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THE REDUCTION OF FOSSIL CARBON DIOXIDE EMISSIONS: A DRAFT PROTOCOL TO THE FRAMEWORK CONVENTION ON CLIMATE CHANGE

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TABLE OF CONTENTS

TOPIC — PAGE

Executive Summary....4

Introduction and Background....5

Causes of Climate Change....6

Objective of the Framework Convention on Climate Change....7

The Warming Limit: What Increment in Global Temperature Is Dangerous?....8
Climates of the Past....9
Implications for the Present....9
Targets for the Future: The Warming Limit....10

What Atmospheric Concentrations of Carbon Dioxide are Compatible with the 2^{o} C Warming Limit?....11

The Carbon Budget: How Much Additional Carbon Can be Emitted into the Atmosphere?....12

What Carbon Emission Milestones are Required?....14

How Could the Remaining Carbon Budget Be Allocated Between Regions and Nations?....16

Conclusions and Recommendations....22

Acknowledgments, Attribution and Disclaimer....25

References Cited....26

Annex: Draft Protocol on the Reduction of Fossil Carbon Dioxide Emissions....27

Figure 1: Projected global carbon release compatible with a warming limit of 2^{o} C between now. and 2100....15

Figure 2: Projected allocation of the remaining carbon budget associated with a warming limit of 2^{o} C between now and 2100....19

Table 1: Emission reduction milestones assuming a 50/50 allocation of a remaining carbon budget of 300 billion tons....19

Table 2: Emission reduction milestones assuming a 50/50 allocation of a remaining carbon budget of 450 billion tons....20

A NOTE ON THE INTENDED DISPOSITION OF CONTENTS

This document is presented in two sections: 1) the Background Paper; 2) the Annex.

The Background Paper is intended exclusively for the internal use of AOSIS members as an information paper, and not for distribution to non-AOSIS states.

The Annex is itself divided into two sections, the Draft Protocol, and the Commentary.

The Draft Protocol is proposed for the consideration of AOSIS as a formal submission to the Intergovernmental Negotiating Committee when it begins to deal with substantive issues, perhaps at INC-7 in early 1993. It is being circulated now to give AOSIS governments ample time for review in capitals prior to possible adoption and subsequent timely submission.

The Commentary is an analysis of the protocol, intended to explain the reasoning behind the articles themselves. Like the Background Paper, the Commentary is intended exclusively for internal AOSIS use and is not intended for distribution to non-AOSIS members.

EXECUTIVE SUMMARY

This paper outlines, in lay terms, the scientific background for a Draft Protocol on the Reduction of Fossil Carbon Dioxide Emissions (shown at Annex) for consideration by AOSIS. The Protocol is designed to minimize global risk from climate change while at the same time maximizing practicality. The approach begins with the Convention's objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Meeting this objective requires first determining the increment in average global warming that could cause dangerous anthropogenic interference with the climate system (termed the **warming limit**; Krause, Bach and Koomey 1989). Based on the best available scientific evidence, average global warming in excess of 2.0^{O} Celsius (C) from the present by the year 2100 could threaten food security, disrupt terrestrial ecosystems and destroy island nations and low coastal areas. A risk-aversive policy in the context of the Convention therefore suggests limiting future increments of average global temperature to 2.0^{O} C.

The best available scientific evidence indicates that, under risk-aversive assumptions, the atmospheric concentration of carbon dioxide corresponding to a 2^{O} C warming limit by the year 2100 (**concentration limit**) is as low as 430 - 450 parts per million (ppm) of carbon dioxide equivalents[1] (400 ppm carbon dioxide), compared with 400 ppm at present (350 ppm carbon dioxide).

Carbon release scenarios consistent with this concentration limit require reductions in global emissions early in the next century. The most prudent yet realistic **emission reduction milestones** entail a small increase in global emissions (relative to 1985 global emission levels), peaking in about 1995; return to 1985 levels by 2005; 20% reduction by about 2015; 50% reduction by about 2030; 75% reduction by 2050; and 80% reduction by 2070 and thereafter.

Assuming aggressive control measures in other sectors, fossil carbon emission reduction schedules consistent with the concentration limit imply a remaining fossil **carbon budget** of 300 billion tons of carbon. That is, no more than 300 billion additional tons of fossil carbon can be released without interfering dangerously with the climate system. Meeting this global carbon budget under realistic mid-range carbon allocation assumptions would require that developed countries cut carbon emissions by 10% (relative to 1985 levels) by 2000, and by one-third by 2020. These targets could be reached by aggressive application of existing efficiency technology to new capital stock, resulting in substantial economic savings (estimated at 10 - 25%). Implementation of these targets by developed countries would enable the emissions of developing countries to grow at about 3% per year within the above global targets. Technology transfer would enable, and economic competitiveness would encourage, developing countries to implement subsequent emission reductions on a voluntary basis. Coordinated policy measures in technology transfer, forestry, agriculture and population growth areas, would require negotiation as part of, or in parallel with, the Fossil Carbon Dioxide Protocol.

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[1] Because gases other than carbon dioxide also contribute to global warming, it has been customary to express the value in "carbon dioxide equivalents." This index represents the total concentration of all gases expressed in terms of the concentration of carbon dioxide that would cause equivalent global warming.

INTRODUCTION AND BACKGROUND

Having successfully negotiated the Framework Convention on Climate Change ("the Convention"), Signatories now face the daunting task of translating the framework into concrete actions consistent with the Convention and its Objective. In undertaking this task, Signatories have agreed that measures to arrest climate change "should take into account the best available scientific knowledge." (Article 1, Principles; and Article 4, Commitments, Section 2 (c)).

Included amongst the most widely accepted present sources of scientific advice on climate change are the World Meteorological Organization (WMO), the United Nations Environment Program (UNEP) and the Intergovernmental Panel on Climate Change (IPCC). The IPCC identified two classes of short-term measures that Parties can take to limit climate change and also yield other benefits. These are **Adaptation** and **Limitation** (see WMO/UNEP/IPCC (1990a) pp. xxvii).

Adaptation refers to measures that would accommodate to the adverse effects of climate change. They include, for example, assessing and paying adaptation costs, developing insurance schemes, monitoring sea level rise, passive and active responses to sea level rise, etc. Adaptation measures therefore target the effects of climate change, namely, reaction to the possible adverse effects of global warming.

AOSIS members have a strong stake in adapting to the adverse effects of climate change. Because we are among the first and chief victims of those effects -- especially ocean warming and consequent coral bleaching and sea level rise -- we may wish to protect our interests by advocating adaptation measures that will reduce the cost and pain of climate change to our peoples insofar as possible.

Limitation refers to activities that would arrest climate change. It includes such measures as improved energy efficiency, use of cleaner energy sources and technologies, improved forest management, improved agricultural and livestock management, etc. Limitation can also mean creating economies that are not based upon fossil fuels ("leap-frogging"). Limitation measures therefore target the causes of climate change, namely the emission of greenhouse gases into the atmosphere.

AOSIS members also have a strong stake in ameliorating the causes of climate change. The main cause identified by the IPCC is the release of greenhouse gases, including carbon dioxide from the burning of fossil fuels, into the atmosphere by developed countries. This cause is to some extent beyond the immediate control of AOSIS states, since the causal greenhouse gases originate mainly in developed countries. AOSIS has nonetheless addressed the causes of climate change constructively during the negotiation of the Convention, by calling for appropriate reductions in greenhouse gas emissions, advocating energy efficiency and renewable sources, etc.

AOSIS can now continue its constructive role in addressing the causes of climate change. Toward this end, the Draft Protocol on the Reduction of Fossil Carbon Dioxide Emissions[2] shown at Annex has been prepared for

consideration by AOSIS. This paper provides, in lay terms, the overview and details of the approach used in developing the Protocol.

The approach utilized in this Background Paper, and in the Draft Protocol shown at Annex, is goal-directed and based on the best available scientific evidence. The goal is to comply with the Objective of the Convention to avoid dangerous anthropogenic interference with the climate system. Toward this end, the maximum increase in average global temperature that can occur without incuring unacceptable risks (the termed the global warming limit) is determined. The approach then progresses in steps from the warming limit through the corresponding level of carbon dioxide concentration in the atmosphere, future carbon emissions compatible with that atmospheric concentration, and finally to the carbon dioxide emission reductions necessary to achieve the desired limit on global warming. Each step of this process is based on the best available scientific information, including that of the IPCC, as required by the Convention.[3]

CAUSES OF CLIMATE CHANGE

Scientists are virtually unanimous that the central cause of global warming is the accumulation of "greenhouse" gases in the atmosphere, including carbon dioxide from burning fossil fuels. Global warming in response to emitted greenhouse gases occurs only slowly, because the oceans comprise most of the earth's surface and they take so long to warm. Past releases of carbon dioxide therefore assure future warming even if net releases could be reduced immediately to zero. The present level of carbon dioxide in the atmosphere ensures that a "latent" warming will occur, estimated at 1 - 1.5^{o} C, calculated using central estimates of climate sensitivity.

To limit global warming to the range of 1 - 1.5^{o} C, therefore, would require immediate reduction in emissions to a level sufficient to stabilize atmospheric concentrations of greenhouse gases at present concentrations. To accomplish atmospheric stabilization of carbon dioxide, emission rates would not have to be cut to zero, because there are natural "sinks" that remove greenhouse gases from the atmosphere, namely, forests, the oceans, etc. Instead, stabilizing the atmospheric concentration of carbon dioxide would require that gross emissions from human activities be cut by "60% or more" according to the IPCC, and by 50 - 80% according to the US Environmental Protection Agency.

Such large cuts could not be achieved overnight, however. A risk-aversive public policy would seek to make cuts as large as feasible as soon as possible. Emission reduction strategies must accommodate two opposing types of risk, however; the risk of climate destabilization if cuts are not made fast enough, and

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2 The term "fossil" limits carbon dioxide subject to the protocol as that which is released as a consequence of burning fossil fuels (coal, oil, natural gas). This is to distinguish carbon dioxide regulated by the Protocol from that which is released from burning wood, deforestation, agricultural practices, and other sources. The purpose of distinguishing fossil from non-fossil carbon dioxide is to target that carbon doixide released mainly by developed countries as part of their energy programs. This source is by far the dominant source and also the most controllable.

3 The approach is similar to that employed by Krause, Koomey and Bach (1989) in their landmark book *Energy Policy in the Greenhouse*.

the risk of economic dislocation should cuts are made too fast. Deciding exactly how fast to cut emissions of which gases in a risk-aversive manner requires first understanding the role of each major greenhouse gas and its contribution to climate change.

According to the IPCC, the main human contribution to climate change from 1980 to 1990 was the combustion of fossil fuels (oil, coal and natural gas) and the consequent release of fossil carbon dioxide (46% contribution to radiative forcing) (WMO/UNEP/PCC (1990a). Three-quarters of fossil carbon dioxide emissions originated from developed countries and remains unregulated. Assuming full implementation of the Vienna Convention and Montreal Accords to regulate the chlorofluorocarbon (CFC) greenhouse gases, carbon dioxide would account for three-quarters of global warming (Krause et al., 1989, p. 1.2 - 19).

The second most important human greenhouse activity during the 1980s was the release of CFCs (24% contribution; WMO/UNEP/PCC (1990a)). This source is now regulated internationally by the Vienna Convention, the Montreal Protocol, and Adjustments to the Protocol. The third most important human greenhouse activity is forestry practices, especially deforestation (18% contribution; WMO/UNEP/PCC (1990a)). Agriculture was a distant fourth human greenhouse activity (9% contribution; WMO/UNEP/PCC (1990a)).

The relative magnitude of these causes of climate change therefore invites the following priority with respect to regulatory measures. First, efforts to limit climate change could be directed usefully toward limitation of fossil carbon dioxide emission. Second, since CFCs are regulated by the Vienna Convention and Montreal Protocol and Adjustments, efforts could be directed toward changing forest practices, especially deforestation. Third, efforts could be directed toward changing agricultural practices. Because the largest unregulated cause of global warming (carbon dioxide emission) is also the most controllable, it merits attention disproportionate to its contribution to global warming.

In achieving regulation of greenhouse gases, the IPCC has recommended an integrated, comprehensive approach, as follows:

> "Strategies that focus only on one group of emissions sources, one type of abatement option, or one particular greenhouse gas will not achieve this [stabilization of global climate]. Policy responses, should, therefore, be balanced against alternative abatement options among the energy, industry, forestry, and agricultural sectors..." (WMO/UNEP/PCC, 1990a, p. xxxiv).

Therefore, although attention could be focussed usefully on fossil carbon dioxide, the IPCC recommends that this effort be integrated with other sources and sinks of greenhouse gases. This is the approach taken by the present paper and the accompanying Draft Protocol on the Reduction of Fossil Carbon Dioxide Emissions.

OBJECTIVE OF THE FRAMEWORK CONVENTION ON CLIMATE CHANGE

In order to achieve the balanced and comprehensive solution recommended by the IPCC and embodied within the Framework Convention on Clmate Change, Parties to the Convention can take guidance from its Objective.

Article 2 of the Convention states the Objective as "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." With respect to the time frame of such stabilization, Article 2 states further that "Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Designing an appropriate response strategy consistent with the Objective, therefore, requires first determining what threshold level of global warming would, if exceeded, constitute "dangerous anthropogenic interference with the climate system;" (the **warming limit**); second, determining what concentration of carbon dioxide and other greenhouse gases in the atmosphere would warm the earth to the accepted warming limit (the **concentration limit**); third, determining the remaining fossil emission **carbon budget** consistent with the warming limit, under the assumption that other sources of greenhouse gases will be regulated optimally; fourth, determining **emission reduction milestones** consistent with the carbon budget; and fifth, **allocation** of the remaining fossil carbon budget among regions and nations on the basis of Principles embodied in the Convention.

Political proclamations in respect to carbon dioxide cuts are welcome and useful as a statement of intent, but they are also arbitrary. In contrast, the "WERM" (Warming limit/ Emission Reduction Milestones) approach, pioneered by Krause et al. (1989), is founded upon scientific and technical considerations and is therefore most compatible with the approach agreed by the Signatories to the Convention. The WERM approach is therefore adopted in this paper and the Draft Protocol shown at Annex.

THE WARMING LIMIT:

WHAT INCREMENT IN GLOBAL TEMPERATURE IS "DANGEROUS?"

To begin, then, it is necessary to determine what degree of global warming would, if exceeded, constitute the "dangerous anthropogenic interference with the climate system"that is highlighted in the Convention's Objective. Agreeing on what effects are "dangerous" is complex for at least three reasons.

First, there are significant scientific uncertainties in determining the effects of a particular global temperature. The Signatories to the Convention have agreed that scientific uncertainties shall not stand in the way of effective action to protect the climate (the precautionary approach). Indeed, policy actions must be taken in the face of scientific uncertainties if they are to be effective, owing to the inertia of the climate system.

Second, even if the scientific uncertainties were resolved, different populations will have different perspectives on the dangers. Alpine people, for example, might not consider a one meter rise in sea level "dangerous;" while it would be catastrophic for island people. Conversely, island people generally do not fear desertification; but sub-Saharan African people view this as the central threat of climate change.

Third, it is not just the absolute level of temperature increase that is relevant, but also the rate of change. If the climate changes too fast, ecosystems cannot keep up and will disappear. "Danger" must therefore be defined not only in terms of **absolute** warming but also with respect to the **rate** of warming. The Convention likewise brings attention to this warming rate limit in its Objective, which states that greenhouse gases are to be stabilized at safe levels "within a time frame sufficient to allow ecosystems to adapt naturally to climate change."

Arriving at a common definition of "dangerous" (i. e., unacceptable risk) requires finding the lowest common denominator of risk to which people of diverse perspectives and views can agree. Toward this end, it is useful to examine climates of the past, for this exercise assists in estimating the likely effects of global warming in the future.[4]

Climates of the Past

Several hundred million years ago, before life had evolved on earth, the average global temperature may have been warmer than today's by 20^{o} C. A scientifically quantified global temperature record, however, is available only for the past 38 million years. Over most of this period, global temperature was about 6^{o} C warmer than today's value of approximately 15^{o} C. The climate cooled to 3 - 4^{o} C warmer than today by the *Pliocene* period, from 5 to 3 million years ago, before the earth had ice caps and fertile soils that could support agriculture.

The most recent 2 million year period of Earth's history (the *Pleistocene* period), however, has been exceptionally steady in climate, and quite similar to the climate of today. During this period, average global temperature has alternated on a regular cycle of 100,000 years, from ice ages (average global temperature about 10 - 11^{o} C) to intervening warm periods such as the present (average global temperature, about 15^{o} C), termed "interstades." The warmest recent peak occurred about 125,000 years ago in a period known as the *Eem-Sangamon interglacial*, when average global temperature was 2 - 2.5^{o} C warmer than today, sea level was five to seven meters (approximately 16 - 23 feet) higher than it is today, and pre-humans existed in tribal hunter-gatherer societies.

The historical rate of change in global temperature was 0.01 - 0.02^{o} C per decade for the past 10,000 years. According to the best scientific evidence available today, global warming faster than 0.1^{o} C per decade could prevent migration of aboreal temperate trees. Such trees could not survive warmer temperatures, and hence if they were unable to migrate, vast temperate forests could perish in place. Therefore, rapid global warming (greater than 0.1^{o} C per decade) could destroy much of the earth's forest cover. A limit in the rate of global warming consistent with the adaptive capacity of temperate aboreal forests would be about 1^{o} C for the period between now and the year 2100.

Implications for the Present

With present average global temperature (about 15^{o} C) as the reference value, a warming of 1 - 1.5^{o} C from the present would represent a climate

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[4] The discussion on climates of the past that follows is based largely on interpretations and references cited in Krause et al., 1989, Chapter 1.

warmer than any experienced since the beginning of agricultural civilization (approximately 4000 BC). A global temperature increase of this amount, which is committed already by emissions of fossil carbon during the past century, may (or may not) threaten food security. This target is approximately within the estimated limit set by the adaptive capacity of major land ecosystems, i. e., temperate forests (about 1^{o} C between now and 2100).

A temperature increase of 2 - 2.5^{o} C would probably raise sea level significantly, eventually by as much as 5 - 7 meters.[5] According to the IPCC, a temperature increase of 2 - 2.5^{o} C would also alter regional rainfall, create more intense storms, increase drought and desertification unpredictably, alter natural ecosystems and destabilize modern agriculture, probably threatening food security. An increment in global temperature of 2 - 2.5^{o} C by the year 2100 would also constitute a rate of change more than twice the 0.1^{o} C per decade estimated to represent the upper limit for the migration of temperate aboreal trees. Destruction of the world's temperate forests could therefore result. These adverse consequences of a 2 - 2.5^{o} global warming are sufficiently severe that they would presumably constitute a "dangerous anthropogenic interference with the climate system," which the Objective of the Convention obligates Parties to avoid.

A temperature increase of 3 - 4^{o} C would create a climate not seen on earth since humans appeared about two million years ago. IPCC's Scenario A (no limitation on greenhouse gases) would produce a temperature increase of 3.2^{o} C by 2100 (best estimate; range, 2.2 - 5.5^{o} C) and a sea level rise estimated at 32 - 113 cm (best estimate, 68 cm). In the words of the IPCC,

> "Already a rise of sea level by 30 - 50 cm would affect the habitability of low-lying coastal regions significantly and a one metre rise (possibly towards the end of the next century as estimated in the Scenario A [business as usual]) would impact 360,000 km of coastline, **render some island countries uninhabitable**, displace tens of millions of people, threaten low-lying urban areas, flood productive land and contaminate fresh water supplies." (WMO/UNEP/PCC, 1990b, p. iii. Emphasis added.)

Moreover, a 3.5^{o} C increase by 2100 would represent a rate of increase more than three times higher than the maximum rate presently considered consistent with survival of major terrestrial ecosystems (temperate aboreal forests).

Targets for the Future: The Warming Limit

The lessons of climate history, together with the best scientific information that is presently available, collectively suggest that the maximum absolute future average global temperature increment consistent with the interests of AOSIS and the Objective of the Convention is 2.0^{o} C from the present time (2.5^{o} C from 1850).[6] This absolute level of temperature increment represents a balance of

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[5] The most recent scientific opinion is that such a large rise in sea level would require the disintegration of the West Antarctic Ice Sheet, which appears at present relatively stable and unlikely to disintegrate rapidly under foreseeable conditions. See, for example, UNESCO, 1990, pp 4-5.

two competing needs -- minimizing risks of all kinds (environmental and economic), and maximizing practicality. The maximum rate of warming should be limited as close as possible to the historical natural rate of change, namely, 0.1^{o} C per decade. Global warming that significantly exceeds this absolute level or rate if increase would presumably be considered an unacceptable risk by all Parties. A global temperature increase of 2^{o} C is therefore taken as the warming limit for purposes of developing the Draft Protocol on Fossil Carbon Dioxide Emission Reductions, shown at Annex.

WHAT ATMOSPHERIC CONCENTRATIONS OF CARBON DIOXIDE ARE COMPATIBLE WITH THE 2^{o} C WARMING LIMIT?

Having established the upper limit of acceptable global warming of 2.0^{o} C from the present to the year 2100 (or 2.5^{o} from 1850), what atmospheric concentration of carbon dioxide would assure that such a global warming limit is not exceeded?

Answering this question requires adopting a comprehensive approach that considers all greenhouse gases, not just carbon dioxide. The present analysis is based on two key assumptions, namely: 1) carbon dioxide emission from forest losses is reversed; 2) a complete phase-out of CFCs is achieved by the turn of the century. It is of course possible to make less stringent assumptions, but this would require more stringent balancing cuts in fossil carbon emissions than those developed here.

Determining the concentration limit associated with a 2^{o} C warming limit also requires knowing the temperature change associated with particular concentrations of greenhouse gases -- termed the "sensitivity" of global temperature to changes in the atmospheric concentration of greenhouse gases. The IPCC stated in 1990 and reaffirmed in 1992 that "the sensitivity of global average surface temperature to doubling of CO_2 is unlikely to lie outside the range 1.5^{o} to 4.5^{o} C." (WMO/UNEP/IPCC, 1990; ibid., 1992, p. 23). That is, each time greenhouse gases in the air double in concentration, the global temperature is predicted by the IPCC to rise by 1.5^{o} to 4.5^{o} C. Although these estimates are lower than those frequently employed in contemporary scientific models of the climate,[7] a conservative policy approach is to assume a 4.5^{o} C temperature sensitivity and to base targets for preventative emission reductions on this sensitivity.

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6 It should be noted that even this estimate is higher than that recommended by several distinguished international panels, scientists and bodies. For example, the UNEP/WMO Climate Impacts Program suggested a warming limit of $1.0 - 1.6^{o}$ for the period until 2100 (Jaeger, 1988) while the German Meteorological and Physics Societies called for a warming limit of $1 - 2^{o}$ (DMG.DPG, 1987).

7 Several widely used contemporary models predict that a doubling of carbon dioxide concentration in the atmosphere will cause an increase in average global temperature of $3.5 - 5.5^{o}$ (e. g., Dickinson and Cicerone, 1986). Incorporation of feedback effects into the models elevates the estimate of the climate sensitivity to a doubling of carbon dioxide equivalent to as high as $6.3 - 8^{o}$ or more (e. g., Lashof, 1989).

What concentration in the atmosphere of carbon dioxide equivalents is compatible with the warming limit of 2.0° C from the present, assuming a climate sensitivity of 4.5°? Utilizing this value in five different modeling scenarios of future energy use (from high to low fossil fuel use), Krause et al. (1989) arrive at the following three conclusions from analyzing three carbon emission scenarios (low, intermediate and high):

> 1. "the warming could range from 2.1 [low emission scenario] to 8.3° C." [high emission scenario].
>
> 2. "Since a major portion of the equilibrium warming is disguised by the inertia of the ocean, the ultimate temperature rise in the years beyond 2100 would be even higher." (Krause et al., 1989, p. 1.2 - 23).
>
> 3. "The maximum allowable equivalent CO_2 equivalents in the next century would be 430 - 450 ppm, provided that concentrations decline again thereafter." (ibid., p. 1.2 - 28)."[8]

The atmospheric concentration range of 430 - 450 ppm of carbon dioxide equivalents is in turn comparable to the two lowest emission scenarios of the IPCC, namely the "Accelerated Policies Scenario" and the Alternative Accelerated Policies Scenario; and slightly lower than that of the IPCC "Control Policies Scenario." (WMO/UNEP/IPCC 1990, p. 15). Inasmuch as greenhouse gases other than carbon dioxide can be expected even under optimistic assumptions to yield carbon dioxide equivalents of 50 ppm, the tolerable atmospheric concentrations of carbon dioxide correspond to 380 - 400 ppm. Remaining carbon budgets are determined on the basis of these values.

THE CARBON BUDGET: HOW MUCH ADDITIONAL CARBON CAN BE EMITTED INTO THE ATMOSPHERE?

Determination of the total carbon emission budget associated with the above concentration of atmospheric carbon dioxide (380 - 400 ppm) is determined using "carbon cycle models" and is subject to assumptions about carbon sinks and other greenhouse gases. As noted earlier, the present projections are conservative, in that they assume forest biomass losses are reversed and CFCs are completely phased out by the turn of the century. The present projections are risk-aversive in that they employ credible "worst case" values for key parameters in the carbon cycle modeling process.

Several different carbon release curves are conceivable and have been modeled, using several different carbon cycle models. These scenarios include

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8 Sensitivity studies performed by Krause et al. (1989; p. 1.2 - 22) show that assuming the mid-range of the IPCC estimates of climate sensitivity (3.0°) would yield a concentration equivalent of 520 ppm, rather than the 430 - 450 ppm resulting from the 4.5° climate sensitivity. Given the uncertainties with respect to climate sensitivities, prudent planning requires using the higher IPCC climate sensitivity estimate of 4.5°, bearing in mind that this value is in the mid-range of credibly estimated values (see footnote 6). At the same time, the Draft Protocol should incorporate flexibility for future adjustments if indicated by scientific developments.

extrapolation of historical growth rates, moderate growth followed by steady state, steady release at the 1985 level, and various forms of decline (e. g., Krause et al., 1989). The results obtained using the most risk-aversive carbon cycle model, the Box Diffusion model, may be summarized as follows.

Continued global fossil carbon release at the historical growth rate from 1985 levels would release 2400 billion tons of carbon into the atmosphere by the year 2100. The resulting atmospheric concentration of carbon dioxide would exceed the concentration limit of 400 ppm by the year 2010 -- 18 years from now. Projected atmospheric concentrations of carbon dioxide in 2100 exceed 1,000 ppm. This modeling scenario shows that significant reduction of carbon emission from historical levels must be achieved if the Objective of the Convention is to be realized, namely, "to prevent dangerous anthropogenic interference with the climate system."

If global carbon release were to grow slowly and level off at approximately half again larger than the 1985 rate by the middle of the next century, the total carbon emitted to the atmosphere by the year 2100 would be 900 billion tons, and the atmospheric concentration of carbon dioxide would exceed the target limit of 400 ppm by the year 2015 -- 23 years from now. Projected atmospheric concentrations of carbon dioxide in 2100 range from 525 to 800 ppm, in comparison with the 400 ppm needed to stabilize the climate. This modeling scenario illustrates that further growth of carbon dioxide emissions followed by a leveling off at a higher level is not consistent with the Objective of the Convention.[9]

If global carbon release were to remain constant at the 1985 rate through the next century, the total carbon emitted by the year 2100 would be 600 billion tons, and the atmospheric concentration of carbon dioxide would exceed the upper limit of 400 ppm by the year 2075. This scenario would yield carbon dioxide concentrations of approximately 440 to 520 ppm by the year 2100 -- up to nearly one third again greater than the limit of 400 ppm determined above. This scenario demonstrates that significant reductions in carbon dioxide release are essential to comply with the Objective of the Convention.

The only carbon release scenarios consistent with the 2.0^{o} C warming limit by 2100 entail significant reductions in global carbon dioxide emissions. Immediate reduction is probably unrealistic from a political and technical viewpoint, and hence a brief period of continued growth in global carbon emissions, followed by a longer period of reduction, may represent the most realistic scenario.

Such a balancing of prudence with realism suggests that the most acceptable carbon release scenario consistent with climate stabilization might entail growth of global carbon emission to a peak in about 2000, followed by a steady decline thereafter to a yearly level that will no longer cause atmospheric carbon concentration to increase -- approximately 1-2 billion tons annually sometime near the middle of the next century. The total carbon budget associated with this warming limit/concentration limit and release curve is about

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9 Note that even the low end of this range (525 ppm) exceeds the permissible concentration under the less conservative climate sensitivity assumption of 3.0^{o} (470 ppm).

300 billion tons; the calculated range of atmospheric concentrations under several different existing models and assumptions is 370 to 432 ppm (Krause et al., 1989 a). Thus, the mid-range value is approximately the same as the calculated concentration limit of 400 ppm.

This carbon budget is substantially smaller than any authoritative estimate of the total carbon contained in recoverable fossil fuels. Among the other implications of a 300 billion ton carbon budget, therefore, is this: the majority of cheaper coal resources, and a significant fraction of oil and gas as well, will have to be withdrawn from exploitation and left undisturbed in the ground. The potential impacts of this fact on nations and regions that produce fossil fuels must be taken into account in negotiating the fossil carbon emission reduction protocol.

WHAT CARBON EMISSION MILESTONES ARE REQUIRED?

Figure 1 illustrates four different global reduction scenarios based upon the 300 billion ton carbon budget that is in turn essential for avoiding dangerous interference with the climate system. In the interest of maximizing a risk-aversion, these projections are based upon carbon cycle models indicating the need for up to 80% reductions to stabilize atmospheric concentrations of carbon dioxide, the maximum calculated by the US Environmental Protection Agency, rather than the "60% or more" identified by the IPCC study. Also in the interest of risk-aversion, the IPCC's highest estimated climate sensitivity estimate of 4.5^{O} C per doubling of carbon dioxide is employed. The IPCC's "high" estimate, however, corresponds to the approximate mid-range of values actually utilized now by scientists (see footnote 7). Moreover, concentration values associated with the middle of the IPCC range (climate sensitivity of 3.0^{O} C) are not fundamentally different (see footnote 8 and below).

The first scenario, designated by the dashed line, shows what would have to occur to keep global temperature within the warming limit of 2.0^{O} C if fossil carbon dioxide emission is not reduced gradually but instead continues at the 1985 release rate. Carbon emission would have to stop abruptly and completely in 2042, 50 years from the present. This scenario is clearly impractical from an economic viewpoint or any other perspective; it is presented merely to illustrate the outer limit of the release calculations.

The three solid curves in Figure 1 show three different emission reduction scenarios, each involving progressively greater delay in the onset of carbon dioxide reductions. Comparison of the three curves illustrates graphically one of the most important conclusions of such modeling studies, namely, the longer the delay in implementing reductions, the more rapid future carbon emission cuts must be if dangerous anthropogenic interference with the climate system is to be prevented in accord with the Objective of the Convention. Postponement of meaningful reductions will simply impose greater burdens upon the next generation (our children), and increase the risk of global economic collapse as necessairly more extreme control measures are implemented.

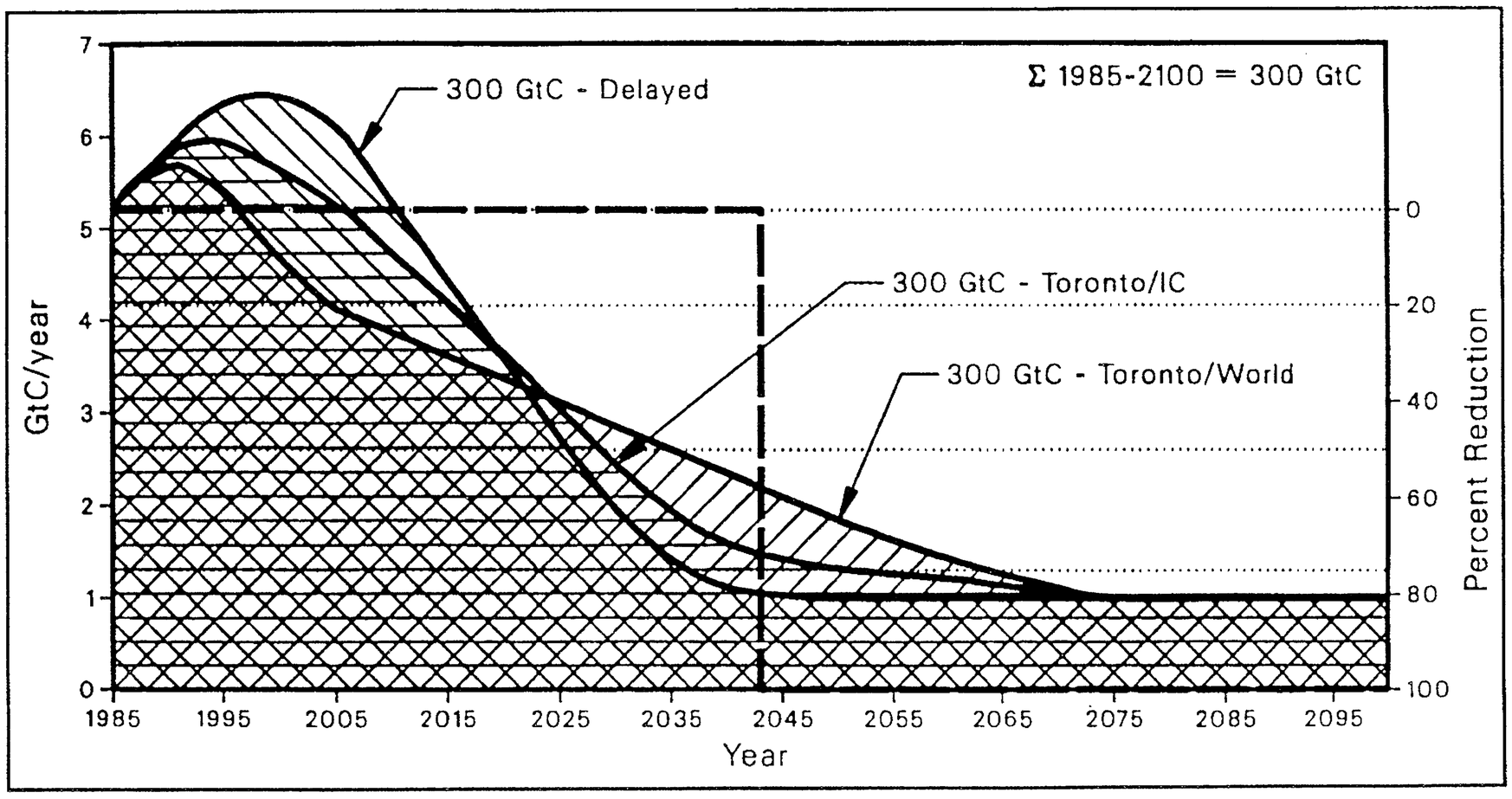

Figure 1: Projected global carbon release compatible with a warming limit of 2^{o} C between now and 2100. Note that postponement of measures in the present imply more extreme reductions in the future. From Krause, Bach and Koomey, 1989, Fig. 1.6.1, with the permission of the authors.

The most rapid phase-out scenario, termed the Toronto/World scenario, is probably not realistic now because it would imply impractical immediate reductions from present emission levels.[10] The least rapid phase-out scenario, termed the delayed scenario, would maximize pressure on the global economy early in the next century, when steep reductions in carbon emissions would be required to avoid exceeding the warming limit, thereby increasing the risk of global economic collapse. The intermediate response, termed the Toronto/IC scenario, is attractive because future reductions are less precipitous, givingour children somewhat more time to adjust smoothly to alternative fuel sources.

Therefore, the intermediate phase-out scenario illustrated in Figure 1 (labeled 300 GtC - Toronto/IC) forms the basis of the emissions reduction schedule contained in the Draft Protocol shown at Annex. According to this scenario, global emissions of carbon dioxide would return to 1985 levels by about 2005; they would decline by 20% from 1985 levels by about 2015; decline to 50% of 1985 emission levels by about 2030; and reach 75% of 1980 levels by about 2050. Emissions would then stabilize at levels 80% below 1985 levels by about 2070, where they would remain indefinitely[11] in order to stabilize atmospheric concentrations of carbon dioxide at acceptable levels.

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10 These figures originate from the 1988 Toronto World Conference on the Changing Atmosphere, one of the earliest international body to call for reductions in fossil carbon emissions.

HOW COULD THE REMAINING CARBON BUDGET BE ALLOCATED BETWEEN REGIONS AND NATIONS?

Given that there are 300 billion remaining tons of carbon that can be emitted to the atmosphere without exceeding the warming limit of 2^{o} C, how could this carbon budget be allocated amongst prospective users? Resolving this question is likely to prove the most difficult and controversial problem that has ever faced climate negotiators. The allocation schedule will determine the lifestyle of countries and peoples for centuries into the future, and impact potentially upon the global economic and power balance.

The developed countries, for their part, will have to accept -- and indeed initiate -- new energy policies, including stringent energy efficiency steps that although consistent with generous economic growth will nonetheless eventually limit material living standards. Moreover, they may have to take such steps in the face of declining or stagnant economies. At the same time, developed countries will need to utilize some of the savings created by greater efficiency to transfer their technology to the developing countries, take steps to preserve the temperate forests that are largely within their jurisdiction, and alter their intensive agricultural practices.

The developing countries, for their part, will have to accept the need to forego the same path to prosperity taken by the developed countries, conserve the rain forests that are largely within their jurisdiction, and eventually bring population growth under control.[12]

If the difficulties of negotiating a carbon allocation scheme seem overwhelming, the alternatives are even more formidable. Based on the best available scientific evidence, presented here in condensed form, the alternatives to successful reduction in global carbon emissions are global economic collapse early in the next century, climatic collapse soon thereafter, or both. These alternatives provide powerful motivation for reaching a timely agreement on allocating the remaining carbon budget.

General constraints on any such agreement already exist. For example, the IPCC recommends a balanced, comprehensive solution that address both adaptation and limitation, and further balances policy actions within different sectors (energy use, forestry, agriculture). In addition, Parties have now agreed to implement Principles that are embodied in the Convention; including: 1) temporary growth of emissions by developing countries;[13]; 2) recognition of the

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11 This carbon emission reduction schedule is significantly less stringent than that estimated by the IPCC for its "Reference Scenario." By that IPCC scenario, "The stabilization of global emissions at 1985 levels would require reductions of 29% by 2000 and 50% by 2025." (WMO/UNEP/IPCC, 1990, pp. xxxiii - xxxiv).

12 As noted by the IPCC: "It is essential...that policies designed to deal effectively with the issue of potential global climate change include strategies and measures to reduce the rate of growth of the world population." (WMO/UNEP/IPCC, 1990, p. xxxv).

13 "Noting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita

special needs and problems of fossil fuel producing countries;[14] and 3) the use of an integrated approach.[15]

The first and perhaps most contentious issue is what fraction of the remaining carbon budget should be allocated to developed and developing countries. Historically, developed countries have controlled 72% of global energy flux. Following the historical *status quo* would therefore give developing countries 28% of the remaining carbon budget (Krause et al., 1989). This formula is clearly inconsistent with the Principles agreed in the Convention, and also politically inconceivable as a basis for cooperative international action to address global warming.

Following a cumulative *per capita* population formula, which takes into account likely future population trends, would assign developing countries 84% of the remaining fossil carbon budget (Krause et al., 1989). This formula is founded on the assumption of the equal worth of every human being and is therefore the most equitable. Unfortunately, applying the most equitable formula is now technically, economically and politically infeasible, because it would imply the rapid contraction of industrialized economies, to the detriment of all countries, including the developing ones. The past emissions of developed countries have pre-empted the most equitable solution; the interests of all now require compromise on the most pragmatic allocation schedule.

A formula that is approximately mid-way between the two unworkable extremes of *status quo* and most equitable is 50/50 allocation of the remaining carbon budget. By this formula, 150 billion tons of fossil carbon would be allocated each to industrialized and developing countries. This 50/50 formula is arbitrary, but so is any other allocation schedule. Ultimately, the selection of a particular formula will require a political resolution. Any alternative to the 50/50 allocation scheme that might be negotiated would simply increase one group's

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emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs," and

"Recognizing that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development and that, in order for developing countries to progress towards that goal, their energy consumption will need to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general, including through the application of new technologies on terms which make such an application economically and socially beneficial," (from the Convention)

14 "Recognizing the special difficulties of those countries, especially developing countries, whose economies are particularly dependent on fossil fuel production, use and exportation, as a consequence of action taken on limiting greenhouse gas emissions," (from the Convention).

15 "Affirming that responses to climate change should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts on the latter, taking into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty," (from the Convention).

allocation in proportion to the decrease in the other group's allocation, within the framework of the global emission scenario shown in Figure 1.

Although the exact allocation schedule can only be determined by negotiation between the affected parties, the 50/50 schedule is very close to what must eventually evolve, and it illustrates the general order of magnitude of the emission reductions that will ultimately be necessary. The Draft Protocol developed here and shown at Annex is therefore based on the 50/50 formula. Any relaxation of emission reductions by the developed countries from those specified in the Draft Protocol represents de facto allocation to the developed countries of proportionately greater than 50% of the remaining carbon budget.

Figure 2 shows a carbon emission schedule that would achieve the 50/50 allocation of the remaining 300 billion ton carbon budget, remain within the global emission framework shown in Figure 1, and consequently constrain global warming to the 2^{O} C warming limit. The schedule shown in Figure 2 is based further on the principle that developed countries should cease emission growth sooner than developing countries, while developing countries should experience a temporary period of increased emissions. Accordingly, two carbon emission tracks are established, one for developed (industrialized) countries and one for developing countries. These two tracks are summarized quantitatively in Table 1, which shows the corresponding timetable of emissions reductions (**emission reduction milestones**).

Developed (industrialized) countries would, by this scenario, collectively reduce carbon dioxide emissions about 10% by the year 2000; one-third by 2010; more than half by 2020; and by three quarters by 2030. Their emissions would stabilize at somewhat under 10% of 1985 emission levels by the year 2070.

Developing countries would, under this scenario, experience a prolonged period of substantial growth in carbon emissions, corresponding to an increase of nearly 3% per year and peaking in 2010. It is unnecessary and counterproductive to mandate subsequent reductions in the emissions of developing countries (see below), except to suggest voluntary targets consistent with the 50/50 allocation scheme. According to these voluntary targets, reductions beginning in 2010 would return emissions to their 1985 level between 2030 and 2040, and stabilize at about 60% of 1985 levels by about 2050. These measures would bring the per capita carbon emissions of developing and developed countries closer to a common level by the end of the next century.

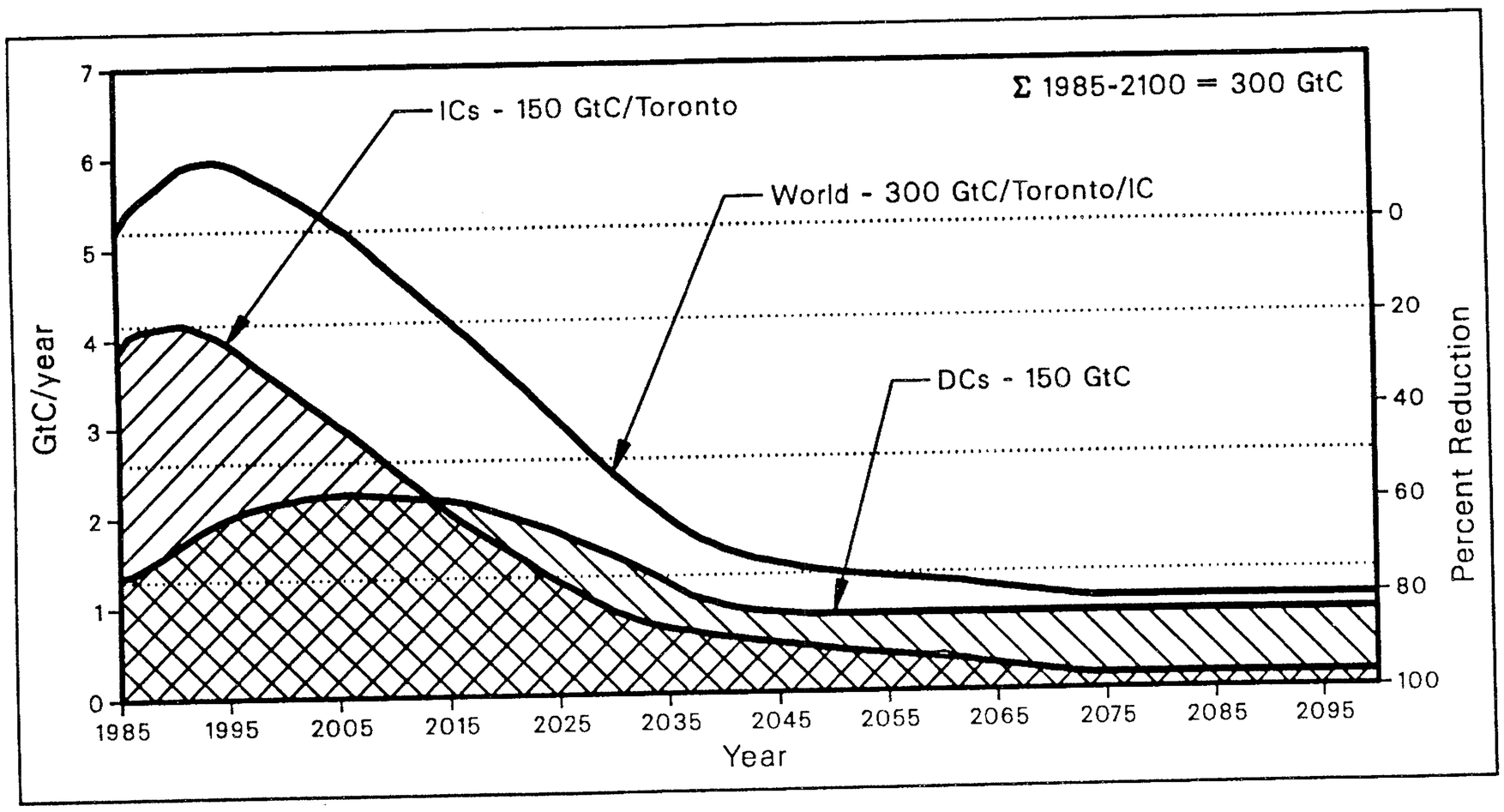

Figure 2: Projected allocation of the remaining carbon budget associated with a warming limit of 2^{o} C between now and 2100. These scenarios assume a 50/50 division of the remaining carbon budget of 300 billion tons of carbon between developed countries (DCs) and industrial countries (ICs). From Krause, Bach and Koomey, 1989, Fig. 1.6.2, with permission of the authors.

TABLE 1
Emission Reduction Milestones Assuming a 50/50 Allocation of a Remaining Carbon Budget of 300 billion tons
Percent growth relative to 1985 levels
(reductions signified by negative numbers)
Calculated from Krause et al., 1989, table 1.6.1.

Year	Industrialized Countries	Developing Countries
1995	+3%	+9%
2000	-9%	+55%
2010	-34%	+59%
2020	-57%	+44%
2030	-76%	+10%
2040	-84%	-30%
2050	-88%	-39%
2060	-91%	-39%
2070	-95%	-39%
2080	-96%	-39%
2090	-96%	-39%
2100	-96%	-39%

It is instructive to compare these emission reduction milestones with a less restrictive carbon budget of 450 billion tons of carbon -- i. e., approximately equivalent to the IPCC's Scenario IS92c).[16] This is done in Table 2, based on the modeling studies reported in Krause et al. (1989), Figure 1.6.5.

TABLE 2
Emission Reduction Milestones Assuming a 50/50 Allocation of a Remaining Carbon Budget of 450 billion tons
Percent growth relative to 1985 levels
(reductions signified by negative numbers)
Calculated from Krause et al., 1989, table 1.6.1.

Year	Industrialized Countries	Developing Countries
1995	+13%	+43%
2000	+7%	+61%
2010	-14%	+88%
2020	-28%	+89%
2030	-41%	+82%
2040	-53%	+71%
2050	-63%	+56%
2060	-73%	+40%
2070	-81%	+19%
2080	-89%	-8%
2090	-93%	-46%
2100	-93%	-46%

Table 2 illustrates that even in this less restrictive emission reduction scenario, the emissions of developed (industrialized) countries would peak in 1995 and be reduced by nearly one third from 1985 levels in 2020. Emissions of developing countries would grow slightly faster and for a slightly longer period of time in this scenario, peaking in 2020 at a level approaching twice the 1985 level and declining thereafter. Absolute reductions from the 1985 level would first be experienced in 2080, in comparison with 2040 under the 300 billion ton carbon budget. More permissive carbon release schedules (e. g., a budget of 450 billion tons) therefore imply broadly similar reduction scenarios over the next three to four decades for industrialized countries (Krause et al., 1989, p. 1.6 - 19), with the greatest relief in the subsequent decades.

Adopting the more precautionary approach therefore makes little difference in the short run. Consequently, the Draft Protocol shown at Annex

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16 Of the six IPCC scenarios modeled, two conform to the warming limit of 2^{o} C or less by the year 2100; these are associated with net carbon releases of 506 and 1,133 billion tons of carbon between 1990 and 2100. These scenarios, however, do not take into account the effects of sulfate aerosol and ozone depletion, and they depend upon optimistic assumptions about economic efficiency and deforestation.

relies upon the more precautionary approach. In the longer run, new scientific understanding of climate change may indicate the need for modified emission reductions in order to achieve the 2^{o} C warming limit. Therefore, the Draft Protocol shown at Annex also incorporates the flexibility to adjust future targets if such adjustments are warranted on the basis of the best scientific evidence then available. The Draft Protocol shown at Annex thus incorporates both precaution and flexibility.

How feasible are the above emission reduction schedules? The answer depends, in part, on their economic impact. The above emission reduction schedules are consistent with continued generous economic growth in the developed countries, as shown by the careful analysis of Krause et al. (1992). According to their conservative models, prompt application of existing energy efficiency technology to new capital stock would enable meeting the above reduction schedule and at the same time save US $50 - 70 billion in Europe alone. For the case of Europe, implementation of existing energy-efficient technology would enable a 60% cut in carbon emissions by the year 2020 and save 10 - 25% over current plans. Similar savings might be realizable in the United States.

The savings realized from implementation of these reductions in developed countries could, in turn, be used to finance new research and development of energy efficiency and renewables, both within industrialized and developing countries, and the transfer of such technology from developed to developing countries. Provision for such technology transfers can be made within Article 12, Technical Assistance, of the Draft Protocol shown at Annex.

There is no need to apply mandatory carbon emission reduction schedules to developing countries at the present time, because developing countries will have both the **incentive** and the **opportunity** to implement such emission reduction schedules voluntarily. The incentive comes from the need for economic competitiveness. If energy efficiency saves money, as suggested by the conservative projections of Krause et al. (1992), then implementing such efficiencies will benefit the corresponding economies by making them more competitive in the common global market. Such economic benefits will not escape the notice of developing countries, who will wish to achieve the same benefits from their own economies by implementing energy efficiency on a voluntary basis.

The opportunity for developing countries to implement voluntary emission reduction schedules will come from institutional developments specified in the Draft Protocol. These instututions -- which are yet to be proposed and negotiated -- would finance research and development of energy efficiency technology and renewable sources of energy, using savings realized from the application of such technologies within developed countries. These same institutions would ensure the transfer the appropriate technology to developing countries, funded in the same way. Such institutions are therefore an essential component of the Draft Protocol; as noted above, they require development within the context of Articles 11 and 12 of the Draft Protocol shown at Annex.

Attempting to apply mandatory schedules to the developing countries is not only unnecessary at the present time; it is also politically infeasible. This is because many developing countries would understandably hesitate to accept mandatory restrictions when they are in acute need of development to eliminate

crushing poverty, and at the same time do not bear hisorical responsibility for the problem of global warming. Any attempt to impose mandatory emission reductions on developing countries at this time would carry the substantial risk of political paralysis within the negotiating process.

Several additional policy issues remain to be negotiated in order to achieve an integrated approach to climate stabilization. These include the fossil carbon allocation to specific regions and countries, regulation of population growth, and modification of forestry and agricultural practices. In addition, consideration must be given to the special problems of fossil fuel producing countries and the least developed countries, without whose cooperation a smooth transition to climate-safe energy policies will be impossible. These issues could be approached either in the same protocol, as proposed here, or in separate protocols that are negotiated in parallel with, or subsequent to, the carbon reduction protocol.

Incorporation of these complex issues leave room for enormous creativity in reaching balanced solutions including, for example, carbon emission trading rights, joint implementation, exchange within and between countries and regions of carbon emission rights for progressive forestry and agricultural practices, approproate compensation to oil producing countries in exchange for taking reserves out of production, emission credits for technology transfer, financing of technology transfer by savings associated with energy efficiency, etc. These are among the issues that will require painstaking and patient, and yet urgent, negotiation by Parties to the Convention.

CONCLUSIONS AND RECOMMENDATIONS

According to the best scientific understanding currently available, implementing the Convention limits Signatories to two and only two policy options consistent with preserving the global climate, each with its own different challenges and concerns.

On one extreme is early phase-out of fossil fuels, proposed here and implemented in the Draft Protocol shown at Annex. The primary challenge associated with this extreme is to mobilize the world community to the consensus needed for quick, decisive action, and to create the necessary international institutions to accomplish this action fairly and promptly.

The other extreme is delayed phase-out. In this case the challenge will be postponed a few years, at which time progressivley more extreme implementation of essential measures will be unavoidable, including accelerated depreciation of capital stock and the possibility of emergency scrap-and-replace strategies. The longer measures are postponed, the greater the risk of both economic collapse and/or climate catastrophe.

Under no circumstances will the choice between these two options have the benefit of definitive scientific proof of the need for preventative measures. The physical inertia of the climate system ensures that by the time definitive scientific proof is available, it will be too late to undertake effective mitigation measures. Policy choices between the two options available -- immediate actions or delayed measures -- will have to be made without the comfort of certainty.

Deciding between the two options -- early but gradual phase-out of carbon dioxide emissions, or later but increasingly rapid phase-out -- therefore requires a policy decision as to which uncertainty is preferable; the uncertainty of taking action now without definitive proof of need, or the uncertainty of delaying action and thereby assuring further global warming commitment.

AOSIS countries may wish to pursue the immediate reduction option, because the more immediate measures confer numerous benefits in their own right (including substantial economic savings), are associated with less future economic and environmental risk, are possible with existing technology, are supported fully by existing scientific evidence, and are in any event subject to review to assure future compliance with the best available scientific evidence. This is the approach taken in the Draft Protocol shown at Annex.

If, after due consideration, the AOSIS countries decide to forward the Draft Protocol shown at Annex to the Intergovernmental Negotiating Committee's future meetings on substantive issues, several immediate priorities for subsequent negotiation would then merit attention, as follows:

First, and probably the most significant single priority, the Draft Protocol deals with the key issue of financing and technology transfer in vague generic terms. As noted above, financing of research and development, as well as the transfer of that technology, could be achieved using savings from application of energy efficiency in the developed countries. Such funds could be allocated through appropriate new institutions, such as the proposed International Agency for Energy Efficiency and Renewable Sources. AOSIS countries may wish to give this issue the greatest priority in negotiating the details of the protocol, in the context of Article 11 (Research, Development, Public Awareness and Exchange of Information) and Article 12 (Technical Assistance). Otherwise the Draft Protocol would not provide explicitly the incentive nor opportunity for developing countries to benefit from energy efficiency and renewable sources, as is required for the Protocol to function properly.

Second, the exact emission reductions to be committed by developed countries (Article 2) will most certainly be the object of further discussion and negotiation. In this process it will be recalled that the existing reduction schedule is based upon a 50/50 allocation of the remaining carbon budget to both developed and developing countries. Any retreat from the emission schedule for developed countries, as specified in Article 2 the Draft Protocol, would therefore represent de facto agreement that the developed countries should be allocated more than 50% of the remaining carbon budget.

Third, there could be pressure to extend mandatory emission standards to developing countries, rather than the voluntary milestones now incorporated into Article 3 of the Draft Protocol. Developing countries will therefore need to decide to what degree, and under what circumstances, they are prepared to accept such mandatory schedules.

Fourth, the emission reduction milestones specified in Articles 2 and 3 are based upon optimistic assumptions with respect to other greenhouse gas emitting sectors. In particular, it will be necessary to ensure that forest biomass loss is reversed; otherwise, more stringent fossil carbon dioxide emission reductions are required in order to constrain warming to the 2^{o} C limit by the year 2100. AOSIS and other developing countries may therefore wish to give

advance thought to the kinds of agreements they are prepared to make with respect to Article 4 issues, Related Measures In Forestry, Agriculture and Population.

Fifth, energy efficiency and renewable sources of energy are mentioned in several Articles of the Draft Protocol, but their possible role in reducing carbon emissions is left vague and generic. AOSIS countries may wish to consider making their role more explicit by, for example, establishing energy efficient standards that are consistent with the indicated fossil carbon dioxide emission reduction schedules.

Sixth, the relation of this Protocol to the Convention (Article 16) will require further detailed thought. The Convention, for example, makes certain provisions for technology transfer and establishes certain relevant institutions. The exent to which these would be the same or different from the instutions specified in the Draft Protocol remains to be established.

Seventh, should AOSIS decide as a group to forward the Draft Protocol on Fossil Carbon Dioxide Emission Reductions shown at Annex, we will require the support of as many countries as possible. AOSIS may therefore wish to assess its options in respect to developing such support from, for example, the Group of 77, The strength and breadth of such support will undoubtedly depend, in part, on the exact wording of several key Articles, which remain to be negotiated, notably Article 5 (Special Situation of Countries Dependent on Fossil Fuel Production), Article 6 (Special Situation of Countries with Economies in Transition) and Article 7 (Special Situation of Least Developed Countries). AOSIS countries may, therefore, wish to give advance consideration to the possible content of these Articles.

ACKNOWLEDGMENTS, ATTRIBUTIONS AND DISCLAIMERS

This Background Paper and the Draft Protocol that follows were prepared for His Excellency Bernard Dowiyogo, President of the Republic of Nauru, by W. Jackson Davis, Ph. D., Professor of Biology and Environmental Studies at the University of California, Santa Cruz, Executive Director of the Environmental Studies Institute, and Scientific Adviser to the Republic. Professor Davis received assistance from: Dr. Florentin Krause, Staff Scientist, Energy Analysis Program, Lawerence Berkeley Laboratories, University of California, Berkeley, who provided expert advice on the Background Paper; and Mr. Jacob Werksman, Staff Lawyer, Foundation for International Environmental Law and Development, London, who reviewed and commented on the draft protocol. Institutional affiliations of the author and assistants are given only for purposes of providing background and do not necessarily imply the support or advocacy by those institutions for the facts or views represented herein.

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ANNEX

DRAFT PROTOCOL ON THE REDUCTION OF FOSSIL CARBON DIOXIDE EMISSIONS

I. Draft Protocol

PREAMBLE

The Parties to this Protocol,

Being Parties to the Framework Convention on Climate Change,

Mindful of the Objective of that Convention to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system,

Determined to take precautionary measures in accordance with the Convention to prevent dangerous anthropogenic interference with the climate system,

Acknowledging that, in accord with that Convention, measures to arrest climate change should take into account the best available scientific knowledge,

Recognizing that, according to the best scientific knowledge, a 60% or greater reduction in the global emission of greenhouse gases is necessary to stabilize concentrations in the atmosphere,

Noting that carbon dioxide is the major and most controllable greenhouse gas,

Conscious that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries,

Accepting that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs,

Conscious that responses to climate change should be comprehensive, integrated and coordinated with social and economic development,

Acknowledging that special provisions are necessary to meet the needs of those countries whose economies are in transition or particularly dependent on fossil fuel production, use and exportation,

Have agreed as follows:

ARTICLE 1

DEFINITIONS

For the purposes of the Protocol:

1. "Convention" means the United Nations Framework Convention on Climate Change, adopted on [ ];

2. "Parties" means, unless the text otherwise indicates, Parties to this Protocol;

3. "Secretariat" means the secretariat of the Convention.

4. "Developed Country Parties" means [from Convention]

5. "Developing Country Parties" means [from Convention]

6. "Countries with Economies in Transition" means [from Convention]

7. "Countries Dependent on Fossil Fuel Production" (CDFFs) means [countries whose economies depend 33% or more on exportation of fossil fuels or refined products.]

8. "Greenhouse gases" means [from Convention?]

9. "IPCC" means Intergovernmental Panel on Climate Change

[10. Etc. as required.]

ARTICLE 2

CONTROL MEASURES FOR DEVELOPED COUNTRIES

1. The Control Measures adopted herein are intended to limit average global warming to 2^{O} C from the present by the year 2100 based on the best scientific information available. This warming limit corresponds to a remaining carbon budget, calculated on the basis of risk-aversive assumptions, of 300 billion tons by the year 2100.

2. Toward this end, Developed Country Parties shall reduce their collective emissions of fossil carbon dioxide relative to 1985 emission levels by: 10% by the year 2000; one-third by the year 2010; and 60% by the year 2020. Continuing reductions from 1985 levels thereafter will be pursued as necessary to achieve a global emission schedule consistent with the 2^{O} C warming limit, based on the best available scientific evidence.

3. Developed Country Parties shall achieve these reductions by whatever means they find appropriate to their national circumstances, including especially the application of energy efficient technologies and increased use of renewable energy resources. The reductions may be achieved unilaterally, or by pooling national emissions on a bilateral, multilateral or regional basis with other Developed Country Parties and/or Countries with Economies in Transition.

4. The above reduction schedule is based on the simultaneous implementation of aggressive control measures in other sectors, specifically, elimination of chlorofluorocarbon emissions by the year 2000, and reversal of forest biomass loss early in the next century. Steps that achieve emission savings beyond these assumed measures, and that result in equivalent reductions in the emissions of other greenhouse gases (comparable carbon dioxide equivalents), shall be credited toward a developed country's carbon dioxide emission reduction schedule.

5. Developed Country Parties that adopt emission reduction measures prior to entry into force of this Protocol for them shall receive credit for such measures prior to accession. For purposes of this paragraph, calculation of

emission reductions shall be undertaken using the comparable methodology referenced in Article 8 below.

ARTICLE 3

CONTROL MEASURES FOR DEVELOPING COUNTRIES

1. Consistent with the average global warming limit of 2^{o} C, Developing Country Parties may experience a period of collective growth in emissions, at a rate of approximately 3% annually between 1992 and the year 2010. As a consequence of this growth, collective fossil carbon emissions of developed countries may increase by as much as 55% above 1985 emission levels by the year 2000, and by as much as 59% above of 1985 levels by the year 2010.

2. Thereafter, developing countries shall take all practicable steps to reach the following voluntary fossil carbon dioxide emission reduction targets, consistent with their social and economic needs and contingent upon the transfer of requisite funds and technology from the developed countries: 44% above 1985 levels by 2020, 10% above 1985 levels by 2030, and reductions thereafter as possible and as necessary to achieve a global emission schedule consistent with the 2^{o} C warming limit.

3. Developing Country Parties may achieve these voluntary targets and timetables unilaterally, or by pooling national emissions on a bilateral, multilateral or regional basis with other Parties. In this process special consideration shall be extended to the least developed country Parties.

ARTICLE 4

RELATED MEASURES IN FORESTRY, AGRICULTURE AND POPULATION

1. Stabilization of concentrations of greenhouse gases in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system requires comprehensive, integrated measures in all areas of human activities that generate greenhouse gases.

2. Parties will therefore address these additional and interrelated issues, in the form of additional Protocols to the Convention, at their first meeting, with a view toward coordinating and integrating the measures adopted in different protocols.

ARTICLE 5

SPECIAL SITUATION OF COUNTRIES DEPENDENT ON FOSSIL FUEL PRODUCTION

ARTICLE 6

SPECIAL SITUATION OF COUNTRIES WITH ECONOMIES IN TRANSITION

Countries with Economies in Transition shall implement the emission schedules of Developing Country Parties until they achieve the status of Developed Country Parties.

ARTICLE 7

SPECIAL SITUATION OF LEAST DEVELOPED COUNTRIES

1. Least Developed Country Parties will receive special consideration in the allocation of carbon emission rights amongst developing countries, according to a formula to be adopted by Parties at the first meeting.

[2. etc. as required.]

ARTICLE 8

ASSESSMENT AND REVIEW OF CONTROL MEASURES

1. For purposes of complying with this Protocol, emission levels shall be determined by a comparable methodology [recommended by the IPCC and] adopted at the First Meeting of Signatories to the Convention.

2. Parties will revise the control measures identified in Articles 2 and 3 above at their future Meetings as necessary and appropriate in view of the best scientific evidence available, currently that of the IPCC, with a view toward achieving the target of a maximum average global warming limit of 2^{O} C by the year 2100.

3. Parties will report measures to comply with the above reduction schedules at their second meeting and at each meeting thereafter.

ARTICLE 9

REPORTING OF DATA

1. Each Party shall provide to the secretariat, within three months of becoming a Party, statistical data on its emission by sources and removal by sinks of carbon dioxide for the year 1985, or the best possible estimate of such emissions and removals where actual data are not available, using comparable methodologies adopted at the first Meeting of Signatories to the Convention.

2. Each Party shall provide statistical data to the secretariat on its annual emission by sources and removal by sinks of carbon dioxide for the year during which it becomes a Party and for each year thereafter, using comparable methodologies adopted by the Parties at the first Meeting of Signatories to the Convention. Each Party shall forward the data no later than nine months after the end of the year to which the data relate.

ARTICLE 10

NON-COMPLIANCE

The Parties, at their first meeting, shall consider and approve procedures and institutional mechanisms for determining non-compliance with the provisions of this Protocol and for treatment of Parties found to be in non-compliance.

ARTICLE 11

RESEARCH, DEVELOPMENT, PUBLIC AWARENESS AND EXCHANGE OF INFORMATION

1. The Parties shall co-operate, consistent with their national laws, regulations and practices and taking into account in particular the needs of developing countries, in promoting, directly or through competent international bodies, research, development and exchange of information on:

(a) Energy-efficient methods in all relevant sectors, including energy, transport, industry, agriculture, forestry and waste management;

(b) New and renewable sources of energy.

(c) Other technological, technical, socio-economic and legal information related to climate change, including the economic and social consequences of various response strategies;

2. The Parties, individually, jointly or through the competent international bodies, shall co-operate in prompting public awareness of the environmental, social and economic effects of fossil fuel use insofar as it impacts upon the climate.

3. Within two years of the entry into force of this Protocol and every two years thereafter, each Party shall submit to the secretariat a summary of the activities it has conducted pursuant to this Article.

ARTICLE 12

TECHNICAL ASSISTANCE

1. The Parties shall in the context of the provisions of Article 4 of the Convention, and taking into account in particular the needs of developing countries, co-operate in promoting technical assistance to facilitate participation and implementation of this Protocol.

2. Any Party or Signatory to this Protocol may submit a request to the secretariat for technical assistance for the purposes of implementing or participating in the Protocol.

3. The Parties, at their first meeting, shall begin deliberations on the means of fulfilling the obligations set out in Article 4 of the Convention and in paragraphs 1 and 2 of this Article, including the preparation of workplans. Such workplans shall pay special attention to the needs and circumstances of the developing countries. Such workplans shall specify financial and institutional mechanisms by which technologies for reducing fossil carbon dioxide emissions will be transferred to developing countries. States and regional economic integration organizations not party to the Protocol should be encouraged to participate in the activities specified in such workplans.

ARTICLE 13

MEETINGS OF THE PARTIES

1. The Parties shall hold meetings at regular intervals. The secretariat shall convene the first meeting of the Parties not later than one year after the date of the entry into force of this Protocol and in conjunction with a meeting of the conference of the Parties to the Convention, if a meeting of the latter is scheduled within that period.

2. Subsequent ordinary meetings of the Parties shall be held, unless the Parties otherwise decide, in conjunction with meetings of the Conference of the Parties to the Convention. Extraordinary meetings of the Parties shall be held at such other times as may be deemed necessary by a meeting of the Parties, or at the written request of any Party, provided that, within six months of such a request being communicated to them by the secretariat, it is supported by at least one third of the Parties.

3. The Parties, at their first meeting, shall:

(a) Adopt by consensus rules of procedure for their meetings;

(b) Adopt by consensus the financial rules referred to in paragraph of Article 15;

(c) Begin to address the additional Protocols referred to in Article 4, Paragraph 2.

(d) Begin to address the special circumstances of LDCs as specified in Paragraph 1 of Article 7.

(e) Adopt agreed methodologies for determining emission by sources and absorption by sinks of carbon dioxide, as specified in Paragraph 1 of Article 8, based upon comparable methodologies adopted by Signatories to the Convention at their First Meeting.

(f) Provide the data to the secretariat on emissions and removals of carbon dioxide, as specified in Paragraphs 1 and 2 of Article 9;

(g) Consider and approve the procedure and institutional mechanisms specified in Article 10;

(h) Begin preparation of workplans pursuant to Paragraph 3 of Article 12.

ARTICLE 14

SECRETARIAT

For the purposes of this Protocol, the secretariat shall:

(a) Arrange for and service meetings of the Parties as provided for in Article 13;

(b) Receive and make available, upon request by a Party, data provided pursuant to Article 9.

(c) Prepare and distribute regularly to the Parties reports based on information received pursuant to Articles 9 and 11;

(d) Notify the Parties of any request for technical assistance received pursuant to Article 12 so as to facilitate the provision of such assistance;

(e) Encourage non-Parties to attend the meetings of the Parties as observers and to act in accordance with the provisions of this Protocol;

(f) Provide, as appropriate, the information and requests referred to in subparagraphs (c) and (d) to such non-Party observers;

(g) Perform such other functions for the achievement of the purposes of this Protocol as may be assigned to it by the Parties.

ARTICLE 15

FINANCIAL PROVISIONS

1. The funds required for the operation of this Protocol, including those for the functioning of the secretariat related to this Protocol, shall be charged exclusively against contributions from the Parties.

2. The Parties, at their first meeting, shall adopt by consensus financial rules for the operation of this Protocol.

ARTICLE 16

RELATION OF THE PROTOCOL TO THE CONVENTION

Except as otherwise provided in this Protocol, the provisions of the Convention relating to its protocols shall apply to this Protocol.

ARTICLE 17

SIGNATURE

This Protocol shall be opened for signature by States and by regional economic integration organizations [in on] [and at United Nations Headquarters in New York, from].

ARTICLE 18

ENTRY INTO FORCE

1. This Protocol shall enter into force on [ ], provided that at least [ ] instruments of ratification, acceptance, approval of the Protocol or accession thereto have been deposited by States or regional economic integration organizations representing at least [one half] [two-thirds] of the 1985 estimated global emission of carbon dioxide by sources and/or [one half] [two-thirds] of the 1985 estimated absorption of carbon dioxide by terrestrial sinks[, and the

provisions of paragraph [ ] of Article 17 of the Convention have been fulfilled]. In the event that these conditions have not been fulfilled by that date, the Protocol shall enter into force on the ninetieth day following the date on which the conditions have been fulfilled.

2. For the purposes of paragraph 1, any such instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of such organization.

3. After the entry into force of this Protocol, any State or regional economic integration organization shall become a Party to it on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

ARTICLE 19

PARTIES JOINING AFTER ENTRANCE INTO FORCE

Any State or regional economic integration organization which becomes a Party to this Protocol after the date of its entry into force, shall fulfill forthwith the sum of the obligations under Articles 2, 3 and 8, that apply at that date to the States and regional economic integration organizations that became Parties on the date the Protocol entered into force.

ARTICLE 20

RESERVATIONS

No reservations to this Protocol may be entered.

ARTICLE 21

WITHDRAWAL

For the purposes of this Protocol, the provisions of Article 24 of the Convention relating to withdrawal shall apply. Any such withdrawal shall take effect upon expiration of one year after the date of its receipt by the Depository, or on such later date as may be specified in the notification of the withdrawal.

ARTICLE 22

AUTHENTIC TEXTS

The original of this Protocol, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

In witness whereof the undersigned, being duly authorized to that effect, have signed this Protocol.

Done at [ ] this [ ] day of [ ], in the year [ ].

II. Commentary

A. Overall Structure of Draft Protocol

The structure for the Protocol is based on the Montreal Protocol on Substances that Deplete the Ozone Layer, modified as necessary to conform to the present issue.

B. Preamble

Inasmuch as the clauses of the preamble are not binding, the best negotiating strategy may be to strive for a short, simple Preamble that achieves maximal consistency with the Convention. This is undertaken in the Draft Preamble by utilizing, in many cases, wording drawn from the Convention, especially its Principles (Preamble) and Objective.

C. Article 1: Definitions

The ones proposed are exemplary. There will doubtless be pressure to minimize the definitions to those that are absolutely essential to the Protocol, and pressure also for consistency with the Convention's definitions.

D. Articles Relevant to Emission Reductions

These Articles (2, 3 and 8) are among the principle concerns of AOSIS countries and hence the heart of the present Draft Protocol. They are fully consistent with earlier AOSIS negotiating positions, and based directly on the accompanying Background Paper.

1. Article 2: Control Measures for Developed Countries

This is based on the more prudent (risk-aversive) remaining carbon budget of 300 billion tons of carbon (btC), as developed in the accompanying Background Paper (see Table 1), and assumes 50/50 allocation of the remaining carbon budget between developed and developing countries.

Paragraph 1 states the assumptions of the emission reduction schedule. This may be desirable as a foundation for future adjustments based on the best available scientific evidence.

Paragraph 2 incorporates the emission reduction schedule implied in Table 1, based on a 50/50 allocation formula. Any relaxation of these emission reduction schedules therefore proportionately decreases the carbon budget remaining for developing countries below 50%.

Paragraph 3 on implementation is intended to provide flexibility by encouraging and legitimizing satellite agreements between Developed Country Parties aimed at collective reduction of emissions. This clause is intended to codify the "joint implementation" provision of Article 4.2 (a) of the Convention.

Paragraph 4 establishes the assumptions made with respect to CFCs and forests in developing the emission reduction schedule outlined in paragraph 2. This is necessary in the event that these assumptions are not realized, in which case the emission reduction schedule would have to be altered accordingly.

Paragraph 4 is also intended to provide flexibility in meeting these schedules while simultaneously offering incentives to reduction of other greenhouse gas emissions.

Paragraph 5 provides for Parties that join at different times, in order to avoid disincentives to adoption of effective measures prior to entry into force of this protocol. This paragraph codifies (Article 4.2 (a) of the Convention) -- "taking into account the differences in these Parties' starting points and approaches." It is possible that this section would be better placed in Article 8.

2. Article 3: Control Measures for Developing Countries

Control measures for developing countries are non-obligatory for the reasons developed in detail in the Background Paper. The figures given are accordingly "targets" to be implemented on a voluntary basis. This should assist in gaining the support of the developing countries (such as G-77). This should not compromise the Objective of the Convention, however, because of the strong opportunities and incentives for developing countries to follow the lead of industrialized countries in reducing carbon emissions, as detailed in the Background Paper.

Paragraph 1 states the goal of the voluntary reductions as restricting maximum warming to the limit of 2^{o} C. It also establishes the voluntary targets for developing countries, from Table 1 of the Background Paper.

Paragraph 2 extends joint implementation opportunities, and hence flexibility, to Developing Country Parties. At the same time it acknowledges the special difficulties of the least developed country parties, paving the way for special consideration in bilateral or regional agreements.

E. Article 4: Related Measures in Forestry, Agriculture and Population

This Article is intended to create the necessary balance with other issues and sectors, emphasized by the IPCC as essential to a comprehensive approach. The present draft defers the issues -- each of which is at least may be as difficult and involved as the present Draft Protocol on the Reduction of Carbon Dioxide Emissions -- but at least puts the issues onto the Parties' future agenda (Paragraph 2). AOSIS may wish to consider developing draft Articles/Protocols on these issues for future consideration by INC.

F. Articles on Special Situations (Articles 5-7)

These are needed to attract the corresponding blocks of countries within the confines of a fossil carbon emission reduction protocol. No text is developed yet inasmuch as the implications have not been analyzed fully. AOSIS countries may wish simply to propose that these Articles be included but leave to the corresponding countries the task of advocating specific text.

F. Remaining Articles

These are patterned largely after the Montreal Protocol, with modifications as appropriate to apply to carbon dioxide emissions. It is possible that some of the clauses presently included under Special Situations should be incorporated solely into Article 15, Financial Provisions, to eliminate redundancy.