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United States Department of State

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

July 2, 1990

UNCLASSIFIED

MEMORANDUM

To: OSTP - Nancy Maynard
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FROM: OES/EGC - Daniel A. Reifsnyder *DAR*

SUBJECT: Draft IPCC Executive Summary

Attached is a copy of the draft IPCC Executive Summary (4 pages) which we received this morning from Geneva. Please provide your written comments on this document no later than 12 noon on Tuesday, July 3. As previously mentioned, specific textual changes, as opposed to general comments, stand a better chance of being incorporated in the final draft.

Please fax your written comments to me at: 647-5947. My telephone number is: 647-4069.

Attachment:

As stated.

UNCLASSIFIED

Executive Summary

- There is a natural greenhouse effect which keeps the Earth warmer than it would otherwise be.
 - Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increase the greenhouse effect, resulting on average in an additional warming of the Earth's surface.
 - The total increase of all human-made gas emissions is at present equivalent to an increase of carbon dioxide since pre-industrial times of about 50%.
 - Based on current model computations the rate of increase of temperature is estimated to be about 0.3 °C per decade (with an uncertainty range of 0.2 °C to 0.5 °C) in the case of an economic development in the world of what might be called Business-as-Usual. This will result in a likely increase in the global mean temperature of about 1 °C above the present value (about 2 °C above that in the pre-industrial period) by 2025 and 3 °C above today's value (about 4 °C above pre-industrial) before the end of next century with an uncertainty range of about 50%.
 - Due to the delaying effect of the oceans the realized temperature change is at any given time between 50 and 80% of the committed temperature change.
 - If the man-made emissions were stopped, the greenhouse gas concentrations would return to pre-industrial concentration only slowly, i.e. in the matter of decades to centuries.
 - The size of the warming that has occurred during the last one to two centuries is broadly consistent with the predictions by climate models.
 - The confidence in regional estimates of climate change is low, especially for the changes of precipitation.
- * * *
- Because of the lack of more accurate estimates of the expected regional changes of climate, more precise predictions of the regional impacts of climate change cannot yet be made.
 - If no preventive measures to limit the further increase of man-induced emissions of greenhouse gases, an average rate of global mean sea level rise of about 6 cm per decade is expected over the next century, with an uncertainty range of 3-10 cm per decade.
 - Although studies have not yet conclusively determined whether on average global agricultural potential would increase or decrease, changes of climate would have important effects regionally.

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- Current forests will mature and decline in a climate, to which they are increasingly poorly adapted.
 - Natural terrestrial ecosystems would be markedly influenced because the rates of climate change are likely to be faster than the ability of some species to adjust.
 - Enhanced carbon dioxide concentrations in the atmosphere might enhance growth of certain plants.
 - Comparatively small changes of climate can cause large water resource problems. The availability of water and biomass might be significantly affected and both are major energy sources in many developing countries.
- * * *
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FROM
PREVIOUS PAGE.
- The long-lived greenhouse gases, carbon dioxide, CFCs and nitrous oxide, would require reductions in emissions from human activities by more than 60% in order to stabilize concentrations at today's levels.
 - A reduction of the use of CFCs would be a most cost-effective measure to slow down the rate of global warming. The CFCs will probably be replaced by HCFCs and HFCs, which are weaker greenhouse gases, but serious consideration should still be given to other replacements, because of the difficulties generally encountered when attempting to prevent a further build up of atmospheric greenhouse gases.
 - Assuming a projected increase of the world population to about 8 billion by 2030, the present global average emissions of carbon dioxide of about 1.45 ton of carbon per capita would have to be reduced to about 0.35 ton of carbon per capita in order to stabilize carbon dioxide concentrations in the atmosphere.
 - A reduction of the rate of increase of carbon dioxide in the atmosphere by 10-15% could be achieved if the present rate of deforestation would be reduced to about half of the present rate.
 - Reforestation of 12 million hectares per year during the next 40 years, would slow down the rate of increase of carbon dioxide in the atmosphere during this period by about 10% compared with the present rate.
- * * *
- Industrialized and developing countries have a common responsibility in dealing with the problem arising from climate change. The former should take the lead in two ways:
 - 1) to limit climate change by adapting their own economies in line with future agreements to limit emissions,
 - 2) to cooperate with developing countries in international action, without standing in the way of the latter's development.

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- Sustainable development requires the proper concern for environmental protection as the necessary basis for continued economic growth. It will increasingly have to take into account the issue of climate change. It is imperative that the right balance is struck between economic growth and environmental objectives.
- The developing countries are rapidly increasing their emissions of greenhouse gases in striving for improving their living standards. Recognizing the poverty that prevails among the populations of developing countries, it is natural that fight against poverty and achieving economic growth is given priority by them. Closing the gap between the industrialized and the developing world is a prerequisite for a full partnership of all nations of the world in the development of a strategy to deal with the climate change issue.
- The potentially serious consequences of climate change give sufficient reasons to begin by adopting response strategies that can be justified immediately even in the face of significant uncertainties. These include
 - CFC controls
 - use of energy sources with lower emissions of greenhouse gases
 - improved energy end use efficiency
 - improved forest management
 - review of agricultural practices
- There is no single quick-fix technological option for limiting greenhouse gas emissions from the energy sources. A comprehensive strategy is necessary.
- A major dilemma of the issue of climate change due to increasing emissions of greenhouse gases into the atmosphere is that actions may be required well before many of the specific issues that are raised can be resolved by further research.
- Measures for adapting to global climate change should be begun as soon as possible, particularly with regard to disaster preparedness policies, coastal zone management and control measures for desertification.
- * * *
- The measures that may be necessary require a high degree of international cooperation, with due respect for national sovereignty of states. To assist in that process, international negotiations on a framework convention on climate change should start as quickly as possible.
- Individual nations, or groups of nations, should consider actions to stabilize emissions and thus assist in the prevention of an acceleration of greenhouse gas concentrations in the atmosphere.
- In the long term perspective, work should begin on defining criteria which would reflect the impacts of climate change and their costs on one hand and practicalities of reductions in emissions on the other. They should take into account what might be an acceptable level of climate

change and reflect the changes of scientific and economic understanding and technological capabilities.

- The IPCC recommends that research regarding the climate change issue in general, and the international economic implications in particular, be intensified.
- Because climate change would affect, either directly or indirectly, almost every sector of society, and also because important policy responses will have to be developed against the background of uncertainty, broad global understanding of the issue will facilitate the adoption and the implementation of such response options as deemed necessary and appropriate. Further efforts to achieve such global understanding are urgently needed.
- The IPCC appeals to multilateral and bilateral funding organizations to assist developing nations in their efforts to take part in the international cooperation with regard to the climate change issue and to do so without awaiting the outcome of future negotiations on a climate convention. It further appeals to governments for continuing and increased contributions to the IPCC Trust Fund on an urgent basis.

Comments
faxed to
OES/DOS

11:10 am 7/2/90
JH

United States Department of State

Bureau of Oceans and International
Environmental and Scientific Affairs

Washington, D.C. 20520

Date 6/29/90

647-
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36 PAGES TO FOLLOW

OVERVIEW AND CONCLUSIONS

Climate Change: a key Global Issue

The consideration of the Final Report by the World Commission on Environment and Development by the UN General Assembly in 1987 brought the issue of a possible future man-induced climate change to world attention and recognition. In 1988, following the decisions of the Tenth World Meteorological Congress, its Executive Council and the 14th session of the Governing Council of the United Nations Environment Programme (UNEP), the Executive Heads of the World Meteorological Organization and UNEP pursued the issue by inviting all nations of the UN to take part in a more elaborate study of a possible man-induced climate change. The first meeting on such a study was held in Geneva in November 1988, in which 30 countries participated. The Intergovernmental Panel on Climate Change (IPCC) thus formed, and open to all countries, agreed on the following tasks (see reference 1):

1. assessment of available scientific information on climate change;
2. assessment of environmental and socio-economic impacts of climate change;
3. formulation of response strategies.

The Panel set up Working Group I on Science, Working Group II on Impacts and Working Group III on Response Strategies to carry out the three tasks listed above.

At its second meeting held in Nairobi in June 1989, IPCC responded to the request by the UN General Assembly (see reference 2) to present its First Assessment Report in September 1990, to be available to the UN General Assembly later that year. The present report is an outcome of the deliberations by the Panel and its Working Groups. At its third session held in Washington D.C. in February 1990, IPCC responded to the request of the Noordwijk Ministerial Conference on Atmospheric Pollution and Climate Change to examine the feasibility of various options to stabilize and/or reduce emissions of carbon dioxide and other greenhouse gases. This work is now under way.

1 It should be emphasized that the issue of a possible man-
2 induced climate change is very different from any other
3 environmental issue that has emerged. It is a truly global
4 problem, and will be a concern for all countries. Although the
5 contributions to the emissions of greenhouse gases into the
6 atmosphere are very different and will remain so in the future,
7 all countries will be influenced in one way or another. Joint
8 actions by all countries will be required in order to prevent or
9 mitigate the consequences of climate change.

10
11 The IPCC's objective has been to provide the scientific and
12 technical basis for action. It is clear that the present
13 overview, supported by the extensive working group reports and
14 their policymakers summaries, that some very specific general
15 conclusions can already be drawn from this first phase of broad
16 assessment of the issue, although many uncertainties remain. It
17 should constitute a useful synthesis for our present knowledge
18 that could serve as basis for negotiations about how to deal with
19 the issue. It is, however, also obvious that we are facing a
20 very difficult problem, and there will be no simple solutions.

21
22 The following overview of the IPCC Assessment presents a
23 synthesis of the most important conclusions that have been
24 reached by the Working Groups and are judged to be of particular
25 importance for the political analyses and the negotiations that
26 will begin after the fourth IPCC plenary meeting. To address
27 more specific questions, in an analysis of this major
28 environmental issue, reference is made to the Working Group
29 reports.

30 31 The Scientific Issue

32 33 Increasing Greenhouse Gas Concentrations

34
35 It is first of all important to emphasize that although
36 uncertainties exist with regard to the likelihood and the
37 character of human-induced climate change, we do know some things
38 with considerable certainty. Working Group I has structured its
39 Policy-makers' Summary to distinguish clearly between:

- 40
41 - what we know with certainty
42 - what we calculate with confidence
43 - what is predicted by current models
44 - what our best judgement is on matters that are more
45 uncertain

46
47 First it is stated that we are certain of the following:

- 48
49 - there is a natural greenhouse effect which already keeps the
50 Earth warmer than it would otherwise be,
51
52 - emissions resulting from human activities are substantially
53 increasing the atmospheric concentrations of the greenhouse
54 gases: carbon dioxide, methane, chlorofluorocarbons (CFCs)
55 and nitrous oxide.

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warming of the Earth's surface.

The table below summarizes the present and pre-industrial abundances, current rates of change and present atmospheric lifetimes of greenhouse gases influenced by human activities. Carbon dioxide, methane, and nitrous oxide all have significant natural and human sources, while the chlorofluorocarbons are only produced industrially.

SUMMARY OF KEY GREENHOUSE GASES AFFECTED BY HUMAN ACTIVITIES					
	Carbon Dioxide	Methane	CFC-11	CFC-12	Nitrous Oxide
Atmospheric concentration	ppmv	ppmv	pptv	pptv	ppbv
Pre-industrial (1750-1800)	280	0.8	0	0	288
Present day (1990)	353	1.72	280	484	310
Current rate of change per year	1.8 (0.5%)	0.015 (0.9%)	9.5 (4%)	17 (4%)	0.8 (0.25%)
Atmospheric lifetime (years)	50-200	10	65	130	150

ppmv = parts per million by volume; ppbv = parts per billion (thousand million) by volume;
pptv = parts per trillion (million million) by volume.

Since the industrial revolution the combustion of fossil fuels and deforestation have led to an increase of 26% in carbon dioxide concentration in the atmosphere. Methane concentrations have more than doubled because of rice production, cattle rearing, biomass burning, coal mining and ventilation of natural gas; also, fossil fuel combustion may have also contributed through chemical reactions in the atmosphere which reduce the rate of removal of methane. CFCs, which were not present in the atmosphere before their invention in the 1930s, are used as aerosol propellants, solvents, refrigerants and foam blowing agents. The total increase of all human-made greenhouse gas emissions is at present equivalent to an increase of carbon dioxide since pre-industrial times of about 50%.

The scenario assumes that, although oil and natural gas will play an important role as energy sources for several decades into next century, the major energy supply will be from coal, while renewable and nuclear energy sources are judged not to play a more important role globally until well into the 21st century. Account has been taken of the Montreal Protocol for reducing the emissions of the CFC-gases but not the possibility of phasing them out. The increase of greenhouse concentrations

Must include natural as well as anthropogenic fluxes in this table

How justified?

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56

... increase of greenhouse concentrations will be
equivalent of a doubling of the carbon dioxide concentration by
about 2025 and quadrupling during the latter part of next century

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must define this term in greater detail.

although the scenario is most uncertain beyond the middle of next century. Emissions in 1985 and 2025 in the Business-as-Usual scenario are given in the table below.

	1985	2025
carbon dioxide (GtC)	5.9	11.5
methane (Tg)	541	761
nitrous oxide (Tg)	13	16
CFCs and HCFCs (Mt)	740	1900

Make clear that this is detailed

It is interesting to note that national plans for the future (Reference Scenario; Working Group III) show a somewhat greater increase of carbon dioxide and methane emissions until 2025 than implied by the Business-as-Usual scenario.

Good

The anthropogenic fluxes of CO₂ are much smaller (approx. 6Gt C/year) than the natural exchange fluxes (200Gt C/year) which occur between the atmosphere and the terrestrial biota and between the atmosphere and the oceans. Note that the figure should also include the emissions due to deforestation and changing land use. However, the anthropogenic fluxes have been large enough to modify significantly the natural balance during pre-industrial times as evidenced by the 25% increase of atmospheric carbon dioxide during the last 200 years.

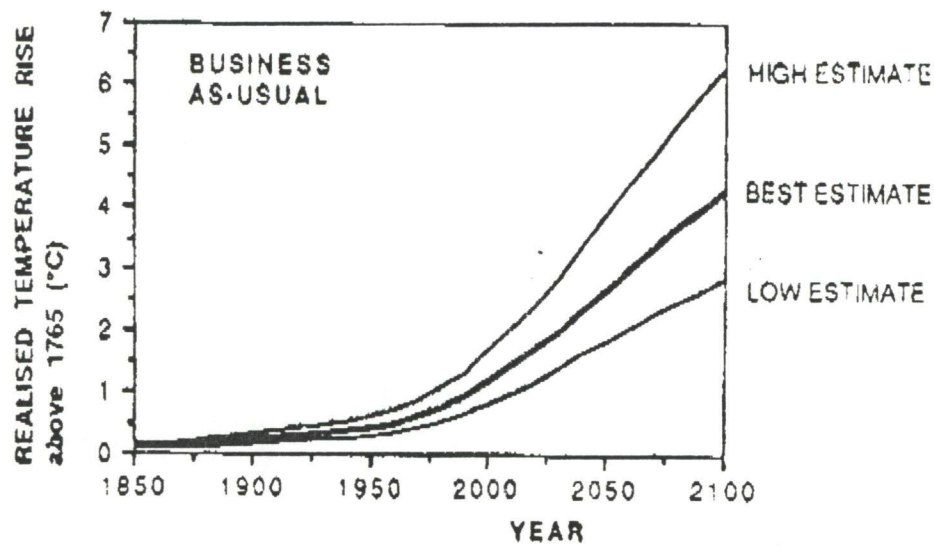
Man-induced climate change

It is relatively easy to determine the direct effect of the increased radiative forcing due to increases in greenhouse gases. However, as climate begins to warm, various processes act to amplify (through positive feedbacks) or reduce (through negative feedbacks) the warming. The main feedbacks which have been identified are due to changes in atmospheric water vapour, clouds, sea-ice and the oceans.

The best tools we have which take the above feedbacks into account are mathematical models of the climate system which synthesise our knowledge of the physical and dynamical processes and allow for the complex interactions between the various components. However, in their current state of development, the descriptions of many of the processes involved are comparatively crude. Because of this, considerable uncertainty is attached to these predictions of climate change, which is reflected in the ranges of values given below. Based on current model results the rate of increase of temperature is estimated by WGI to be about 0.3°C per decade (with an uncertainty range of 0.2°C to 0.5°C this is greater than any changes seen over the past 10,000 years. This will result in a likely increase in global mean temperature of about 1°C above the present value (about 2°C above that in the

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above pre-industrial) before the end of the next century with an uncertainty range of about 50%. The projected temperature rise out to the year 2100, with high, low and best-estimate climate responses, is shown in the diagram below. Because of other factors which influence climate, we would not expect the rise to be a steady one.



The temperature rise shown above is the realised temperature; due to the delaying effect of the oceans at any given time we would also be committed to a further temperature rise which would become apparent in decades to a century. Models predict that the realised temperature rise at any time is between 50 and 80% of the committed temperature rise.

It is finally important to recognize that a climate change that has occurred because increase concentrations of greenhouse gases in the atmosphere will disappear only slowly, even if all man-induced emissions would be stopped instantaneously. This is due to the fact that the life-times in the atmosphere of the major greenhouse gases with which we are concerned, carbon dioxide, nitrous oxide and the CFC-gases about half a century to a few centuries. From a point of view, a climate change due to increasing amounts of greenhouse gases in the atmosphere is irreversible.

How much confidence do we have in our predictions?

There are many uncertainties in our predictions, particularly with regard to the timing magnitude and regional patterns of climate change. These uncertainties arise from our imperfect knowledge of:

- future rates of human-made emissions
- how these will change the atmospheric concentrations
- the response of climate to these changed concentrations

Firstly, it is obvious that the...

...ity, it is obvious that the extent to which climate will change depends on the rate at which greenhouse gases (and other

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gases which affect their concentrations) are emitted. This in turn will be dependent on various complex economic and sociological factors.

Secondly, because we do not fully understand the sources and sinks of the greenhouse gases, there are uncertainties in our calculations of future concentrations arising from a given emissions scenario. Furthermore, because natural sources and sinks of greenhouse gases are sensitive to a change in climate, they may substantially modify future concentrations. It appears that, as climate warms, these feedbacks will lead to an overall increase, rather than decrease, in natural greenhouse gas abundances. For this reason, climate change is likely to be greater than the estimates we have given.

Thirdly, climate models are only as good as our understanding of the processes which they describe, and this is far from perfect. The ranges in the climate predictions given above reflect the uncertainties due to model imperfections; the largest of these is cloud feedback (those factors affecting the cloud amount and distribution and the interaction of clouds with solar and terrestrial radiation). Note a factor of two is larger than the total uncertainty range. Others arise from the transfer of energy between the atmosphere and ocean, the atmosphere and land surfaces, and between the upper and deep layers of the ocean. The treatment of sea-ice and convection in the models is also crude. Nevertheless we have substantial confidence that models can predict at least the broadscale feature of climate change, and we are confident that existing reliability of the predictions can be improved by further research.

Furthermore, we must recognise that our imperfect understanding of climate processes (and corresponding ability to model them) could make us vulnerable to surprises; just as the human-made ozone hole over Antarctica was entirely unpredicted. In particular, the ocean circulation, changes in which are thought to have led to periods of comparatively rapid climate change at the end of the last ice age, is not well observed, understood or modelled.

Testing Model Computations against Observations

It is of course essential to test model calculations against reality in order to validate the results.

We know from observations that the global mean temperature has increased between 0.30C and 0.60C, since the middle of last century and that most of this change has occurred primarily during two periods, i.e., the first four decades of this century and since 1975. Working Group I has carefully considered the criticism that local warming at observations sites within or in the vicinity of densely populated regions may explain some part of the observed change; such urban biases have been removed from the record.

Since we really don't understand the feedback mechanisms, how do we know that the positive ones are dominant? Note inability to do regional predictions here even tho it is picked up later.

the record.

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When trying to validate the model computations with the aid

Should also be mentioned that the most precise global temp measurements available show that from 1979-1988 there was no net increase in global temp. despite common contention that 6 of the hottest years etc occurred in this decade

of these observations a further complication arises in that the global mean temperature has not been increasing steadily; even a slight decline was observed in the Northern Hemisphere during the period 1949 -1975. Such irregular variations of the global mean temperature by several tenths of a degree are to be expected due to internal interactions (eg between ocean and atmosphere) in the climate system. These natural variations further obscure the warming trend that may result from increasing amounts of greenhouse gases in the atmosphere.

The size of the warming over the last century is broadly consistent with the predictions of climate models, but is also of the same magnitude as natural climate variability. If the sole cause of the observed warming were the human-made greenhouse effect, then the implied climate sensitivity would be near the lower end of the range inferred from the models. The observed increase could be largely due to natural variability; alternatively this variability could have offset a still larger man-made greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more, during which time the commitment to future climate change would have grown considerably larger than it is today. *assuming business as usual scenario.*

Regional Patterns of Climate Change

Knowledge of the global mean warming is of limited use in determining the impacts of climate change, for instance on agriculture. For this we need to know changes of temperature and precipitation regionally and seasonally. Models predict that regional climate changes will be different from the global mean. For example, temperature increases in Southern Europe and central Northern America are predicted to be higher than the global mean, accompanied on average by reduced summer precipitation and soil moisture. In general, confidence in regional estimate is low, especially for the changes in precipitation and soil moisture. Therefore we cannot yet give reliable regional predictions at the smaller scales demanded for impacts assessments.

A completely different, and potentially useful way of predicting patterns of future climate is to search for periods in the past when the global mean temperatures were similar to those we expect in future, and then use the past spatial patterns as analogues of those which will arise in the future. Paleoclimatological information can provide useful insights into climate processes, and can assist in the validation of climate models. In addition, paleo-analogue scenarios are useful for sensitivity studies to evaluate regional impacts of climate change.

Changes in the variability of weather and the frequency of extremes will generally have more impact than changes in the mean climate at a particular location. With the possible exception

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an increase in mean temperature, episodes of high temperatures will most likely become more frequent in the future, and cold episodes less frequent.

Environmental Impact of Climate Change and Socio-Economic consequences

Impacts and Sensitivity

Because we are not yet able to foresee future likely changes of the regional distribution of climate with much accuracy we cannot predict more specifically the probable impacts of regional changes and are therefore limited to assessing them in rather general terms. Quantitative assessments of the socio-economic implications of a climate change for specific regions and countries are not either yet possible. We can, however, analyze the sensitivity of the environment to a given change of climate and much of what is brought out in the report of the Working Group II should be interpreted in that way.

Our ability to make more precise assessments of the impacts of global change will only come gradually during the 1990s, as regional predictions of climate change become more reliable.

The Working Group II Report concludes that:

The uncertainty of the regional predictions of climate change at present, limits our possibility to assess quantitatively the impacts of such a change. For the time being we rely on sensitivity analyses for the assessment of the likely impacts, which should, however, yield rather clear qualitative views about the vulnerability of nations to such changes. This uncertainty about the spatial characteristics of regional and local changes of climate must not overshadow the earlier conclusion that a significant change of the global mean temperature is associated with larger changes on the regional and local scale.

A climate change will bring with it both positive and negative impacts, although the negative ones will dominate (cf Working Group II). It is likely that, to a greater or lesser extent, all countries will be affected either directly or indirectly by climate change.

A rising sea level and its impacts

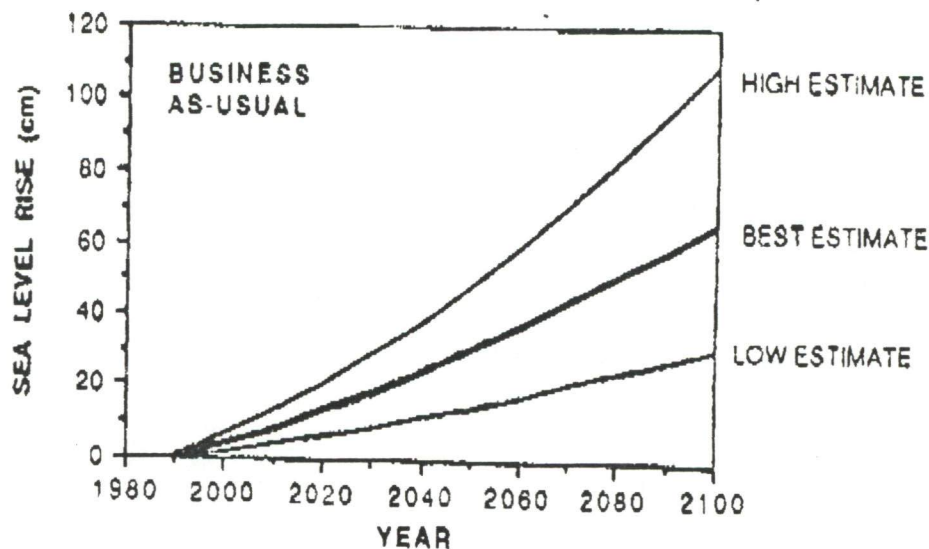
A warmer climate will induce a rise of the sea level, partly due to the expansion of sea water when being warmed. The response of the ice sheets over Greenland and particularly in the Antarctica is more uncertain, since both accumulation (due to change of snowfall) and melting is influenced by a change of climate. Working Group I concludes that:

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under the IPCC Business-as-Usual emissions scenario, an average
rate of global mean sea level rise of about 6cm per decade over

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under the IPCC Business-as-Usual emissions scenario, an average rate of global mean sea level rise of about 6cm per decade over the next century (with an uncertainly range of 3-10cm per decade is expected); this is three to six times faster than that seen over the last 100 years. The predicted rise is about 20cm in global mean sea level by 2030, and 65cm by the end of the next century, more detail is shown in the diagram below. There will be significant regional variations. Furthermore, even if greenhouse forcing stabilised, there would still be a commitment to a continuing sea level rise for many decades and even centuries, due to delays in climate, ocean and ice mass responses.



These values are less than those given in earlier assessments, particularly the upper bounds. The lower values do not give rise to an immediate concern except in the coastal areas of some countries with extensive coastlines of low-lying land and for some island states. The Working Group II recommends a more precise assessment of the risks to coastal areas and islands and to living resources caused by a 0.3-0.5 m rise of sea level which might be expected towards the latter part of next century, if no preventive measures were taken.

The slowly rising mean sea level is not an immediate threat. Increased damage will rather be experienced during storms, when short term variations of sea level induced by winds and by high waves would cause more destructive flooding. Delta regions of major rivers are obviously sensitive and often also heavily exploited for agricultural production.

The rise of sea level might threaten some low island and coastal zones by the middle of next century. A one meter rise, which is at the upper limit of what might occur in 100 years time, would impact 360,000 km of coastline (Working Group III), would render some island countries uninhabitable, displace tens of millions of people, seriously threaten low-lying urban areas, flood productive land and contaminate...

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1 The West Antarctic Ice Sheet is of special concern because
2 a large part of it is grounded far below sea level. However,
3 Working Group I concludes that "within the next century, it is
4 not likely that there will be a major outflow of ice from the
5 West Antarctica due directly to global warming".

6 Impacts on land, water and ecosystems

7
8
9 Turning next to the more difficult question of impacts of
10 climate change on land, water and ecosystems, it is first
11 important to recognize that a warmer climate is not necessarily
12 harmful, if precipitation is adequate. The ecosystem composition
13 might of course change, which in turn would imply the loss of
14 plant species.

15
16 It is likely, however, that the distribution of
17 precipitation would change and that soil moisture predominantly
18 might decrease in continental regions. A change of the
19 distribution of climatic zones would probably also occur and be
20 associated with large regional local changes. Some ecosystems
21 might well have difficulties to adjust in this process. Working
22 Group II Policymakers' Report gives a more detailed analysis of
23 the expected impacts in the case of the Business-as-Usual,
24 Scenario A. Some key features of these impacts as described by
25 Working Group II have been extracted for the present overview.

26
27 "Changes of climate would have an important effect on
28 agriculture, including livestock. Studies have not yet
29 conclusively determined whether on average, global
30 agricultural potential would increase or decrease. Negative
31 impacts could be felt at the regional level" and "there may
32 be severe effects in some regions, particularly decline in
33 production in regions of high present-day vulnerability,
34 that are least able to adjust." These include Brazil, Peru,
35 Sahel, S.E. Asia, Asian USSR and China. "Patterns of
36 agricultural trade could be altered by decreased cereal
37 production in some of the currently high-production areas."
38 Although not analyzed more specifically, the supply of food
39 would become more vulnerable to disturbances caused by
40 changes of climate in a world with a rapidly growing
41 population.

42
43 "The rotation period of forests is long and current forests
44 will mature and decline in a climate, to which they are
45 increasingly more poorly adapted. "Major forest-type zones
46 and species ranges in the Northern Hemisphere could shift
47 significantly as a result of climate change." "The most
48 sensitive areas will be where species are close to their
49 biological limits in terms of temperature and moisture", as
50 "for example in semi-arid areas. Social stresses can be
51 expected to increase and consequent damage to forest may
52 occur. These increased and non-sustainable uses will place
53 more pressure on forest investments, forest conservation and
54 sound forest management."

55
56 "Natural terrestrial ecosystems would be markedly influenced

11

1 because the rates of projected climatic change are likely
2 to be faster than the ability of some species to respond.
3 Flora and fauna would lag behind these climatic shifts and
4 could find themselves in a different climatic regime. Major
5 vegetation zones could face severe disturbances and
6 disruptions, influencing plant and associated animal
7 populations". "Species could disappear and lead to
8 substantial reduction in biological diversity". "The socio-
9 economic consequences of these impacts will be significant,
10 especially for those regions of the globe where societies
11 and related economies are dependent on natural terrestrial
12 ecosystems for their welfare. Changes in the availability
13 of food, fuel, medicine, construction materials and income
14 are possible as these ecosystems are changed. Important
15 fibre products could also be affected in some regions."

17 Enhanced carbon dioxide concentrations in the atmosphere
18 would increase the water-use efficiency in the process of
19 photosynthesis which might enhance growth for certain plants
20 in some regions of the globe, which might be beneficial in
21 agriculture and forestry as well as for natural ecosystems.
22 "Consequences of CO₂ enrichments and climate change could be
23 modified by other environmental factors, both natural and
24 man-induced (e.g. by air pollution)."

26 "Relatively small climate changes can cause large water
27 resource problems. In many areas, especially in arid and
28 semi-arid regions and those humid areas where demand or
29 pollution has led to water scarcity." While "many areas
30 will have increased precipitation, soil moisture will
31 decrease in other areas, particularly in those that are
32 "already in marginal situations such as the Sahelian zone
33 in Africa." Increased drought risk represents potentially
34 the most serious impact of climate change on agriculture.
35 "Future design in water resources engineering will need to
36 take possible impacts into account when considering
37 structures with life span to the end of the next century",
38 but necessary analyses are uncertain at present because of
39 the lack of adequate regional predictions.

41 "Global warming can be expected to affect the availability
42 of water and biomass, both major energy sources in many
43 developing countries. These effects are likely to differ
44 between and within regions with some areas losing and others
45 gaining water and biomass. Such changes in areas which lose
46 water may jeopardise energy supply and materials for human
47 habitation and energy."

49 It is obviously difficult to judge how serious a climatic
50 change might be to an individual nation, or to humankind as a
51 whole, on the basis of the still largely qualitative findings as
52 given in the Working Group II report.

54 Means to integrate more quantitatively the implications of
55 these many possible impacts, both positive and negative, are
56 needed. The impacts as briefly described call for careful

(2)

consideration of the consequences of climate change in the developments of plans for resource use and management.

Impacts on People

Direct impacts of climate change on people are modest. A warmer climate may imply, however, that previously hot places become even hotter. Even though this may cause problems for elderly and sensitive people, it usually cannot be considered as a serious problem.

Changing climate could, on the other hand, affect human settlement and change the geographical distribution of diseases in the world and stimulate a spread of epidemic diseases. The IPCC recognizes the views as expressed by Working Group II, that

"The most vulnerable human settlements are those especially exposed to natural hazards, e.g. coastal or river flooding, severe drought, landslides, severe wind storms and tropical cyclones. Most vulnerable populations are in developing countries, in the lower income groups, residents of coastal lowlands and islands in semi-arid and in grasslands."

"Changes in precipitation and temperature could radically alter the patterns of vector-borne and viral diseases by shifting them to higher latitudes and thereby putting large populations at risk." This could initiate migrations of people in turn leading to disruptions of settlement pattern and social instability in some areas."

Reducing emissions of greenhouse gases -- the scope of the problem

Emission Scenarios

As pointed out above, man's emissions of greenhouse gases have enhanced their concentration in the atmosphere so that their present integrated effect is equivalent to a concentration of carbon dioxide in the atmosphere of about 150% of the pre-industrial concentration. Half of this increase has occurred in less than 25 years. The analysis of different scenarios of the future increase of greenhouse gases in the atmosphere show that the equivalent carbon dioxide concentration in the atmosphere probably measures to limit future emissions were taken. Before considering what measures to limit future emissions might be justified, it is important to recognize the very major efforts that are required in order to slow down or to halt climate change.

The Scope of the Problem

It is important to clarify first the relative importance of the different greenhouse gases in bringing about a climate change. We need to understand the difficulties that will be encountered in efforts to reduce their emissions and thereby to slow down their rates of increase or ultimately to stabilize

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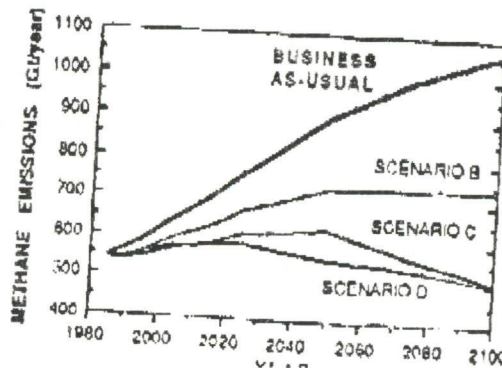
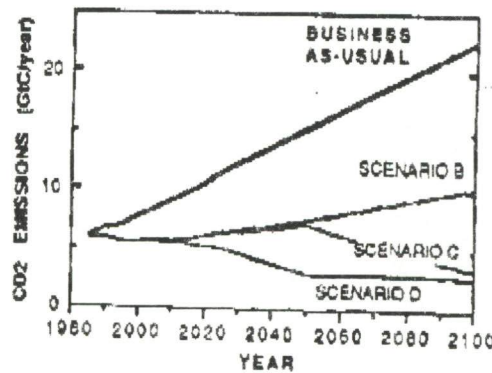
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their atmospheric concentrations. Working Group I and III have presented relative contributions to the additional forcing (heating) of the atmosphere during the period 1765 - 1990, the last decade and their predicted contributions for the period 2000 - 2025 under the Business-as-Usual, (in percent);

	1765-1990	1980-90	BaU 2000-25
Carbon dioxide	61	55	63
Methane	23	15	17
CFC	12	24	7
HCFCs	0	0	8
Nitrous Oxide	4	6	5

(Ozone may be an important contributor, but its effects are difficult to quantify and have not been included above)

The recent (1980 - 1990) reduction in the proportion of forcing change due to carbon dioxide is primarily due to the very rapid increase in the role of the CFC-gases as forcing agents. Because of the Montreal agreement on limiting the use of CFC-gase, the relative contribution of carbon dioxide as a heating agent will increase throughout the 21st century according to the Business-as-Usual scenario. Working Group III has developed three other scenarios, all having the same assumptions about population growth as the Business-as-Usual (Scenario A). The man-made emissions of carbon dioxide and methane from all four WGI/II scenarios are shown in the diagrams below.



But we need to put this in perspective by looking at the natural fluxes as well as the anthropogenic ones.

But surely we need to have a feeling for the sensitivity to the rate of population growth. How would IPCC pick its particular growth scenario and why?

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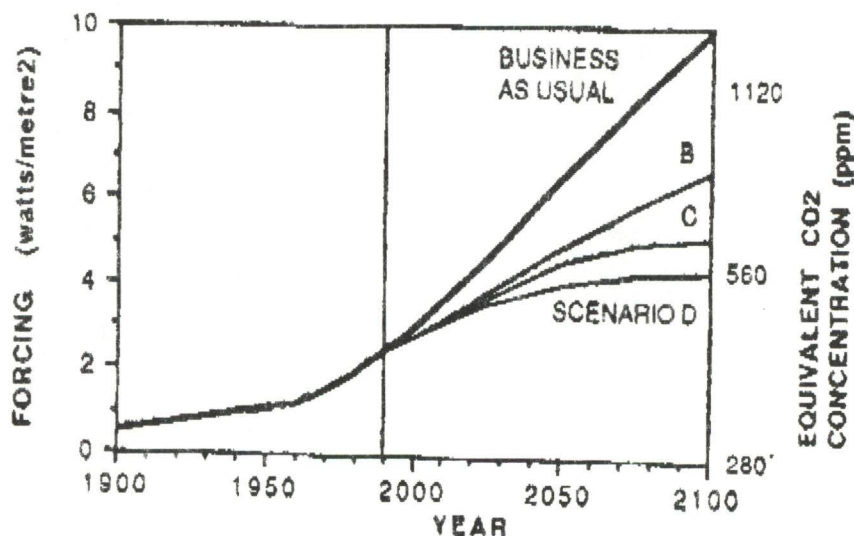
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Scenario B, Low Emission, assumes the energy supply mix of fossil fuels shifts towards natural gas, large efficiency increases are achieved, deforestation is reversed and the Montreal Protocol on CFCs is fully implemented. This results in a doubling of equivalent carbon dioxide by about 2040.

Scenario C, Control Policies, assumes a shift towards renewable energies and nuclear energy takes place in the latter part of the next century, CFC-gases are phased out and agricultural emissions (methane and dinitrogen oxide) are limited; an equivalent doubling of carbon dioxide will occur in about 2050. It should be recalled that there is a 50% uncertainty range around each one of the curves shown in the figure.

Scenario D, Accelerated Policies; assumes a rapid shift to renewable energies and nuclear energy takes place early in the next century in the cases of Scenarios B, C and D will be between 70% and 50% of the stringent emission controls in industrial countries and moderate growth of emissions in developing countries. This scenario stabilises equivalent dioxide concentrations at about twice pre-industrial levels towards the end of the next century.



Contribution by Sector

"For the later analysis of possible measures to be implemented it is of interest also to give the relative contributions to the enhanced radiative forcing during the decade of the 1980s and the projected distribution for the period 2000 - 2025 by sector. The still relatively large contribution from CFC-gases is due to the assumption made that these will largely be replaced by HCF and HCFC-gases" The numbers given in the text should be presented in a table and the relative distributions from the different groups

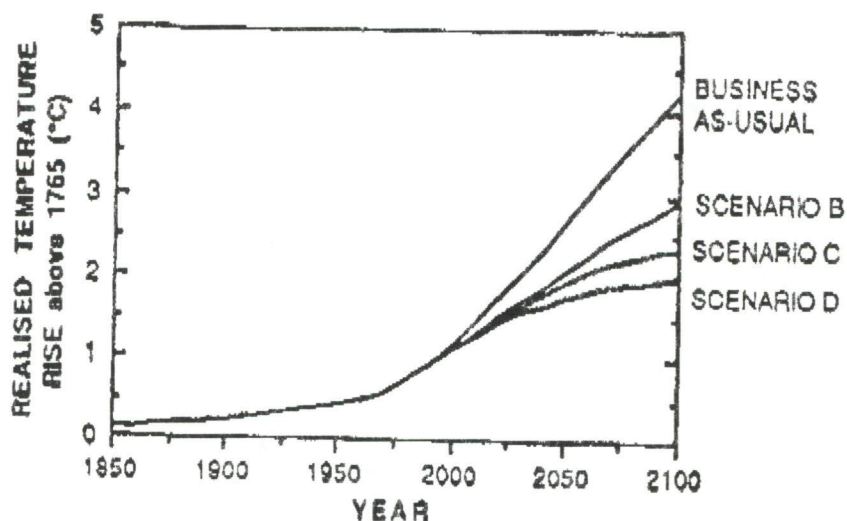
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also included from the different greenhouse gases as presently
in the report. also included can be deleted, since they have been given earlier

15

Climate change when emissions are controlled

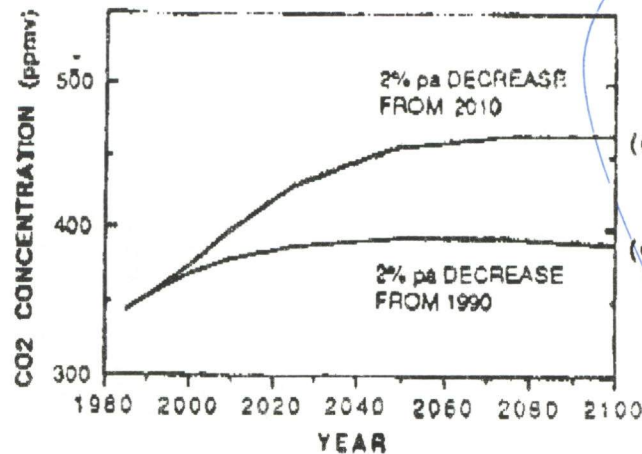
Under the other Working Group III emission scenarios which assume progressively increasing levels of controls, rates of increase in global mean temperature are predicted to be about 0.2°C per decade (Scenario B), just above 0.1°C per decade (Scenario C and about 0.1°C per decade (Scenario D). Further details are shown in the diagram below.



Sea level rise by the end of the next century will be between 50% and 70% of the Business-as-Usual scenario.

Reducing emissions of greenhouse gases

To limit future climate change we need to examine the effectiveness of reductions in the emissions of each of the greenhouse gases. Atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide and the CFCs) adjust only slowly to changes in emissions. Continued emissions of these gases at present rates would commit us to increased concentrations for centuries ahead. The longer emissions continue to increase at present day rates, the greater reductions would have to be for concentrations to stabilise at a given level (see diagram below). The long-lived gases would require immediate reductions in emissions from human activities by more than 60% in order to stabilise their concentrations at today's levels; methane would require a 15-20% reduction.



Since they are typically 20 times larger a much smaller relative change here could provide the same net effect with presumably much less socio-economic impact.

- (c) emissions reduced by 2% pa from 1990
 (d) emissions reduced by 2% pa from 1990 to 2010, Then reduced by 2% pa

There are other technical criteria which may help policymakers to decide, in the event of emissions reduction being deemed necessary, which gases should be considered. Does the gas contribute in a major way to current, and future, climate forcing? Does it have a long lifetime, so earlier reductions in emissions would be more effective than those made later? And are its sources and sinks well enough known to decide which could be controlled in practice? The table below illustrates these factors.

Here we need to discuss the fact that anthropogenic modification of the natural fluxes needs to be investigated

GAS	MAJOR CONTRIBUTOR?	LONG LIFETIME?	SOURCES KNOWN?
Carbon dioxide	yes	yes	yes
Methane	yes	no	semi-quantitatively
Nitrous oxide	not at present	yes	qualitatively
CFCs	yes	yes	yes
HCFCs, etc	not at present	mainly no	yes
Ozone	possibly	no	qualitatively

1. The first part of the paper is devoted to a review of the literature on the topic of the role of the state in the development of the economy. It is found that the state has played a significant role in the development of the economy in many countries, particularly in the case of developing countries. The state has been involved in the provision of infrastructure, the regulation of the economy, and the provision of social services. The role of the state has been particularly important in the case of countries that have experienced economic crises, where the state has been able to provide the necessary support to the economy.

41

Chlorofluorocarbons

The Working Group I assessment clearly show that the CFC-gases are much more effective per kilogramme emitted in heating the atmosphere than any of the other greenhouse gases in today's atmosphere.

A reduction of the use of CFC-gases would be a cost-effective measure to contribute to the slowing down of global warming.

The role of the CFCs is expected to decrease because of the Montreal Protocol. It should be noted, however, that the CFCs will probably be partially replaced by HCFCs and HFCs which are weaker greenhouse gases because their atmospheric lifetimes are shorter than those of the CFCs. Still, because of the difficulties being encountered when attempting to prevent a further build up atmospheric greenhouse gases, serious consideration should be given to other replacements to the CFC-gases than HFCs and HCFCs as is now being proposed.

Methane, nitrous oxide and ozone

Reductions of the emissions of methane and particularly nitrous oxide are difficult to achieve, since they are primarily due to wide spread activities in society related to agriculture, forestry and waste management. Because the quantitative importance of each of these sources is not well known at present the effectiveness of different control strategies is hard to evaluate. We are less able to specify the sources of nitrous oxide; thus, strategies to reduce their emissions are even more difficult to develop. Tropospheric ozone is predicted to increase due to enhanced emissions of carbon monoxide, hydrocarbons and nitrogen oxides released mainly by transport and industry.

Carbon dioxide

It is clear from the analysis above that the major and increasing source of greenhouse emissions is due to the emission of carbon dioxide from fossil fuel combustion and deforestation. Carbon dioxide emissions are due to fossil fuel burning, at present 5.5 - 6.0 billion tons of carbon per year (GtC pa), and a net decrease of the terrestrial biosphere due to deforestation and changing land use of 0.6 -2.5 GtC pa in 1980 (at present probably somewhat larger). The total emissions are thus at present at least 6.5 - 8.5 GtC pa. The world population is about 5.2 billion and the emission per capita thus about 1.1 tons of carbon due to fossil fuel emissions and 0.35 billion tons due to deforestation and changing land use.

The emissions due to fossil fuel burning are, however, very unevenly distributed between regions of the world as shown in the following table:

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16

	Year: 1985	Carbon emissions billion tons of carbon per year	Carbon emissions tons of carbon per capita and year	Carbon emissions tons of carbon per GNP
8	Global Totals	5.15	1.06	
9	North America	1.34		
10	Western Europe	0.85	5.08	
11	OECD Pacific	0.31	2.14	
12	Centr. Planned Europe	1.33	2.14	
13	Africa	0.17	3.19	
14	Centr. Planned Asia	0.54	0.29	
15	Latin America	0.22	0.47	
16	Western Asia	0.13	0.55	
17	South and East Asia	0.27	1.20	
18			0.19	

It is difficult to deduce accurate values for the carbon dioxide emissions due to deforestation and changing land use. It seems clear, however, from the reports by Working Groups II and III that the net emission of carbon dioxide from the tropics due to deforestation amounted to about 1.7 GtC pa (range 0.6-2.5) in 1980. The average emissions per capita in the tropical countries is about 1 ton of carbon per year while some with more intense exploitation of their forests account for a per capita emission that approaches that of industrial countries due to fossil fuel emissions.

"On the basis of the various emission scenarios and assuming that the global population is about 8 billion in 2030, we compute the per capita emissions at that time to be (revised numbers from Jenkins) and that at due to deforestation and changing land use about 0.35 tons of carbon per year. If now, on the basis of the various emissions scenarios, we project the per capita emissions to the year 2070, assuming that the global population is 10 billion at that time, we arrive at the figures in the following table for the per capita emissions.

Scenario	CO2 (tC/capita)	Methane (t/capita)
Business-as-Usual	1.8	
Scenario B	0.8	0.1
Scenario C	0.5	0.07
Scenario D	0.3	0.06
		0.05

1 Noting that, only under scenario D is the carbon dioxide
2 concentration stabilised, and then at a level 50% above pre-
3 industrial, it is clear that achieving the figures in this table that
4 achieving stabilisation of atmospheric carbon dioxide concentrations
5 would require very major efforts by the global society. Even to
6 reduce the rate of change of climate as in scenarios B and C would
7 clearly be very difficult.

8
9 It is important in this context also to compare the possible
10 importance of reducing the rate of deforestation and expanding
11 reforestation. We note first that, at present, the total emissions
12 of carbon dioxide due to man's use of the terrestrial ecosystems are
13 about 25% of the total man-induced emissions of carbon dioxide into
14 the atmosphere. A major decrease of the rate of deforestation would
15 contribute significantly to slowing down the rate of carbon dioxide
16 increase in the atmosphere, but not stop it.

17
18 It has been proposed that a major programme for reforestation
19 should be initiated. The Noordwijk Ministerial Declaration in
20 November 1989 requested the IPCC to explore the effects of an annual
21 reforestation of 12 million hectares. Working Group I has calculated
22 roughly the transfer of carbon from the atmosphere into the
23 terrestrial biosphere that thereby would be achieved. If such a
24 policy would be maintained for a period of 40 years an area as large
25 as about 50% of the total area of the United States would have been
26 reforested. By 2030, i.e. 40 years from now, about 25 billion tons
27 of carbon would have been sequestered into the terrestrial biosphere,
28 possibly somewhat more if also the soil carbon would increase. After
29 100 years the accumulated uptake might be 50-70 billion tons of
30 carbon. This is 5-10% of the emissions of carbon dioxide into the
31 atmosphere that is expected during these periods of time due to fossil
32 fuel burning according to the Business-as-Usual and the Reference
33 Scenario. The practical difficulties of implementing such a policy
34 have not been analysed by Working Group III.

35
36 A reduction of the rate of increase of carbon dioxide in the
37 atmosphere by 10-15% could be achieved if the present rate of
38 deforestation would be reduced to about half of the present rate. In
39 tropical countries this would also contribute to maintaining
40 biological diversity. A major program of reforestation as considered
41 by the Noordwijk Ministerial Conference in November 1989 would play
42 some role in slowing down the rate of increase of carbon dioxide in
43 the atmosphere, but would at most reduce it by 5-10% if fossil fuel
44 use would continue to increase in accordance with the scenario
45 Business-as-Usual (Scenario A).

46 47 48 49 50 Future Programme of the Working Groups

51 a. Science and Impacts

52 Because of the pace with which scientific research is advancing,
53 it is vital that IPCC is provided with timely updates to its reports,
54 so that policymakers are provided with the best foundation for their
55
56

20

1 deliberations. Whereas complete new assessments will probably not be
2 required until about 1995, revisions in areas of major progress and
3 greatest uncertainty should be made by about 1992. In addition, the
4 capability should be provided to respond to ad hoc scientific
5 questions which may arise from negotiations toward a climate
6 convention.

7
8 Close liaison should be maintained with elements of WCP to ensure
9 that latest scientific results contribute to the assessment process,
10 and that the scientific programmes are structured to maximise their
11 relevance to IPCC.

12
13 b. Response Strategies

14 (para from WG3)

15
16
17 Narrowing the Uncertainties

18
19 To improve our predictive capability, Working Groups I and II
20 point out the need:

- 21
22 * to understand better the various climate related processes,
23 particularly those associated with clouds, oceans and the
24 carbon cycle;
25
26 * to improve systematic observation of climate variables on
27 a global basis, and further investigate changes which took
28 place in the past;
29
30 * to develop improved model of the Earth's climate system;
31
32 * to increase support for national and international
33 activities especially in developing countries,
34
35 * to facilitate international exchange of climate data;
36
37 * to understand better the impacts of climate change on
38 natural terrestrial and marine ecosystems, agriculture and
39 forestry, water resources and human settlements and health;
40

41 In addition to the increased support for national activities, the
42 required programme of research will need unprecedented international
43 cooperation with the WCRP of WMO and ICSU and IGBP of ICSU playing
44 vital roles. The IPCC points out that there is no need to establish
45 new international mechanisms, but rather urges all countries to
46 contribute to these programmes through their national efforts, and to
47 increase financial support and assistance in kind to these programmes,
48 and to the climate related components of WMO, UNEP, UNESCO and its IOC
49 and FAO.
50

• to examine the possible anthropogenic
modification of natural greenhouse
gas fluxes.

21

1 RESPONSE STRATEGIES

2 The scientific assessment of a possible man-induced climate
3 change, the environmental and socio-economic consequences of
4 such a change, and the difficulties we encounter in attempting
5 to slow down or halt it calls for the development of strategies
6 on a long term basis. The great diversity in the situation of
7 different countries and their responsibilities for combatting
8 climate change will have to be taken into account in such
9 development. It is clear that this is not going to be a simple
10 undertaking.

11
12 With time, we will learn more from further research and
13 monitoring activities, and from experience with implementing
14 limitation/adaptation measures. To take maximum advantage of such
15 growing knowledge and experience, a flexible and progressive
16 approach to addressing climate change is required.

17
18 Working Group III has addressed the issue of formulating
19 response strategies. The following subsections are extracts of
20 the main findings of the policymakers summary of that Working
21 Group.

22
23 MAIN FINDINGS

24
25 The following findings have been identified as a basis for
26 action now and in the future:

- 27
28
29 1) Climate change is a global issue; effective responses would
30 require a global effort which may have a considerable impact
31 on humankind and individual societies.
32
33 2) Industrialized countries and developing countries have a
34 common responsibility in dealing with problems arising from
35 climate change.
36
37 3) Industrialized countries should take the lead and have
38 specific responsibilities on two levels:
39
40 a) Major part of emissions affecting the atmosphere
41 at present originates in industrialized countries where
42 the scope for change is greatest. Industrialized
43 countries should adopt domestic measures to limit
44 climate change by adapting their own economies in line
45 with future agreements to limit emissions;
46
47 b) To co-operate with developing countries in
48 international action without standing in the way of the
49 latter's development by contributing additional
50 financial resources, by appropriate transfer of
51 technology, by engaging in close co-operation
52 concerning scientific observation, by analysis and
53 research, and finally by means of technical co-
54 operation geared to forestalling and managing
55 environmental problems.
56
57 4) Emissions from developing countries are growing and may

22

need to grow in order to meet their development requirements and thus, over time, are likely to represent an increasingly significant percentage of global emissions. Developing countries should, within the limits feasible, take measures to suitably adapt their economies.

- 5) Sustainable development requires the proper concern for environmental protection, as the necessary basis for continuing economic growth. Continuing economic development will increasingly have to take into account the issue of climate change. It is imperative that the right balance between economic and environmental objectives be struck.
- 6) Limitation and adaptation strategies must be considered as an integrated package and should complement each other to minimize net costs. Strategies that limit greenhouse gases emissions also make it easier to adapt to climate change.
- 7) The potentially serious consequences of climate change on the global environment give sufficient reasons to begin by adopting response strategies that can be justified immediately even in the face of significant uncertainties.
- 8) A well-informed population is essential to promote awareness of the issues and provide guidance on positive practices. The social, economic and cultural diversity of nations will require tailored approaches.

Because large, projected increase in world population will be a major factor in causing the projected increase in global greenhouse gases, it is essential that global climate change strategies include strategies and measures to deal with the rate of growth of the world population.

Working Group III has also identified measures at the national, regional and international levels as applicable which, while helping to address the issue of climate change, can yield other benefits in the shorter term.

LIMITATION OF NET EMISSIONS FROM THE ENERGY SECTOR

The energy sector plays a vitally important role in economic well-being and development for all nations. At the same time, because energy production and use accounts for about one half of the radiative forcing from human activities, energy policies need to ensure that continued economic growth occurs in a manner that, globally, conserves the environment for future generations.

However, there is no single, quick-fix technological option for limiting greenhouse gas emissions from energy sources. A comprehensive strategy is necessary which deals with improving efficiency on both the demand and supply sides as a priority and emphasizes technological research, development, and deployment. Achieving even a 20% reduction in CO₂ from current emission levels would require major changes in global energy markets, plans, and infrastructure, with intervention by governments. Maintaining this emission reduction goal would require continued

23

1 technological improvements, structural changes in the global
2 economy, and changes in the proportion of carbon-based fuels
3 utilized over the whole of the next century.

4
5 In the energy category, Working Group IIT especially noted
6 that:

7
8 --Improved energy efficiency reduces emissions of carbon
9 dioxide, the most significant greenhouse gas, while
10 improving overall economic performance and reducing other
11 pollutant emissions and increasing energy security;

12
13 --Use of cleaner energy sources and technologies reduces
14 carbon dioxide emissions, while reducing other pollutant
15 emissions that give rise to acid rain and other damaging
16 effects.

17
18 Working Group III recognizes the particular difficulties
19 which will be faced by countries, particularly developing
20 countries, whose economy is heavily dependent on production
21 and/or export of fossil fuels, as a consequence of actions taken
22 by other countries to limit or reduce energy related greenhouse
23 gas emissions. These difficulties should be taken into account
24 when elaborating international strategies.

25
26 Various potential options have been identified for reducing
27 greenhouse gas emissions from energy systems. The most relevant
28 categories of options appear to be:

- 29
30 - efficiency improvements and conservation in energy
31 supply, conversion, and end use;
32
33 - fuel substitution by energy sources which have lower
34 or no greenhouse gas emissions;
35
36 reduction of greenhouse gas emissions by removal,
37 recirculation or fixation;
38
39 - management and behavioral changes (e.g. increased
40 work in homes through information technology) and
41 structural changes (e.g. modal shift in transport).

42
43 The potential for energy efficiency savings in a number of
44 these options ranges from 15 to as much as 60% (see the
45 Policymakers Summary of Working Group III).

46
47 The feasibility of a particular option depends on more than
48 its technical potential alone. Important additional factors are
49 its economic potential (economic efficiency and cost
50 effectiveness) and its market potential (the likelihood of
51 consumer acceptance, reflecting attitudes to risk and non-
52 monetary costs).

53
54 The challenge to policy makers is to enhance the continual
55 diffusion of technological options into the market place, to
56 encourage behavioral and operational changes, and to address the
57 broader issues outside the energy sector in order to capture
58 more of the potential that exists.

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It's the
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large block
of electrical
energy.

24

LIMITATIONS OF NET EMISSIONS FROM THE AGRICULTURAL AND FORESTRY ACTIVITIES

Agriculture, forestry and other human activities are also responsible for substantial quantities of greenhouse gas emissions.

About 9 percent of anthropogenic greenhouse gas emissions can be attributed to the agricultural sector. Limitation of emissions from this sector presents a challenge because the processes by which greenhouse gases, in particular methane and nitrous oxide, are released in agricultural activities are not well understood. In addition, response options in the agricultural sector must be designed to ensure maintenance of food supply.

In the short term, reductions can be achieved through improved livestock waste management, altered use and formulation of fertilizers, and other changes to agricultural land use, without affecting food security.

Forestry practices and other human activities associated with land use, such as biomass burning and landfills, account for about 18 percent of anthropogenic greenhouse gas emissions. The forest crisis is rooted in the agricultural sector and in the human need for employment and income. Deforestation will be stopped only when the natural forest is economically more valuable for the people who live in and around the forests than alternative uses for the same land. Useful steps might include:

--Improved forest management and, where feasible, expansion of forest areas as possible reservoirs of carbon.

--Possible key elements of a world forest conservation protocol could be identified in the context of a climate convention process, that also addresses energy supply and use and practical means of implementing it.

--Use of forest products and wood could be strengthened and improved through measures such as substituting a portion of fossil energy sources by wood or other sustainable managed biomass; partial replacement of high energy input materials by wood; further recycling of forest products; and, improved efficiency of use of fuel wood.

LIMITATION BY PHASING OUT CFC'S UNDER THE MONTREAL PROTOCOL

CFCs represent a very important source of greenhouse gas emissions and account for about 25% of the total contributions to the enhanced radiative forcing for the period of the 1980s. Phasing out of CFCs under the Montreal Protocol would remove some of the most powerful and long-lived greenhouse gases, while also protecting the stratospheric ozone layer.

But the review of the Montreal Protocol now underway, may need to be revised as appropriate after London should take into

25

substitutes. For a given emission rate, HCFCs and HFCs are less effective greenhouse gases than the CFCs because of their shorter lifetimes. The growth rates assumed in the IPCC scenarios will result in the atmospheric concentrations of HFCs and HCFCs becoming comparable to the CFCs during the next several decades assuming that the CFCs had continued to be used at current rates.

MEASURES FOR ADAPTING TO GLOBAL CLIMATE CHANGE

In addition to the limitation options discussed above, Working Group III reviewed measures for adapting to potential climate change with respect to coastal zones and resource use management. These include:

--Developing emergency and disaster preparedness policies and programs.

--Assessing areas at risk from sea-level rise and developing comprehensive management plans to reduce future vulnerability of populations and coastal developments and ecosystems as part of coastal zone management plans.

--Improving the efficiency of natural resource use, research on control measures for desertification and enhancing adaptability of crops to saline regimes.

A programme could begin now to enable developing countries to implement coastal zone management plans by the year 2000. The programme would provide for training of country experts, data collection and technical assistance and co-operation.

IMPLEMENTATION MEASURES

Working Group III also considered several priority areas which must be addressed in order to adequately implement limitation or adaptation responses. These "implementation mechanisms" represent the primary vehicles through which national, regional and international responses to climate can be effected.

Public Information and Education

A well informed global population is essential for addressing and coping with an issue as complex as climate change. Because climate change would affect, either directly or indirectly, almost every sector of society, broad global understanding of the issue will facilitate the adoption and implementation of such response options as deemed necessary and appropriate. The dissemination of information also represents a powerful economic instrument for ensuring that markets accurately take into account potential consequences and/or opportunities of climate change.

Technology Development and Transfer:

The development and transfer of technologies is vital to

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development and transfer of technologies is vital to
any effort to address global climate change. The development of
new technologies may provide the means by which societies can

26

1 meet their energy, food, and other needs in the face of changes
2 in global climate, while at the same time minimizing emissions
3 of greenhouse gases.

4
5 Technological development, including improvement and
6 reassessment of existing technologies, is needed to limit or
7 reduce anthropogenic greenhouse gas emissions; absorb such gases
8 by protecting and increasing sinks; adapt human activities and
9 resource use and management to the impacts of climate change;
10 and detect, monitor and predict climate change and its impacts.

11
12 There is a need for the rapid transfer of technology to the
13 developing countries on a preferential basis, of technologies
14 for addressing climate change. Developing countries are of the
15 view that transfer of technologies on a non-commercial basis is
16 necessary and that specific bilateral and multilateral agreements
17 should be established to promote this. Some other countries where
18 technologies are not owned by the government believe that
19 transfer of technologies would be a function of commercial
20 negotiations. The issue of intellectual property rights also
21 presents a case where international opinion is mixed.

22 23 Economic Mechanisms

24
25 It is important that any potential measures to limit or
26 adapt to global climate change be as economically efficient and
27 cost-effective as possible, while taking into account important
28 social implications.

29
30 In general, environmental objectives can be achieved either
31 through regulations requiring the use of a specific technology
32 or attainment of specified goals, or through economic instruments
33 such as emissions fees, subsidies, sanctions, tradeable permits,
34 or a comprehensive system that might address all greenhouse gas
35 sources and sinks. Market based economic instruments encourage
36 limitations in emissions by those who can achieve them at least
37 cost. Careful and substantive analysis of the implications of
38 such instruments is needed.

39
40 Economic instruments, through their encouragement of
41 flexible selection of abatement measures, frequently offer the
42 possibility of achieving environmental improvements at lower
43 cost than regulatory mechanisms. Unlike many regulations, they
44 tend to encourage innovation and the development of improved
45 technologies and practices for reducing emissions. Economic
46 mechanisms also have the potential to provide the signals
47 necessary for more environmentally sensitive operation of
48 markets. It is unlikely, however, that economic instruments
49 will be applicable to all circumstances.

50 51 Financial Mechanisms

52
53 Industrialised and developing countries consider it
54 important that assurances of financial mechanisms are needed for
55 undertaking adequate measures to limit and/or adapt to climate
56 change.
57

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Financial resources channelled to developing countries would

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be most effective if focused on those activities which contribute both to limiting greenhouse gas emissions and promoting economic development. Areas for cooperation and assistance could include:

- . Efficient use of energy resources and the increased use of fossil fuels with lower greenhouse gas emission rate or non-fossil sources;
- . Rational forest management practices and agricultural techniques which reduce greenhouse gas emissions;
- . Facilitating technology transfer and technology development;
- . Measures which enhance the capacity of developing countries to develop programs to address climate change, including research and development activities and public awareness and education;
- . Participation by developing countries in international fora on global climate change, such as the IPCC.

Legal Measures

The measures noted above would require a high degree of international cooperation, with due respect for national sovereignty of states. To assist in that process, international negotiation on a framework convention on climate change should start as quickly as possible after the completion of the IPCC First assessment Report. This, together with any additional protocol(s) that might be agreed upon, would provide a firm basis for effective cooperation to act on greenhouse gas emissions and to adapt to any adverse effects of climate change.

The framework convention should, at a minimum, contain general principles and obligations. It should be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced range of countries while permitting timely action to be taken.

Working Group III compiled a list of possible elements for a framework convention. The inclusion of any particular element in this list does not imply consensus with respect to that element, or the agreement of any particular government to include negotiating such a convention; these include:

- o the political imperative of striking the correct balances (a) between the arguments for a far-reaching, action-oriented convention and the need for urgent adoption of a convention so as to begin tackling the problem of climate change; and (b) among the risks of inaction, the costs of action and current levels of scientific uncertainty;
- o the extent to which specific obligations, particularly on the control of emissions of greenhouse gases, should

28

be included in the convention itself, possibly as annexes, or be the subject of a separate protocol(s);

o the timing of negotiation of protocol(s) in relation to the negotiations on the convention;

o the introduction as appropriate of sound scientific bases for establishing emission targets (such as total emission levels, per capita emissions, emissions per GNP, emissions per energy use, climatic conditions, past performance, geographic characteristics, fossil fuel resource base, carbon intensity per unit of energy, energy intensity per GNP, socio-economic costs and benefits or other equitable considerations);

o the extent to which specific goals with respect to global levels of emissions or atmospheric concentrations of greenhouse gases should be addressed;

o whether obligations should be equitably differentiated according to countries' respective responsibilities for causing and combatting climate change and their level of development;

o the need for additional resources for developing countries and the manner in which this should be addressed, particularly in terms of the nature, size and conditions of the funding, even if detailed arrangements form the subject of a separate protocol;

o the basis on which the promotion of the development and transfer of technology and provision of technical assistance and co-operation to developing countries should take place, taking into account considerations such as terms of transfer (preferential or non-preferential, commercial or non-commercial), assured access, intellectual property rights, the environmental soundness of such technology, and the financial implications;

o the nature of any new institutions to be created by the convention (such as a Conference of the Parties, an Executive Organ, as well as other bodies), together with their functions, composition and decision-making powers, e.g., whether or not they should exercise supervision and control over the obligations undertaken;

o the criteria, timing, legal form and incidence of any obligations to control the net emissions of greenhouse gases.

*What happened
to the concept of
comprehensive
greenhouse gas
indices following
all gases to be
treated in a
common forcing
context was
raised by the
US*

29

Strategies for the future

The major dilemmas

The conclusions of Working Group I show clearly that the scientific community essentially agrees about the climate changes that could occur if the present build-up of greenhouse gas emissions continues or even accelerates into the next century as projected by both the Scenario A (Business-as-Usual) and the Reference Scenario. Working Group II envisages potentially far-reaching environmental consequences of such changes. This threat to the global environment and its implications for countries and the peoples of the world must be weighed against the costs and other socio-economic implications for limiting, and/or adapting to, any adverse effects of climate change. It is, therefore, essential to address a few fundamental questions in this context.

The developed countries have emitted most of the greenhouse gases into the atmosphere that now cause us concern. The developing countries are rapidly increasing their emissions in striving for improving their living standards, particularly by increasing their use of fossil fuels as the prime source of energy. Cheap energy has in the past contributed substantially to the rapid increase of the standards of living in industrialized countries. They possess the knowledge and the human and financial resources to develop the necessary means to combat climate change. Recognizing the poverty that prevails among the populations of developing countries, it is natural that fight against poverty and achieving economic growth is given priority by them. Closing the gap between the industrialized and the developing countries is a prerequisite for a full partnership of all nations of the world in the development of a strategy to deal with the climate change issue.

A rapidly increasing world population will mean greater demands for resources in general and energy in particular. Management of the world's natural resources is also closely linked to the climate change issue. It is obvious, that all these and other global issues have to be addressed simultaneously.

Climate change issue is a long term, evolutionary issue. We are not able to foresee its long term consequences very well yet and will not be able to do so soon. However, scientific data indicate that at present the atmospheric concentrations of carbon dioxide and methane are on their way to reaching values well outside the range that has prevailed for more than 100,000 years. It seems prudent, then, to consider that an unlimited growth in the concentrations of greenhouse gases in the atmosphere is not acceptable. Although stabilization of the greenhouse gas concentrations in the atmosphere is ultimately a necessity, we cannot as yet determine at what levels they should be stabilized or the costs of such stabilization.

The discussions in Working Group III show that the difficulties in assessing the social and economic costs of climate change, as well as the consequences of the measures required to slow and ultimately stop...

with serious difficulties when trying to develop a strategy to
Extended Page 32.1
measures

310

1 deal with the greenhouse gas issue. An obvious reason is that
2 we cannot as yet predict reliably enough how a change of climate
3 would influence different countries directly. On the other hand,
4 the implications and particularly the costs, of the specific
5 actions that are being considered to slow down or prevent a
6 change of climate can be envisaged more easily by economists and
7 politicians. Yet, it is not evident that more stringent and
8 therefore costly measures would find approval amongst a broad
9 majority of people even in countries where they may be reasonably
10 well informed about environmental problems.

11
12 International agreements are necessary in order to have a
13 balanced development of the world economy and to safeguard at
14 the same time the global environment. This applies particularly
15 when confronted with as complex an issue as that of climate
16 change. If individual countries can optimize their benefits by
17 letting other countries share their costs (i.e. pay for
18 pollution) without they themselves taking the necessary
19 precautions (reducing pollution), the economy of the total system
20 becomes unstable and a catastrophic development may occur ("the
21 law of the commons"). We must also recognize the vast differences
22 in economic strength between the players on the international
23 scene, i.e., the nations and the large multinational companies
24 in the world. The fundamental question becomes: How can a
25 sustainable and improving future for the developing countries
26 i.e., for three quarters of humanity, as well as for the
27 industrial countries, be achieved faced with the potential threat
28 of climate change?

29
30 It is also clear that the effects of specific preventive
31 actions being considered on the countries of the world vary much
32 from one to another. At present fossil fuels account for 80 -
33 85% of the primary energy supply in the world, but different
34 countries are very differently dependent on their use. Producers
35 and users of fossil fuels will experience restrictions on the
36 emissions of carbon dioxide into the atmosphere very differently.

37
38 Many developing countries have extensive plans of using
39 fossil fuels for meeting their increased energy demands for
40 development. The infrastructure of most countries to a large
41 extent has been based on a fossil-fuel driven transport system.

42
43 Deforestation is in part an expression of the need to expand
44 agriculture or the dependance on forest products for export.
45 Measures to limit methane production in wet-land agriculture may
46 imply major changes of traditional management practices with
47 unpredictable consequences for the farmers involved. Any plan
48 for combatting man-induced climate change must carefully consider
49 these and many other concerns that will be faced by the world's
50 countries. As a matter of fact, it is not surprising that
51 controversies arise about as complex an issue as the present one,
52 in particular when the detailed understanding of the likely
53 problems is as yet incomplete. The major dilemma is that actions
54 may be required well before many of these specific issues can be
55 resolved.

1 Elements of a strategy and an action programme

2
3 The complexity of the problem as outlined above based on the
4 detailed reports of the IPCC Working Groups, means that
5 agreements on necessary actions will not be easy to reach.
6 Working Group I has concluded that "the longer emissions continue
7 to increase at present day rates, the greater reductions would
8 have to be for concentrations to stabilize at a given level".
9

10 The IPCC emphasizes that despite scientific uncertainties
11 phenomena and timing of climate change, but because of the
12 very long response times of the atmosphere, climate and society,
13 it would be prudent to initiate negotiations on a framework
14 convention on climate change as soon as possible.
15

16 First we address actions that could be taken now.
17

18 It is clear from the Working Group III report that there
19 are a number of actions that also would be beneficial for other
20 environmental reasons and that would cost comparatively little,
21 as a matter of fact in some cases rather imply savings. These
22 deserve attention now. An action program to take advantage of
23 such possibilities has been called a "no regrets policy" defined
24 as a policy of taking "measures in the shorter term which while
25 helping to tackle climate change also can yield other benefits".
26 Numerous measures of this kind have been considered by the
27 Working Group III and are summarized in a previous section of
28 this overview.

29 IPCC confirms that such measures would, if widely used,
30 significantly slow down the further increase of greenhouse
31 concentrations in the atmosphere. These measures to be taken at
32 the national, regional and international levels include:

- 33 * CFC controls to include restricted use of greenhouse
34 active alternatives,
35 * use of energy sources with lower emissions of greenhouse
36 gases,
37 * improved energy end use efficiency,
38 * improved forest management and where feasible expansion
39 of forest areas,
40 * review of agricultural practices aiming at reduced
41 greenhouse gas emissions.
42

43 More elaborate descriptions of these are given in earlier
44 sections of this report.
45

46 IPCC further believes that individual nations, or groups of
47 nations, should consider actions to stabilize emissions in order
48 to reduce the rate of increase in global emissions and thus
49 assist in the prevention of an acceleration of greenhouse gas
50 concentrations in the atmosphere. Such initiatives may
51 accelerate progress towards international agreements.
52

53 Secondly, we address the need for a phased strategy for the
54 longer term.
55

56 Awaiting the outcome of negotiations for general agreements
57 on a convention, it is important to explore how long term
58 and policies...

31

1 Because existing information is inadequate to understand
2 what rate of change of climate, and of greenhouse gas emissions,
3 might be acceptable, there is a need for a phased approach. The
4 first step would be to set criteria.

5
6 The IPCC considers that work should begin on
7 defining criteria which would reflect the impacts of climate
8 change and their costs on the one hand, and the costs and
9 practicalities of reductions in emissions on the other.
10 Such criteria would be evolutionary; they should take into
11 account what might be an acceptable level of climate change and
12 reflect the changes in our scientific and economic understanding
13 and technological capabilities.
14

15 In the light of the importance of understanding better the
16 economics of the greenhouse gas issue,
17

18 the IPCC recommends that research on the international
19 economic implications of the global climate issue be
20 intensified, with particular regard to the specific
21 circumstances of individual countries as well as the broad
22 generic differences between developed and developing
23 countries. Governments may consider developing mechanisms
24 by which the international market can find optimal means to
25 recognize the implicit climate change cost of human
26 activities without hampering sustainable development, and
27 in this regard, should fully evaluate economic consequences of
28 such mechanisms.
29

30 Working Group III also emphasizes in this context the
31 importance of public information and education.
32

33 IPCC supports the view that because climate change would
34 affect, either directly or indirectly, almost every sector of
35 society, and also because important policy responses will have
36 to be developed against a background of uncertainty, broad global
37 understanding of the issue will facilitate the adoption and the
38 implementation of such response options as deemed necessary and
39 appropriate. Further efforts to achieve this are urgently
40 needed.
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The Special Circumstances of the Developing Countries

It is obvious that the impact on and the participation by the developing countries in the further development of a future strategy is essential. The IPCC has addressed this specific issue by establishing a Special Committee on the Participation of Developing Countries. This subsection summarizes the findings on the issue.

Although emissions of greenhouse gases are increasing in developing countries, where about 75% of the world population lives, they emit only about 25% of the world total. Their per capita emission is only about a tenth of that in the industrialized world.

Industrialized countries and developing countries have a common responsibility in dealing with the adverse effects of climate change, taking into account not only the past and present responsibility of the industrialized world in the accumulation of greenhouse gases but also the present technological, human and financial capacities of the developed countries. An acceptable standard of living in the developing countries needs to be achieved before a developing country can be expected to participate fully in addressing issues related to climate change. In this context,

a) Industrialized countries should take the lead and have specific responsibilities on two levels:

i) To adopt domestic measures to limit greenhouse gas emissions by adapting their own economies in line with relevant future international agreements;

ii) To cooperate with developing countries in international action without standing in the way of the latter's development by contributing additional financial resources, by appropriate transfer of technology, by engaging in close cooperation concerning scientific observation, by analysis and research, and finally by means of technical cooperation geared to forestalling and managing environmental problems;

b) Emissions from developing countries are growing and need to grow in order to meet their development requirements. Thus, over time, they are likely to represent an increasingly significant percentage of global emissions. Developing countries should, within the limits feasible, take measures to suitably adapt their economies.

Against this background, IPCC requested its Special Committee to identify factors inhibiting the full participation of the developing countries in IPCC and recommend remedial measures where possible. The Committee stresses that full participation includes not only the physical presence at meetings but also the development of national competence to address all issues of concern such as the appreciation of the scientific basis of climate change, the potential impacts on society of such change and evaluations of such impacts.

24

The factors identified by the Special Committee are:

- *insufficient information;
- *insufficient communication;
- *limited human resources;
- *institutional difficulties;
- *limited financial resources.

On some of these factors, the IPCC Working Groups have developed policy options which are to be found in their respective reports. The Special Committee itself has made a number of specific recommendations including the development of specific programmes of action; these are to be found in its report. The implementation of the recommendations and appropriate policy options will require commitment of financial resources and mechanisms.

Financial resources channelled to developing countries would be most effective if focused on those activities which contribute both to limiting greenhouse gas emissions and/or adapting to any adverse effects of climate change, and promoting economic development. Areas for cooperation and assistance could include:

- Efficient use of energy resources and the increased use of fossil fuels with lower greenhouse gas emission rate or non-fossil sources;
- Rational forest management practices and agricultural techniques which reduce greenhouse gas emissions;
- Facilitating technology transfer and technology development;
- Measures which enhance the capacity of developing countries to develop programs to address climate change, including research and development activities and public awareness and education;
- Participation by developing countries in international fora on global climate change, such as the IPCC.

It was recognized that cooperation and assistance for adaptive measures would be required, noting that for some regions and countries, adaptation rather than limitation activities are potentially most important.

The IPCC concludes that the recommendations of the Special Committee need not and should not await the outcome of future negotiations on a climate convention. It appeals to the multilateral and bilateral funding organizations to implement the recommendations. It further appeals to the governments for continuing and increased contributions to the IPCC Trust Fund on an urgent basis.

Timothy E. Wirth

Hotter and Hotter in the Greenhouse

In its lead editorial of Feb. 7, The Post continues the media pattern of oversimplifying the state of scientific knowledge about global warming. A bewildering false debate persists about what we know and don't know about global warming.

The Post's editorial—"Getting Warmer?"—asserts that "true, the evidence of global warming so far is confused and inconclusive." The editorial goes on to praise the administration for taking the implications of global warming seriously, as its predecessor did not and for "fighting over the right questions." The editorial goes further that "no case exists yet for the kind of emergency action that would require disruptive and hugely expensive changes in the economy."

In my opinion, the case for strong action is

Taking Exception

ear, and the administration has not come close to taking this issue seriously enough. Claiming scientific uncertainty," the administration has delegated the United States to the sidelines at international meetings about how we deal with this monumental problem.

Simply put, a handful of environmental nay-sayers have overwhelmed the chorus of scientists who are urging societies to take concrete steps to avoid climatic catastrophe. Just recently, half of this nation's Nobel Laureates, 64 recipients of the National Medal of Science and almost half of the members of the National Academy of Sciences have signed a

We were promised the "White House effect." What we've gotten from the administration is more like the whitewash effect.

declaration calling for an end to our complacency.

Those who, like the administration, argue that not enough is known about the problem rely on scientific assertions that are shaky at best. The two most widely distributed critiques of global warming warnings have been "Scientific Perspectives on the Greenhouse Problem," issued by the George C. Marshall Institute, and an unpublished report by Dr. Richard Lindzen of the Massachusetts Institute of Technology.

Surprisingly, the two documents questioning global warming science have never been peer reviewed, as is standard scientific practice. Both reports have been torn apart by the scientific community. The Journal Science has published blistering critiques of these reports in recent issues—calling the Marshall report a "slim, unrefereed report that many scientists have dismissed as biased and misleading [that] is said to be at least partly behind the White House's recent temporizing on climate change." Two senior White House officials are "impressed with the report. . . . We have a coherent policy in the federal government that is not inconsistent with the Marshall Institute report."

Indeed, these views are raised at every turn by individuals unable or unwilling to sort through the facts—including the media. Once again, these were the views presented by the

Clearly, we need to continue a strong program of research to answer these questions. But I would argue against The Post's view that no case exists yet for emergency action. We are gambling with the climatic underpinnings upon which all societies depend for survival.

We must develop a comprehensive national energy policy that makes reduction of greenhouse gases and air pollutants a national objective. Energy conservation, as The Post points out, must be the cornerstone of this effort in the United States, where we use twice as much energy per unit of GNP as do our prime economic competitors. Why, then, has this administration proposed cuts for energy conservation programs in its recent budget?

Similarly, we should embark on an all-out program to develop nonpolluting sources of energy—whether it be new solar panels or a new, safe generation of nuclear power plants. Third, we need to find new uses for the cleanest burning of the fossil fuels—natural gas. Fourth, the rich and the poor nations must reach an agreement to protect and replant forests—our natural atmospheric filters.

Finally, the United States must reassert itself as the world's leader in the effort to halt the staggering pace of population growth.

Global environmental ills have replaced the Cold War as the greatest threats to international security, and we do nothing. We must change course.

The writer, a Democratic senator from Colorado and member of the Energy and Natural Resources Committee, is the author of global warming legislation.

Washington Post
Feb. 24, 1990

Dr. Bransden-

thinks the att'd. is the

John Houghton
report cited above.
Thurs. hearing, you might want to skim it.

Since Wirth will be at your
Sarah K.

10/7 to admin

chior out

"Document Control"

TYPE: ACTION DOCUMENT NUMBER: 9120669
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS C

FROM: ASHLEY, Carlye M.

TO: JOHN SUNUNU

DATE OF
CORRESPONDENCE: 02/19/91

SUBJECT: THE LACK OF GREENHOUSE EFFECT OF CO.

DIRECTORATE STAFF
ASSIGNED: ENVIRONMENT ASSIGNED: ENVIRONMENT

ACTION
REQUIRED: DIRECT REPLY/
IF APPROPRIATE STAFF
ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: 03/20/91 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO:

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:
REMARKS: Does not require a response per NGM

OSTP RECEIVED: 03/08/91 DEPT RECEIVED:
FILE: ENVIRONMENT
CENTRAL FILES:



Bromley

CARLYLE M. ASHLEY
CONSULTING ENGINEER
7320 BARBERRY LANE

MANLIUS, NEW YORK 13104

February 19, 1991

RECEIVED

91 MAR 8 A 8:34

Dr. John H. Sununu
Chief of Staff
White House

Washington, D. C. 20500

Subject: Lack of Greenhouse Effect of CO₂

DIRECTOR

Dear Dr. Sununu:

I have been Chief Engineer at Carrier Corporation and Presidential Member of ASHRAE. When they first started talking about the added "Greenhouse Effect" of more CO₂ in the air I dismissed it as being just some crank. Now I discover they seem to be serious about it. The memorandum which I am enclosing tries to present the case against it. I believe that the effect will be almost negligible but in some ways even an improvement.

I am strongly in favor of conservation and I believe that we need to keep other greenhouse gases out of the atmosphere because these could have a serious effect, but the restriction on CO₂ could be very costly and also unnecessary. The effect on the weather is not nearly as great as some of the other things which we do such as cutting down our forests.

I will be glad to send added copies to others whom you might suggest. You may also be interested to know that ASHRAE is planning on studies of the Greenhouse Effect of the possible future refrigerants which take the place of the present R-11 and R12.

Yours very truly

Carlyle M. Ashley

WILL MORE CARBON DIOXIDE IN THE ATMOSPHERE WARM OR COOL THE EARTH?

by Carlyle M. Ashley, Consulting Engineer

Water vapor is the principal "Greenhouse Gas" which reradiates heat energy back to the earth from the atmosphere. Carbon dioxide has only a minor role and doubling its concentration in the atmosphere has a very slight effect. Both gases absorb incoming solar radiation so that more carbon dioxide could cool the earth instead of heating it. This memorandum gives the engineering data to support these statements. Turn first to the Figure page.

Figure 1 shows the absorption bands of carbon dioxide plotted vs wave length of the heat radiation. Note that the absorption bands are high compared to the length of travel so that they should have 100% absorption in travelling through a small part of the atmosphere. But they are widely spaced so that most of the radiation will pass through the transparent part of the spectrum.

Figure 2 shows the absorption bands of water vapor plotted vs wave length of the radiation. Note that there are multiple overlapping absorption bands, particularly in the long wave lengths of the earth radiation at ordinary temperatures.

Figure 3 shows the solar radiation and also the earth radiation spectrums plotted vs wave lengths. The visible radiation lies between 0.4 and 0.8 microns. The solar radiation shows a plot outside of the atmosphere and at ground level (for direct radiation).

In the ultraviolet section the atmospheric absorption is largely by ozone in the upper atmosphere. In the visible section, particulates reflect and absorb the radiation and the air molecules diffuse it. In the infra-red section, water vapor and carbon dioxide absorb the radiation as shown by the absorption bands as shown in Figure 3 which may be compared with the bands in Figures 1 and 2. Most of this absorption occurs in the upper atmosphere and does not directly affect the radiation in the lower atmosphere.

Note also that the earth radiation spectrum peaks at 10 microns for 95F and slightly higher wave lengths for lower temperatures. Carbon dioxide has no absorption bands close to the peak.

Figure 4 shows the emissivity (absorptivity) of carbon dioxide vs the partial pressure P_p and the length of travel s with separate curves for temperature. Ordinary temperatures can use the 500 800 C curve. Note that these curves are very flat, particularly at the upper end where a doubling of the abscissa will increase e by only about 10%. The maximum value of e is only 20% which checks with the information on Figures 1 and 3.

Figure 5 shows the emissivity (absorptivity) of water vapor. Even with a dew point temperature of -25F the point is off to the right of the chart and the value e is very high compared to the values on the carbon dioxide chart. For higher water vapor dew points the value of e close to the earth is still very high.

Table 1 shows typical summer-winter temperatures and pressures vs the altitude of the atmosphere. If no energy was transferred (adiabatic), the temperature would drop 9.1C for every kilometer increase in elevation. Thus, the deviation from this relationship provides insight as to the addition of energy at different elevations which is large at the bottom and top and minimum in the middle. The stabilization at the top is probably due in part to the addition of solar energy and in part to the decrease in density.

Since water vapor and carbon dioxide are both absorptive (emissive), the values must be combined to be able to solve problems. Since there is an overlap of their spectrums as shown in Figure 1 and 2 this must be compensated. If we assume that the carbon dioxide is 100% absorptivity within its range as measured by its emissivity, then the emissivity of water vapor energy in this range should be eliminated but there is a band of carbon dioxide near the upper end of the earth's spectrum which should be included.

Thus, a conservative equation would seem to be:

$$e_{c,w} = e_w + e_c(1 - 0.8e_w) \text{ and } \alpha_{c,w} = \alpha_w + \alpha_c(1 - 0.8\alpha_w)$$

To be realistic, there must be an energy balance between the amount of energy into and out of the earth. Thus there is the equation:

$$E(\text{earth radiation}) = E(\text{solar absorption}) + E(\text{gas radiation})/2 + (\text{gas convection}).$$

The reason for the gas radiation being divided by 2 is because only half of the radiation is toward the earth.

Example 1 is to set up a model of the pre-existing situation under mean conditions. Assume:

Clear sky over ground on March 21
 Solar energy outside the atmosphere 438 btu/hr.ft²
 Solar energy striking the ground 337 " "
 Solar energy absorbed by the ground 261 " "
 Mean solar energy per ft² of ground 65.25 btu/hr.ft² ground.
 Infrared 53% absorbed in atmosphere 53.5 btu/hr.ft²

Ground temperature 51F. Emissivity 92.5%
 Air temperature, ground 51F, 1/32nd atmosphere 45F, 1/16th atmosphere 38.5F, 1/8th atmosphere 30.5F.

Water vapor partial pressure $P_{pw} = 0.00343$ atmospheres, 20F D.P..

Carbon Dioxide partial pressure $P_{pc} = 0.0003$ atmosphere

Beam length for the atmosphere: 2x elevation.

The calculations were based on the Radiant -Heat Transmission Chapter by Hoyt C. Hottel in the book: Heat Transmission by McAdams. The data were designed primarily for enclosed vessels but it has been possible to adapt them to the atmospheric problem. The Hottel data are slightly different from that shown on Figures 4 and 5.

Atmospheric Elevation, $P/P_{atmos.}$	1/16	1/8	1/4
Atmospheric temperature	45F	38.5F	30.5F
Abscissa, $2P_w L$ water vapor	11.4	22.8	45.6
Water vapor Emissivity, adjusted e_w	.59	.645	.69
Abscissa, $2P_c L$ carbon dioxide	1.0	2.0	4.0
Carbon Dioxide Emissivity, adjusted e_c	.155	.174	.191
Combined Emissivity $e_{w,c}$	.672	.732	.776
Equivalent $btu = \sigma (T_a/100)^4 e_{w,c}/2 *$	37.45	40.63	42.81
mean solar energy absorbed by ground 51F			<u>65.25</u>
Total			108.06
Ground Emissions = $\sigma(511/100)^4 \cdot 0.925$			108.04

Double the concentraion of carbon dioxide in the atmosphere

Abscissa, $2P_c L$	2.0	4.0	8.0
Carbon Dioxide Emissivity, adjusted e_c	.174	.191	.206
Combined Emissivity, $e_{w,c}$	.682	.737	.782
Equivalent $btu = \sigma(T_a/100)^4 e_{w,c}/2 *$	38.01	40.92	<u>43.15</u>
Added btu radiation due to doubling			.34
Equivalent temperature rise of ground			0.37°F

Assumed extra solar radiation absorption by extra $CO_2 = 1.6$ btu
Mean value $1.6/4$ $btu/hr \cdot ft^2$ ground = 0.4 btu vs $.0.4$ btu

* the $btus$ for the higher elevations are for the difference in $e_{w,c}$ added to the lower values.

The absorption of radiation for the doubling case was not given because it is essentially the same as the emission and thus the gas temperature is not changed.

For higher water vapor content the possibility of any increase in ground temperature is still further decreased while for lower contents it is increased. However, this should not be objectionable because it should result in a longer growing season and a higher growth rate for more carbon dioxide.

The example chosen is somewhat idealized because it fails to take into account the convection which the solar radiation stimulates and because it does not make allowance for the evaporation of water which might occur over most of the earth surface. Both of these would reduce any possible temperature increase.

The reason that the added carbon dioxide has so little effect on the total "Greenhouse Effect" is that there was already enough carbon dioxide in the atmosphere to make a significant contribution and the added amount increases this effect very slightly. Of course, compared to water vapor, carbon dioxide makes a very small contribution.

However, one of the serious dangers is that some of the pollutants which humans have added to the atmosphere will contribute new absorption bands which could have a very significant addition to the "Greenhouse Effect".

There are a number of human activities which can contribute either to the "Greenhouse Effect" or to other environmental changes. The nearly four to one increase in human population during this century and the increasing use of fossil fuels have both exacerbated the damage. The stripping of the earth of its trees and other vegetation is important because these normally absorb the solar energy. The increasing vaporization of water in lakes, irrigation, cooling towers tends to absorb solar energy. The release into the atmosphere of very fine particulates absorbs and reflects solar energy before it reaches the earth and the natural release has in the past been associated with "ice ages".

Clouds are an important part of our weather pattern. Not only do they as well as snow have a high reflectivity for solar radiation but they also have a very high emissivity for the long wave-length radiation at ordinary atmospheric temperatures. Low overcast traps the earth's energy and re-radiates it back to the earth. Higher altitude clouds which are at a lower temperature still help to mediate the effect of the solar radiation in between them.

The example which is given above for a single set of conditions can be expanded to other conditions so as to cover other environmental and atmospheric conditions so that it should be possible to compute what to expect from both increased carbon dioxide as well as other pollutants of the atmosphere. It also should be combined with the effects of convection, evaporation and condensation of water. The effect of cloud cover should be added to the equation.

The amount of re-radiation can be measured using a btu meter and a repeated measurement of the atmospheric column temperature should be made to determine whether there have been any changes with time. The message of population as well as environmental control must be made effective. But please let us get our facts straight so that we can control the things which need control and not proclaim a false apocolypse.

We scientists and engineers have a responsibility to get the technical facts straight and to put proper priorities on the things which need to be done urgently and avoid putting needless controls on others which don't need them.

The example chosen was intended to be the mean value of the various variables as far as it is possible to get a mean. It must be realized that the temperature and radiation levels change for any one location from minute to minute and hour to hour and day to day. Also they are different for different locations on the earth. In addition there is a substantial heat storage in the ground and some heat storage in the air. In addition there is heat storage due to evaporation and condensation of water and plant growth.

Also, in the air the emissivity is normally somewhat greater than the absorptivity but this may be compensated in energy flow by a higher ground than air temperature. In any case, the difference between the emissivity and the absorptivity is virtually constant when the carbon dioxide is doubled so that that should not be a factor in comparing the two conditions.

Another important variable is the convective heat transfer. At 15 MPHr the convective heat transfer is about 5 btu/hr.ft².degF and at about 7.5 MPHr about 3 btu. However, when the ground is cooler than the still air the convective transfer is a small part of 1 btu and when it is warmer it is about .7 btu. This compares with radiative heat transfer varying between about 0.7 and 1.0 btu/hr.ft².degF for cooler and warmer temperatures. The convective heat transfer between the ground and the air is primarily a local situation. But on hot sunny days there can be dust devils which extend several thousand feet into the air. Furthermore, the convective weather pattern which creates winds which have a vertical as well as a horizontal component.

The earth reflectivity for solar energy is different for the whole earth and for reflection directly from the earth. Also, the emissivity of the earth for long wave lengths may be a slight variable. But neither of these should affect the conclusion about the lack of further "greenhouse effect" of carbon dioxide

It should be recognized that the combination of the water vapor and carbon dioxide provide more than 75% of the available re-radiation at a given ground temperature and a still higher amount when taking into account cloud cover. But at the same time they also remove about half of the infra-red solar radiation. In evaluating the effect of other greenhouse gases it is important to evaluate both the re-radiation and the absorption of solar radiation to get the net effect.

It is important to expand this model with respect to both time and place so as to show clearly what the effects of the greenhouse gases are. Then, when evaluating new gases their effect can be superimposed on the available model.

It should be possible to measure the reradiation at any one point and time. This can be done using the "Btu meter" modified to make it a radiation measuring device. Along with this it is desirable to measure the atmospheric temperature gradient, and of course the amount of solar radiation.

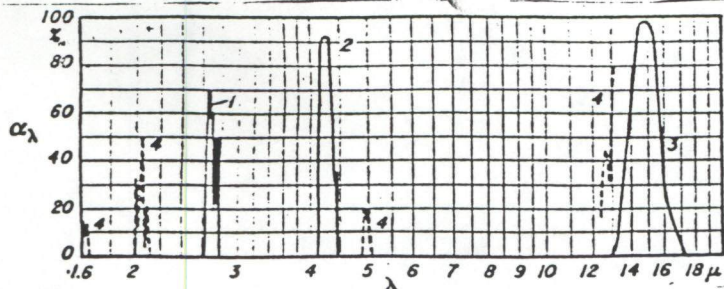


Figure 1. Absorption Bands of Carbon Dioxide. (1) 5-cm, (2) 3-cm, (3) 6.3-cm, (4) 100-cm layers.

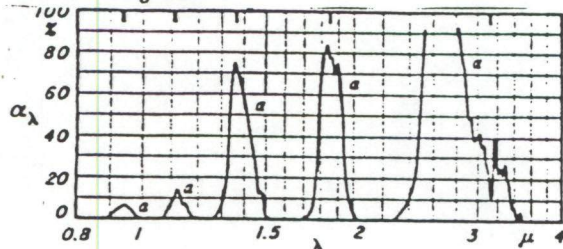


Figure 2. Absorption Bands of water vapor. (a) 127°C & 109cm, (b) 127°C & 104cm, (c) 127°C & 32.4cm, (d) 81°C & 32.4cm at 4 cm atm. (e) R'm Temp. & 220cm at 7cm atm.

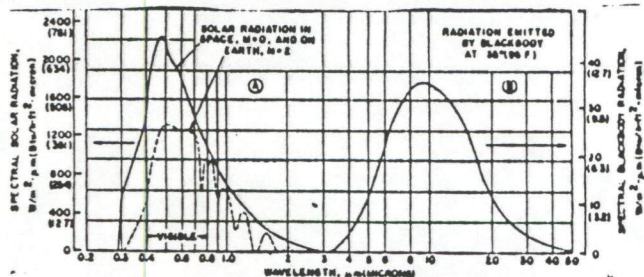


Figure 3. Spectral Transmittances and Solar Radiation.

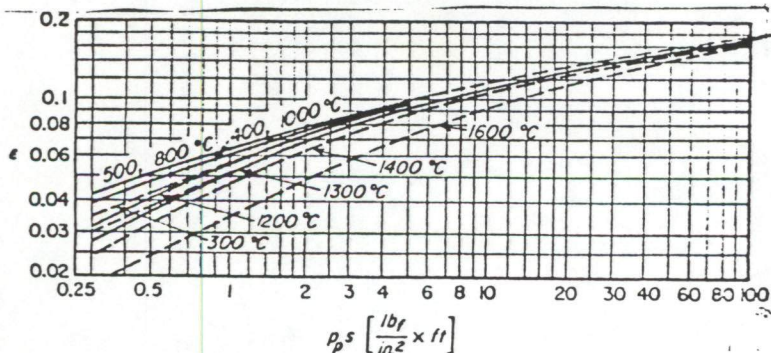


Figure 4. Emissivity of carbon dioxide in mixture with nitrogen or air. s is the thickness of the gas layer; p_p is the partial pressure of CO₂.

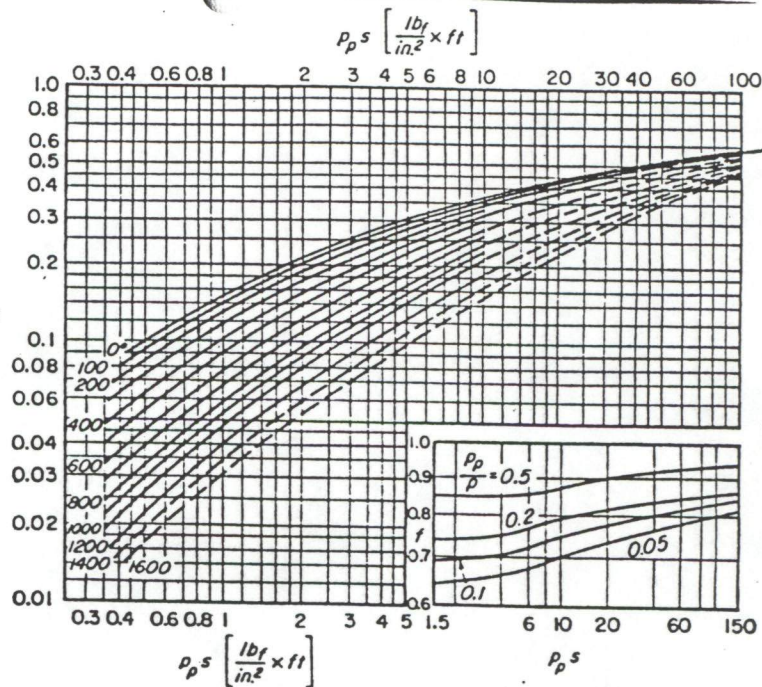


Figure 5. Emissivity of water vapor with Nitrogen or Air. s is the thickness of the gas layer, p_p is the partial pressure of water vapor, total pressure p = 1 atm. When the partial pressure p_p is different from 1., the emissivities read in the big figure have to be multiplied by f read from the small diagram. Dashed lines indicate extrapolated values.

Table 1

Variation of Temperature, Pressure and Density of the Atmosphere with Altitude

Compiled by Humphreys

Elevation		Summer			Winter		
Km	Mi.	Temp. °C	Pressure mm of Hg.	Density, dry air g/cm³	Temp. °C	Pressure mm of Hg.	Density, dry air g/cm³
20.0	12.4	-51.0	44.1	0.000092	-57.0	39.5	0.000085
19.0	11.8	-51.0	51.5	.000108	-57.0	46.3	.000100
18.0	11.2	-51.0	60.0	.000126	-57.0	54.2	.000117
17.0	10.6	-51.0	70.0	.000146	-57.0	63.5	.000137
16.0	9.9	-51.0	81.7	.000171	-57.0	74.0	.000160
15.0	9.3	-51.0	95.3	.000199	-57.0	87.1	.000187
14.0	8.7	-51.0	111.1	.000232	-57.0	102.1	.000220
13.0	8.1	-51.0	129.6	.000270	-57.0	119.5	.000257
12.0	7.5	-51.0	151.2	.000316	-57.0	140.0	.000301
11.0	6.8	-49.5	176.2	.000366	-57.0	164.0	.000353
10.0	6.2	-45.5	205.1	.000419	-54.5	192.0	.000408
9.0	5.6	-37.8	237.8	.000470	-49.5	224.1	.000466
8.0	5.0	-29.7	274.3	.000583	-43.0	260.6	.000526
7.0	4.3	-22.1	314.9	.000649	-35.4	301.6	.000590
6.0	3.7	-15.1	360.2	.000722	-28.1	347.5	.000659
5.0	3.1	-8.9	410.6	.000803	-21.2	398.7	.000735
4.0	2.5	-3.0	466.6	.000892	-15.0	455.9	.000821
3.0	1.9	+2.4	528.9	.000942	-9.3	519.7	.000915
2.5	1.6	+5.0	562.5	.000990	-6.7	554.3	.000967
2.0	1.2	+7.5	598.0	.001043	-4.7	590.8	.001023
1.5	0.9	+10.0	635.4	.001100	-3.0	629.6	.001083
1.0	0.6	+12.0	674.8	.001157	-1.3	670.6	.001146
0.5	0.3	+14.5	716.3	.001223	0.0	714.0	.001215
0.0	0.0	+15.7	760.0		+0.7	760.0	.001290