losses, particularly in its initial stages, even if spread over a couple of centuries. If it is spread over a substantial number of decades, these losses could still be serious. If it involves a 'flip-over' of a couple of decades or less, the losses could be disastrous.

In considering such effects, it has hitherto been customery to direct attention to areas whose product enters into international trade, such as the American Wheat Belt. (e.g., it has been stated that a global rise of one degree will shift the border of the Wheat Belt 150 km). Seasonal factors in such areas get special attention because they

have a direct impact on grain prices; but most of the world's food does not come from them - it never enters into international trade because it is locally consumed. Where production comes largely from small farmers living not far from the subsistence level, it is specially vulnerable to any climatic shift.

It is fairly clear that real concern should centre on the Monsoon and adjacent areas of South-East Asia, where over half the world's population lives and where the pattern of production is most vulnerable. From the meteorological viewpoint this is also an area where any global warming would be rather more likely than in most to cause a climatic shift. A *rapid* climatic shift in these areas (taking say, two or three decades), whether or not it comes from a 'flip over', could cause a famine without precedent in human experience. But until we can identify with certainty areas which would be affected by climatic shifts, it is obvious that we cannot undertake plans of agricultural re-location.

All effective remedies so far suggested against the uncertain climatic effects of Greenhouse are hideously expensive, and probably none of them (excepting of course, research) seem worth undertaking on the basis of present knowledge. This conclusion, of course, might be radically changed as knowedge expands.

FURTHER RESEARCH

At present there are so many unknowns that we cannot lay down a firm policy to deal with the possible consequences of those few firm observations which are available, and urgent research should be directed to those unknowns. Major studies should lie in the physical area, including astronomy, meteorology, oceanography, botany and geology. These require both theoretical work and (which is more expensive), a vastly expanded network of observations. Mathematics and statistics must be called in to process the results.

A crash research programme is justified, and no financial impediments should be allowed to limit projects from being reasonably sponsored.

Beyond these, more attention should be paid to historical research. We know, for example, that the proportion of Greenhouse gases in the atmosphere was relatively constant for the five thousand years before the Industrial Revolution, although major shifts in climatic patterns occurred during that time, including the Little Ice Age, which is reasonably documented. This may serve as a 'control' when we ask ourselves whether any climatic changes which we currently observe are due to Greenhouse or to natural causes.

Again, Quaternary events are more accurately known than those of earlier times, and these include both the growth and the melting of the Northern Ice Sheet, the rapidity of the latter process being still inadequately explained. Astronomically the world is not at present so far off from an Ice Age turning point, and it may be that man's contribution to changes in the atmosphere will merely delay an ice accumulation which would otherwise occur naturally.

Man lived through most of this Quaternary (and especially through the last Ice Age incident) and his artifacts and quasi-historical records (even the Flood Myth) may help us to understand the natural processes on which Greenhouse is superimposed. When it is the rapidity of change which is practically so important, these archaeological and historical studies may produce valuable results.

THE INTERNATIONAL ASPECT

Greenhouse is a world problem. Carbon dioxide, for example, emitted in the United States, would soon spread, so that its effects would be felt in the Asian atmospheres. Control must be global if it is to be effective.

There is another reason why internationalisation is desirable. Research is urgent to determine some of the unknowns, and such research will be expensive. No one nation can be expected to bear an unfair share, and some international treaty (or perhaps a United Nations Agency) should be constituted to finance it.

One corollary to this is that the Third World would have a special reason to co-operate. If fears about Greenhouse are well-founded, then it is the Monsoon and near-Monsoon nations which are most at risk. It is their populations which would die by famine if anything drastic developed, and they therefore have a special interest in research to resolve present uncertainties and to devise remedial action if it turns out that there is any real cause for alarm.

AUSTRALIAN PARTICIPATION

Many nations might have special opportunities for research within their own borders. Australian responsibilities include :

1. We have claims on much of Antarctica. Study of glaciology and ice-cores there can contribute significantly to relevant research, as can the study of the local ocean currents.

2. Vegetation relics, old river beds and profusion of artifacts provide evidence of a quite different climate in Central Australia in recent times.

3. Zones in coastal and inland sandhills and a zone of dust deposition from Lake Eyre can help to determine the chronology of recent climate shifts.

4. The relative stability of the continent provides a comparatively good means of estimating recent sea levels.

5. Aboriginal myths throw some light on the recent past.

Australia already plays a significant part in the study of the global atmosphere, and could well participate in a wider world-study of Greenhouse.

AN IMMEDIATE PROGRAMME

What advices should scientists be offering to Parliamentarians as at April, 1990?

It has already been suggested that, in spite of some remaining doubts, international action to *halt the production of C.F.C.'s* is warranted, and that there should be an ongoing programme of research to resolve those doubts, monitor developments and find substitutes.

So far as the *warming effect* of atmospheric gases is concerned, the situation is substantially different. Doubts are deeper, specific remedial action is more difficult to determine, and the real costs of any effective action so far suggested are an order of magnitude greater.

Research is the first priority. This should include theoretical research, field research, the establishment of monitoring systems, enquiries into ways of reducing the emission of Greenhouse gases, and investigation of remedial action against probable warming effects. A comprehensive research programme would be very expensive (at least hundreds of millions of dollars per year) and would be best set up as an international agency. *Costs should not be permitted to deter the research programme.*

Beyond research, it is difficult to suggest effective action on present knowledge. Doubts about the nature, extent and location of dangers reduce the ability to plan against them.

Except in regard to C.F.C.'s and methane, the source of most Greenhouse gases is combustion. Carbon dioxide is by far the most important of these gases, and it appears to be an inescapable product of combustion : oxides of nitrogen and sulphur are more amenable to control.

There are four main sources of combustion gases - power plants, motor vehicles, industrial processes and burning of forests and wastes. With electrification, a proportion of industrial and vehicle combustion is being transferred to power plants : net deforestation can be controlled, and more wastes can be re-cycled. The important

matter is thus combustion in power plants. Here the control of oxides of sulphur and nitrogen etc., should be enforced, at some additional cost, but carbon dioxide remains.

In the industrialised world net energy savings can be made by changing life styles; more efficient use can be made of available energy; and solar energy can substitute for electricity with heating etc. However, in at least some of these countries total energy use continues to increase with improving living standards. For the industrialised world as a whole, it would be unreasonable to expect eventual energy consumption to stabilise at less than three-quarters of present U.S. per capita consumption, with eventual combustion (in default of new techniques of power production) two-thirds of present U.S. levels.

Such reductions would not halt the increase of total global emissions of Greenhouse gases. Nations outside the industrialised world cannot be denied the right to raise their living standards, and their populations are so great that the consequent rise in their emissions will vastly outweigh any conceivable reductions elsewhere.

The figures therefore show that even the most vigorous campaigns for changing life styles and reforming energy practices in the industrialised nations cannot halt the increase in global emission of these Greenhouse gases. On the assumption that the effect of such gases is harmful, such tactics must fail, and if they delay other effective action in the fallacious hope that they will succeed, then their eventual result can be positively harmful.

We should face the fact that halting increased emissions involves finding ways of producing energy without combustion.

The main thrust of Greenhouse action should be directed towards this.

Such a way, of course, already exists - power through nuclear fission. Twenty years ago this seemed the way out, but it has been closed by two objections :

- It increases the risk of the spread of atomic weapons.
- It involves unacceptable radiation risks.

The former of these objections is valid : the latter is essentially trivial, but has been blown up out of all reason by sustained propaganda campaigns.

There may be other means of large-scale production of energy which do not involve combustion. Direct conversion of solar energy is the most promising candidate, but is not yet practicable. All such avenues should be intensively researched - indeed a 'crash programme' for this purpose would be justified.

Such a 'crash programme' should include research into measures to reduce objections to the use of nuclear power. It is possible that international action could reduce or eliminate the extra weapons risk, and other measures (perhaps locating nuclear plants underground) could reduce the present public apprehensions which, however ill-founded, are certainly politically effective.

As of now, the only known way out of the Emissions Bind is nuclear energy. Perhaps another way will be found in the future, or perhaps it will not. Only the event will tell, but we should keep looking - and the best prospect is still nuclear. Curiously enough, the Greenies, who hold the anti-nuclear stance as an article of faith, are also the most ardent advocates of action against the Greenhouse effect - it will be interesting to see how they resolve the conflict.

There is little action which should be taken today to reduce any damage caused by rising sea levels. In the coming century not more than a metre or two would be involved, and levee banks in coastal cities (and perhaps in countries such as Bangladesh) could be contemplated in the future. A possible (not certain) rise might be contemplated within the anticipated life of new construction.

The nature of any possible climatic change is so uncertain that no specific measures can be taken against it. Studies in re-location of sensitive areas (especially South-East Asia) could be made, and perhaps emergency food storage on an unprecedented scale could be examined - but no practical action seems to be immediately warranted.

In summary :

1. Under our present practices, it is highly likely that emission of industrial gases (principally carbon dioxide) into the atmosphere will cause rapid global warming.

2. If rapid global warming occurs, it is highly likely that the consequences will be serious. It is possible (though less likely), that they would be disastrous.

3. Any practicable reduction of total energy production in the Industrialised World can do no more than delay warming. It cannot stop it.

4. The only practicable way out seems to be combustion-free energy production.

5. Except for nuclear energy, no method of producing large-scale energy without combustion is at present practicable. A crash programme to find any other possible solution is justified.

6. Nuclear energy could be an immediate solution, but there are powerful impediments (mainly political) against its adoption. They require urgent re-examination.

7. If no non-combustion energy source can be found, the choice between accepting nuclear energy and accepting the Greenhouse Effect (whatever it may be) will be inescapable.

We should avoid panic action under the influence of public hysteria, but we should not defer reasonable action. The middle course is the best, and scientists have the responsibility of charting where that middle course most probably lies. There is no certainty ahead - as yet we can only assess probabilities.

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