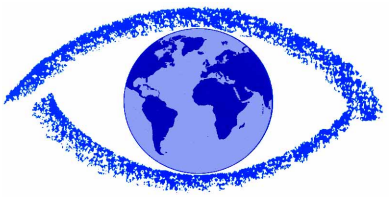
German Advisory Council
on Global Change (WBGU)



Targets for Climate Protection, 1997

A Study for the Third Conference of the Parties to the Framework Convention on Climate Change in Kyoto

September 1997

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Adopted at the 52nd Session of the Council,

19 September 1997, Göttingen

Contents

Executive Summary

This statement is issued by the German Advisory Council on Global Change on the occasion of the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (the Climate Convention, FCCC), and contains recommendations on the commitments to be agreed upon in a protocol to the Convention. According to the "Berlin Mandate" adopted at the first Conference of the Parties, the commitments of the industrialized countries listed in Annex I of the Climate Convention are to be strengthened by setting quantified limitation and reduction objectives within specified time frames for their greenhouse gas (GHG) emissions. These measures are aimed at achieving the ultimate objective of the FCCC, namely a "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

According to the current state of climate research, as summarized in the latest Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the balance of evidence suggests a discernible human influence on global climate. If present-day lifestyles and economic systems fail to change, the probability of global climate changes occurring at a scale and at a rate greater than any seen in the last 10,000 years (the recent Quaternary period) becomes immensely threatening.

In order to ascertain the emission reductions necessary to protect the climate system, the Council again applies the tolerable window concept it developed in its statement to the first Conference of the Parties in 1995. By defining the maximum boundary conditions or "crash barriers" of climatic development and climate policy that can be tolerated by the environment, the economy and society, it is possible to establish the scope for action that remains over the next 200 years. Taken together, the crash barriers define the tolerable window for climate protection.

The Council assumes that specific reduction targets can apply at first to the Annex I Parties (industrialized countries) only, as envisaged by the "Berlin Mandate" of 1995 and the principles of international law laid down in the FCCC. With regard to the distribution of commitments between the individual countries, the Council recommends applying the "per capita approach" as a basic criterion, although other approaches may be used temporarily during a transitional phase. The invariable implication is that the "action space" of industrialized countries is subjected to severe restrictions.

The Council concludes that the emission profile recommended in its 1995 statement to the first Conference of the Parties (the "WBGU scenario") is only compatible with the environmental, economic, social and legal crash barriers on condition that it takes into account not only carbon dioxide, but also the other important greenhouse gases such as methane and nitrous oxide.

From the integrated analysis of climate protection strategies, the Council derives specific reduction targets for the industrialized countries; these objectives should be included in a Protocol to the FCCC as binding commitments on the

part of Annex I Parties (industrialized countries). In quantified terms, Annex I Parties must reduce their greenhouse gas emissions by 11%, 23% and 43% by the years 2005, 2010 and 2020 respectively, relative to 1990 as the base year. In the long term (by 2050), a 77% reduction in GHG emissions is imperative.

Accordingly, the target proposed by the Council of EU Environment Ministers – a mere 15% by the year 2010 (relative to 1990) – is totally inadequate. One should also realize that the tolerable limits calculated by the Council are the absolute minimum demands for climate protection policy. Even if the recommendations of the Council were to be put into effect, current scientific understanding of the basic inertia within the climate system suggests that such a response would still not suffice to prevent further sea level rise, for example. Developed countries with very strong economies should therefore commit themselves to reduce their emissions by much more than 11% by the year 2005, in order to compensate for the limited options available to industrialized countries with less powerful economies.

The Council therefore recommends that the Federal Government maintain its climate policy objective of reducing carbon dioxide emissions by 25% relative to 1990 by the year 2005. However, part of this reduction commitment could be achieved through joint implementation of activities in other countries where reduction costs are lower.

These reduction targets can only be achieved by abandoning non-sustainable patterns of consumption and production, especially in industrialized countries. This, in turn, requires a comprehensive transformation of society. Any strategy aimed at modifying patterns of action that damage the climate must include a greater focus on environmental education as an indispensable component of climate protection policy, alongside technological solutions, economic instruments and legal regulations.

To ensure that emissions are abated in the most efficient way possible, thus providing the greatest cost effectiveness for the economy, international and/or global instruments such as the joint implementation of activities and an international system of tradable emission permits should be deployed in addition to policies at national level.

Concerning North-South relations, the industrialized countries are committed to bearing the “full agreed costs” incurred by developing country Parties in complying with their reporting obligations under the Climate Convention (Art. 4.3, in association with Art. 12.1). Moreover, the Convention calls on the industrialized countries to provide financial assistance to developing countries in connection with other activities, particularly those involving promotion and cooperation to protect the climate (Art. 4.3, sentence 2 in association with Art. 4.1). The Convention also emphasizes that the extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by Annex I Parties of their commitments under the Convention related to financial resources and transfer of technology. Against this background, the Council recommends increasing the

level of funding provided for under the Climate Convention. Efforts must be made to maximize cost effectiveness and to minimize administrative costs.

1 Introduction

The objective of the 1992 United Nations Framework Convention on Climate Change (FCCC) is "to achieve (…) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. 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" (Article 2 FCCC).

In view of the growing body of scientific evidence for anthropogenic climate change, it is becoming increasingly apparent that the objective of the FCCC cannot be achieved on the basis of the agreed commitments as they currently stand. In particular, there are no quantified reduction targets for the period beyond 2000. The central issue at the next Conference of the Parties in Kyoto in December 1997 is therefore to supplement the Convention with further agreements (Protocols) in which specific commitments to reduce greenhouse gas emission are stipulated for specified time frames. Pursuant to the "Berlin Mandate" adopted at the first Conference of the Parties, the countries bearing the greatest responsibility for the anthropogenic enhanced greenhouse effect – the industrialized countries and other Parties listed in Annex I – should be subjected first and foremost to agreed and quantified reduction commitments. The Annex I Parties include the western industrialized countries and the eastern European countries undergoing the transition to a market economy.

In this statement by the German Advisory Council on Global Change (WBGU), specific obligations to reduce greenhouse gas emissions are recommended which appear necessary, on the basis of current scientific understanding, to ensure the protection of the climate system required by Article 2 of the Climate Convention. Proceeding from the current state of climate research and with the help of an integrated analysis of climate protection strategies, we derive the minimum requirements that would have to be met by international reduction objectives if they are to comply with the principles of international equity. Strategies for implementing these obligations are also recommended.

2 Current state of climate research

The Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) provide up-to-date summaries of the current state of international climate research. The contributions relating to the science of climate change made by Working Group I of the IPCC, involving numerous climate research experts from all over the world, contain the carefully scrutinized consensus among the research community regarding the assessment of the complex climate system and changes to it as a result of human activities.

The most important tools for studying climate changes are coupled atmosphere-ocean circulation models. These climate models are mathematical descriptions of the processes which govern the highly complex climate system as they are currently understood. Their capacity to operate simultaneously with interdependent variables makes these models superior to any intuitive approach. The models have been tested intensively by comparing their outputs against observed data (IPCC, 1996a). There is no doubt that climate models have various shortcomings, especially in integrating biosphere processes, land-use changes and the indirect effects of aerosols, and in describing the hydrological cycle, including the effects of clouds. Nevertheless, they are able to simulate global climate on a continental scale and over time scales ranging from decades to centuries.

2.1 Climate change until the present

In its most recent Assessment Report (IPCC, 1996a), the IPCC has confirmed the conclusions of the earlier Reports (IPCC, 1990 and 1992) that the atmospheric concentrations of greenhouse gases have increased considerably since pre-industrial times and that the Earth's climate has undergone changes over the last hundred years. The most important contributors to the enhanced greenhouse effect are carbon dioxide, methane and nitrous oxide. These gases are released to the atmosphere through fossil fuel use, land-use change and agriculture. Anthropogenic aerosols (microscopic particles in the air) resulting from the combustion of fossil fuels and biomass have a cooling effect at regional level, but at global level this is not sufficient to offset the warming due to enhanced greenhouse gas emissions.

Natural climate variability makes it very difficult to prove whether the observed climate change is partly attributable to anthropogenic influences. However, research has achieved major advances since the first IPCC Report (1990) due to improvements in methods and in our scientific understanding of the human impacts on climate. The methods used to detect a human "fingerprint" in observed climate change are based on comparisons of measured and simulated spatial patterns of climate over various time scales. Multi-century simulations of natural climate variability are used as the yardstick for detecting the statistical significance of climate change. Anthropogenic climate change is considered to be statistically verified if it is highly improbable that the observed patterns of climate change are a result of natural climate variability only. In order to confirm the anthropogenic "signal", various other potential factors explaining the observed changes are examined. The spatial patterns of observed temperature change can now be modeled with reasonable accuracy by including the complex impacts of three anthropogenic influences (emission of greenhouse gases, depletion of the ozone layer and emission of sulfate aerosols).

Bearing in mind the possible sources of error – such as deficiencies in the climate models, incomplete knowledge about the different kinds of anthropogenic forcing, and erroneous or heterogeneous measurement data (Santer et al., 1996;

Nicholls, 1996; Michaels et al., 1996) – the IPCC Assessment comes to the conclusion that *"the balance of evidence suggests a discernible human influence on global climate"* (IPCC, 1996a). This core statement is generally accepted in scientific debate (as conducted through publications subjected to expert review), and has been corroborated by further research findings since the Assessment appeared (Santer et al., 1996; Hegerl et al., 1997). The ministers present at the second Conference of the Parties in Geneva in summer 1996 recognized and endorsed the Second IPCC Report as currently the most comprehensive and authoritative assessment of the science of climate change. It provides a scientific basis for urgently strengthening action at the global, regional and national levels to limit and reduce emissions of greenhouse gases, and to support the development of a Protocol ("Geneva Ministerial Declaration", FCCC/CP/1996/15/Add. 1, p. 71-74, paragraph 1).

2.2 Future climate change

In order to assess the extent to which humankind is causing dangerous climate change *in the future*, projections of *possible future* climate change are studied using climate models. These projections are derived from a set of scenarios, each based on a different set of assumptions about economic development, energy consumption and population growth.

The IPCC Assessment Report (IPCC, 1996a) evaluates the results obtained from numerous simulations using different climate models. For the mid-range emission scenario ("business as usual"), the models project an increase in global mean surface air temperature of about 2°C by 2100, whereby the estimates for global warming obtained from different models and with different predictions of population and economic trends vary in a range between 1–3.5°C (by 2100) (IPCC, 1996a). These estimates are lower than in the first Assessment Report (IPCC, 1990), because the cooling effect attributed to aerosols has now been taken into consideration. The projections of the climate models involve much greater uncertainty with regard to regional temperature changes, which may deviate substantially from the global mean value, than is the case with projections of global mean temperature. This applies in particular to changes in the water budget, which cannot be predicted with any degree of precision. According to these simulations, average sea level could rise as a result of thermal expansion of the oceans and melting of glaciers and ice sheets by about 50 cm from the present to 2100, whereby estimates vary between 15–95 cm. This range of uncertainty is due to lack of knowledge about the precise impacts of global warming on precipitation and the melting of ice sheets. Higher temperatures will lead in all probability to a more vigorous hydrological cycle, which can bring about an increase in extreme weather events such as severe storms.

2.3 Possible consequences of climate change

Recent years have seen numerous climate impact research studies into how a continuation of present greenhouse gas emissions and the resultant climate changes could impact on nature, human health and on people's economic and social situation (IPCC, 1996b). The aim of such assessment is to determine the extent to which expected climate changes represent what Article 2 of the Framework Convention on Climate Change refers to as a "dangerous anthropogenic interference with the climate system", and at what level and in what time frames the concentration of greenhouse gases must be stabilized.

The problem is that it is very difficult to determine the adaptive capacity of the ecosystems and socioeconomic systems referred to in Article 2. In order to assess the impact of climate change on ecosystems or economic systems, what is needed are climate simulations with a high degree of spatial and temporal resolution – but these are not available at present. Due to the non-linearity of the climate system, any future change in climate could lead to totally unexpected results; for example, formation of North Atlantic Deep Water could be interrupted within a relatively short space of time, possibly with calamitous (cooling!) impacts on Europe. This prevents any precise estimates of the scale of damage to expect and the resultant costs to the economy. However, there is now certainty that a rise in sea level would threaten millions of people in the densely populated coastal regions. Other regions will experience severe floods or droughts. On the other hand, climate change may also produce some "winners" – for example, colder regions in which land becomes cultivable in a warmer world.

On the whole, however, climate change will most probably generate *additional* pressures on natural systems and human societies, the stability and viability of which are already threatened by factors other than the enhanced greenhouse effect (IPCC, 1996b). These include non-sustainable patterns of production and consumption, especially in the industrialized world, the excessive use of water, air and land for disposing of wastes of all kinds, the overexploitation of natural resources, the destruction of habitats and the uneven distribution of affluence. Due to their less favorable economic, technical and institutional setup, developing countries are generally much more vulnerable to the impacts of climate change than industrialized countries (IPCC, 1996b). The WBGU has identified and investigated at some length the mutual interdependencies between the alarming trends worldwide that are leading to a whole series of global "syndromes" – illnesses afflicting the Earth System. The linkages and potential for mutually reinforcing impacts, in combination with worsening soil degradation, for example, must also be taken into consideration when assessing the effects of climate change.

There are signs that humankind is risking changes to its environment on a global scale – unless it succeeds in radically reducing its emissions of greenhouse gases. This change would occur on a scale and at a rate greater than any seen in the last 10,000 years (the recent Quaternary period). Much of the evidence suggests that the costs of doing nothing will be greater than the costs of taking

action. This is particularly relevant when one considers the leeway that exists for a policy of gradual change (as shown below), and that the costs for adaptation could be kept within manageable limits if effective policies to protect the climate are implemented swiftly. The Council therefore appeals for a rapid switchover to a policy of emission reduction.

3 The international legal framework of climate policy

One of the principles of international law is that no state may assert its rights in a way that damages another state. International environmental law places limits on national sovereignty in the sense that no state may use its territory in ways that cause serious environmental damage to another state. The Framework Convention on Climate Change goes beyond this traditional principle by declaring the change in the Earth's climate to be a "common concern" of humankind (Biermann, 1996; Brunée, 1989). The fact that this Convention has been ratified by almost all the world's nations makes it a key starting point for deliberations on the international legal framework for climate policy.

However, the Convention does not contain a clear definition of states' commitments, which must now be specified as a matter of urgency in the envisaged Protocol. The Convention itself refers only to objectives and principles, as well as the generally formulated commitments in Article 4. The ultimate objective of the Convention and any related legal instruments that may be adopted is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (see Art. 2). Reduction commitments can be derived from Art. 4.2 (a) and (b) for the industrialized countries only – whereby these commitments have yet to be specified in detail. It is precisely this inadequacy of the Convention that the Protocol is supposed to eliminate.

The starting point for defining reduction quotas in the Protocol are the principles laid down in Article 3.1 of the Convention, which states that "the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities". Accordingly, the industrialized countries should take the lead in combating climate change and its adverse impacts. The Convention also emphasizes the specific needs and special circumstances of developing countries.

In this way, it manages to integrate two innovative principles of modern international law: the principle of intergenerational equity and the principle that states have common but differentiated responsibilities; these are to be applied when allocating greenhouse gas emission rights in the Protocol to be adopted by the Parties to the Convention. The principle of differentiated responsibilities takes into account the huge disparities between the shares of historical and cur-

rent global emissions of greenhouse gases, and is therefore compliant with the "polluter pays principle". By referring to the "respective capabilities" of states, the Convention also embraces a key principle of national taxation law. Accepting the differing obligations on the part of the industrialized and other Parties listed in Annex I, on the one hand, and the remaining Parties, on the other, the first Conference of the Parties in 1995 adopted the non-binding "Berlin Mandate". First and foremost, the "Berlin Mandate" is an agreement to begin a process of negotiations, and, in line with the distinctions in the Convention, is guided by the special obligations of industrialized and other Annex-I countries deriving from their past and current levels of emissions, whereby new commitments for the other Parties are excluded from the outset. The "Berlin Mandate" reaffirms the existing commitments of the latter and emphasizes their right to sustainable development, which in developing country Parties will involve an increase in emission levels. However, the "Berlin Mandate" is valid only until the Kyoto conference; in the longer term, the developing countries, too, will have to honor certain commitments in a framework of shared responsibility for the world's climate.

There are various criteria that provide a feasible basis for allocating reduction commitments. In the following, the Council examines these criteria with respect to their compliance with the objectives and principles laid down in the Convention, in particular with the equity principle that addresses the differentiated responsibilities and respective capabilities of states, as well as with principles of general international law.

One conceivable approach would be to borrow the "protection of vested rights" and "protection of bona fide acts" principles already established in the field of human rights protection, and to proceed on the basis of the emission levels of certain states or groups of states at the time the Convention was first adopted (1992). Reduction obligations could then be derived in a subsequent step. Basing the approach on present-day levels would reward high emission levels and hence environmentally harmful behavior in the past, and for that reason is incompatible with the objective and purpose of the Convention.

A contrasting approach would be to place greater weight on the polluter pays principle and to take past emissions fully into account. This would mean that the high emission levels of industrialized countries in the past would be debited fully to their account, whereas developing countries with extremely low emission levels due to their lack of industry in the past would be granted a right to catch up in their development, with all the emissions intensity this involves. High emission levels in the past were not outlawed in international law, however, which means that the states concerned could not anticipate such future penalties. Moreover, the objective is to achieve global reductions in greenhouse gas emissions through concerted efforts by all countries, not just a redistribution of current emission levels. To that extent, this approach is similarly incompatible with the Convention's objective, in that equity principles are not observed.

Given the lack of convincing alternatives, the only criterion for determining emission quotas that is compliant with the principle of equity as required by the Convention is the number of inhabitants in a particular state. Other criteria

appear to ignore the dramatic growth in importance that modern international law now attaches to the rights of the individual, as expressed in the development of human rights protection, while national sovereignty is subjected to increasing limitation. One critical factor on which opportunities for individual personal growth depend is whether the person lives in an industrialized country – which generally implies a relatively high level of emissions. The per capita approach also harmonizes with the Convention principle of common but differentiated responsibilities, in that the industrialized countries would be committed to much greater reductions on account of their much higher emission levels at present. Furthermore, it harmonizes with the principle of "respective capabilities" of states, because reductions should be easier to implement in a state with high per capita emissions than in a state with low per capita emissions.

When applying the per capita principle, should the parameter be the population of the respective country at the time the Convention was adopted (1992), or its future population? Neither international law nor the wide principle of equity provides an answer to this question. A per capita approach with adoption of the Convention as its base line would probably generate better incentives for reductions, while welcome side effects for the environment and human rights could be induced – policies for population control and women's education, for example.

The Council's recommendations in Section 4 concerning the allocation of burdens between industrialized and developing countries is based on this ("static") per capita approach. The Council then derives specific reduction commitments for the Annex I Parties for the time frames proposed in the "Berlin Mandate" (2005, 2010 and 2020). During an initial transition phase, there should be no per capita differentiation within this group of states due to the implementation problems involved. However, the Council recommends – especially with regard to the negotiations that can be expected after the COP3 in Kyoto – that the per capita principle be applied in the long term as the international legal basis for the allocation of emission rights. At extended intervals, the emission rights of nations can be adjusted to eliminate any distortions that may arise through rapid population growth or population decline.

However, the principle of equity permits and requires that all the circumstances in each individual case be taken into consideration when operating the basic "per capita" principle. This means that, in addition to the different responsibilities and capabilities of states, there are other factors – such as the cooler or warmer climate in a certain region and the more or less emissions-intensive industries that are located there – that can and must lead to certain modifications of the basic principle. In view of the problems involved in adjusting to such a system, this modified per-capita approach should be implemented in a series of steps. During such a transition phase, the ratio of energy consumption to economic output may also be used as a parameter for energy efficiency.

4 Integrated assessment of climate protection strategies

4.1 The tolerable window approach

This section sets out global and national targets for the reduction of greenhouse gas emissions, obtained using the tolerable window concept (Toth et al., 1995) that the Council developed in 1995 (WBGU, 1995 and 1996). A characteristic feature of this approach is the normative definition of non-tolerable conditions, the so-called *crash barriers*. These can relate to the impacts of climate change, for example, or the burden on society imposed by reducing greenhouse gas emissions. In this way, the minimum demands for global and/or national reduction strategies can be derived. From the total sum of potentially admissible climate protection strategies, a certain global trajectory for reducing greenhouse gas emissions (the "WBGU Scenario") is selected; this trajectory is optimal in terms of implementability and socioeconomic compatibility. From this, the Council has been able to calculate the reduction commitments for the Annex I Parties by applying the principle of international equity.

The tolerable window approach, it should be emphasized, does not attach absolute priority to environmental protection at the expense of economic and social objectives. By making a strict distinction between the normative definition of crash barriers and the scientific determination of the acceptable climate protection strategies that these entail, the tolerable window approach avoids a number of problems that arise when performing cost-benefit analysis. A cost-benefit analysis would be welcome in principle, but it fails in practice due to the sheer abundance of virtually irresolvable problems concerning data and methods. The Council's approach is therefore a pragmatic strategy in which normative positions are explicitly stated. Environmental assets and damage to health are not valued monetarily, and future damages are not set-off against current ones. The uncertainties associated with the estimation of benefits and costs of climate changes are taken into consideration on a rather more intuitive level. In particular, the different categories of benefits and damages are not viewed as mutually compensatable. Losses in one category (e.g. the irrecoverable loss of essential life-giving resources) cannot be arbitrarily compensated for by gains in a different category (e.g. a regional increase in recreational value).

4.2 The crash barriers of the climate window

Borrowing from its statement for COP1 (WBGU, 1995), the Council considers the "climate window" defined therein as a suitable tool for defining the crash barriers or boundaries to "dangerous anthropogenic interference with the climate system" as mentioned in Article 2 FCCC. Warming of more than 2°C (relative to the pre-industrial value) and/or a warming rate of more than 0.2°C per

decade constitute climate changes that are absolutely intolerable. The Council also assumes that the adaptability of ecosystems and social communities will decline with increasing proximity to the upper temperature limit. The definition of non-tolerable warming is based here on the observed fluctuation range in the recent Quaternary period that has shaped today's climate. It expresses the goal of preserving a natural environment without which humankind and the biosphere could not survive. The temperature span to the tolerable maximum has shrunk to only about 1.3°C (WBGU, 1995). Setting the maximum tolerable warming rate at 0.2°C per decade is based partly on the assumption that the maximum monetary burden that can be imposed on humankind as a consequence of and in order to adapt to climate change is 5% of world GNP. However, it should be borne in mind that this maximum tolerable value is still very approximate. One reason is that the resultant costs of climate change are very difficult to assess, another is that global distribution effects must be taken into consideration. Moreover, it will be almost impossible to define maximum global stress levels for society that are independent of time. One can only refer to certain experience, from which many economists conclude that pressures and stresses (such as the costs of German unification) of an order greater than 3% to 5% of GNP are critical.

Setting crash barriers in this way should not mislead one into thinking that there are critical thresholds of climate change, definable by scientific methods, below which damages are excluded. Global maxima are unable to reflect the substantial variations between regions and sectors in the precise impacts of climate change. Even compliance with the crash barriers, in the sense of limits, can involve a certain intensity of ecosystem damage, as well as threats to the life and limb of people. Setting non-tolerable stress limits must not be a preserve of the scientific community alone, but must occur in a democratic decision-making process – supported by scientific expertise – and with responsibility for present and future generations. The Council has deliberately applied *broad* limits when calculating the values proposed. The Enquete Commissions on "Preventive Measures to Protect the Earth's Atmosphere" and "Protecting the Earth's Atmosphere" established by the 11th and 12th Sessions of the German Bundestag assume that natural vegetation is able to tolerate a rate of warming of only 0.1°C per decade (Enquete Commission, 1990 and 1994), as opposed to the maximum tolerable rate of 0.2°C per decade defined here. All results obtained from these crash barriers are therefore to be seen as *minimum demands* that should be met by global (or national) strategy responses to protect the climate.

When designing an economically and socially acceptable strategy to protect the climate, it is essential to realize that the reduction of greenhouse gas emissions may also generate substantial costs to the economy. These costs cannot be assessed with certainty because they depend on many factors, such as prevailing patterns of consumption and production, the availability of resources and technologies, and the choice of policy instruments. For example, if early action ensures effective investments are made to enhance energy efficiency or to switch to alternative energy carriers, then society incurs lower costs than if it delays action and is compelled later to implement rapid measures (IPCC, 1996c). In general,

costs will be higher the more rapidly emissions must be reduced. The "maximum" rate for reducing carbon dioxide emissions that can be achieved without serious side effects (such as negative impacts on growth, employment and prices) depends here on various factors, including sectoral structure (proportion of energy-intensive industries) and the capital intensity of a national economy, the age structure of real capital, the regional concentration of high-emission sectors, and the rate of employment. It is therefore very difficult to derive generally applicable maximum reduction rates that are at the same time economically acceptable. Studies on the German case indicate that these rates are approximately 2% per annum for industrialized countries (Hillebrand et al., 1996; Hillebrand and Wackerbauer, 1996; Klemmer, 1997). Because the emission reduction costs (in DM per ton of carbon dioxide) in industrialized countries are still very high for technologies providing considerable reduction potential (e.g. in the low-temperature field), and the emission reduction costs are spread across a very wide range, the Council points out that joint implementation is a way to increase the economically acceptable rates of reduction. Under these conditions, reduction rates as high as 4% per annum could be achieved over certain periods.

4.3 Minimum requirements to be met by climate protection strategies

The results presented in the following were obtained using a simplified climate model markedly superior with respect to complexity and accuracy to the model previously used by the Council (WBGU, 1995). The model takes account not only of carbon dioxide, but also of the other main greenhouse gases (methane, nitrous oxide and chlorofluorocarbons) as well as the influence of aerosols. With the help of a biogeochemical model, it is possible to derive the specific atmospheric concentrations from the level of trace gas emissions. Models for radiative forcing then permit the change in global mean temperature and the associated sea level rise to be assessed.

With the help of the climate model, the Council was able to examine whether a certain trend in greenhouse gases emissions would be compatible with the crash barriers referred to in Section 4.2. Using mathematical methods developed at the Potsdam Institute for Climate Impact Research (PIK) in the context of a research project entitled "Integrated Assessment of Climate Protection Strategies" (ICLIPS), the so-called "necessary corridor of emissions" corresponding to the normatively defined crash barriers can be calculated (Fig. 1). The corridor portrays the scope for reduction strategies as delimited by the crash barriers. Any curve representing an emissions abatement path must be within the corridor to be admissible (Toth et al., 1997). However, a path that runs along the upper edge of the corridor the whole time is considered inadmissible. Examples of admissible timepaths are shown in Fig. 1a. *If greenhouse gas emissions are reduced only marginally over the next decades, then bigger efforts will have to be made later. Conversely, large-scale reductions in early years allow emissions to remain constant over a longer period of time later in the future.*

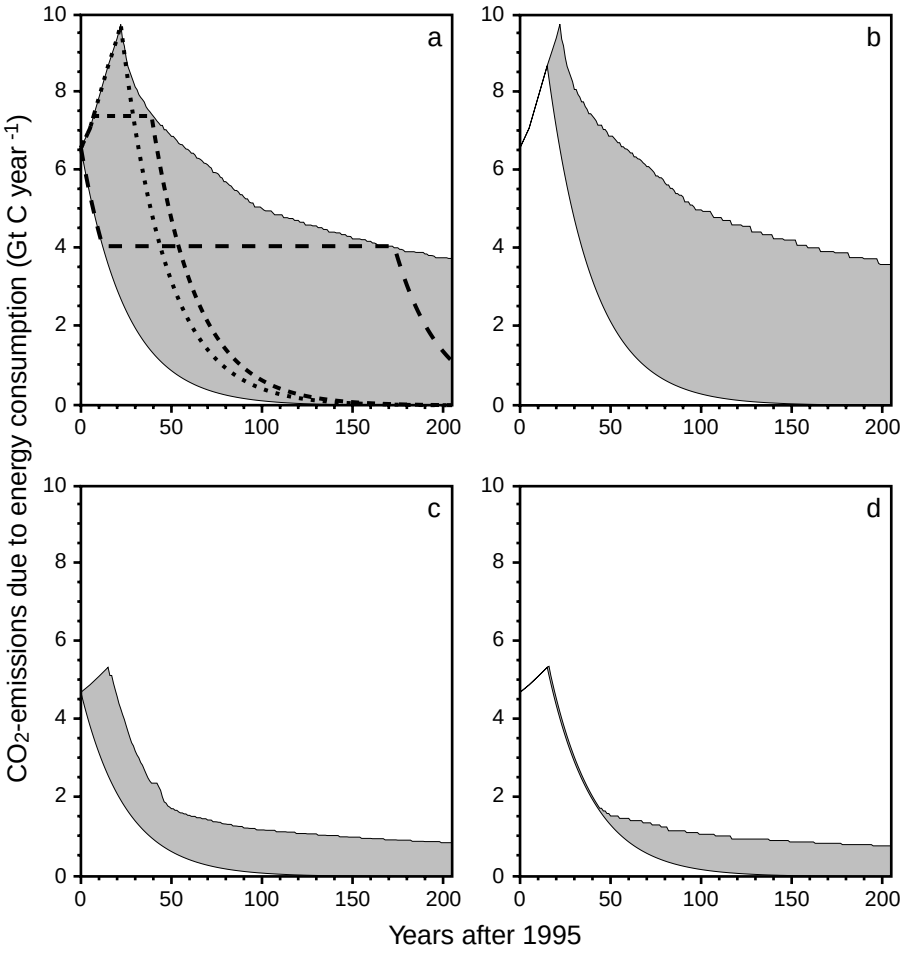

Figure 1

Necessary corridors of emissions for carbon dioxide emissions (due to energy consumption and cement production) until the year 2200 (starting in 1995). Any curve representing a emissions path admitted by the crash barriers must lie within the corridor (shaded area).

a: Global corridor for immediate commencement of climate protection measures: Necessary corridor for global carbon dioxide emissions. Broken lines are examples of admissible paths. No abatement path may run the whole time along the upper boundary of the corridor.

b: Global corridor if climate protection measures are delayed: The necessary corridor for global carbon dioxide emissions resulting if no abatement measures are implemented before 2010.

c: Annex-I corridor: Necessary corridor of emissions for all Annex I states resulting if the developing countries are permitted to increase their emissions until the same per capita emissions are reached.

d: Annex-I corridor if climate protection measures are delayed: Necessary corridor of emissions for all Annex I states resulting if no abatement measures are taken before 2010, while developing countries are permitted to increase their emissions until the same per capita emissions are reached.

The shaded area in Fig. 1a represents the *necessary corridor of emissions* for global energy-related carbon dioxide emissions until the year 2200 (starting in 1995). It was assumed here that emissions of the other greenhouse gases (methane and nitrous oxide) are reduced at the same percentage rates, so that their corridors are determined by simple rescaling. One can see that this global emissions corridor requires a major reduction in greenhouse gas emissions over the long term.

Although the corridor permits several response options, emission reductions must begin in any case by the year 2015 at the latest. *However, delaying reductions will cause the range of response options open to future generations to be substantially curtailed*, as shown in Fig. 1b. The corridor becomes substantially narrower if global emissions until the year 2010 follow the business as usual timepath (the IPCC IS92a scenario; IPCC, 1996a). Any failure to take action today will impose ever-greater burdens on future generations, in that the latter will be forced to implement massive reduction measures in order to avoid overstepping the crash barriers.

A global corridor of emissions does not specify directly how reduction commitments are to be distributed among the individual states. Allocation of these commitments must be agreed upon at the *political* level. In the view of the Council, adequate consideration is given to the special responsibility of the industrialized countries and the equity principle if developing countries are permitted to pursue the business as usual scenario for the time being, adopting the international climate policy of the Annex I Parties when they have reached the same admissible per capita emissions *on the basis of 1992 population size* (see Section 3). This stipulation narrows down the response options of Annex I Parties, as illustrated by the necessary corridor of emissions in Fig. 1c, which shows the timepath of greenhouse gas emissions by Annex I Parties. Again, the corridor itself says nothing specific about *how to implement* the reduction commitments.

However, if the Annex I Parties follow a business as usual timepath until the year 2010, they will severely restrict the response options of future generations, as illustrated in Fig. 1d. The implication, in the view of the Council, is that delaying abatement is non-compliant with the principle of intergenerational equity.

4.4 The new WBGU scenario

In its statement for the first Conference of the Parties (WBGU, 1995), the Council recommended a global scenario for emission reductions based on the assumption that reduction measures would commence as soon as possible. Following a 5-year transitional period, global emissions of carbon dioxide must be reduced by roughly 1% per annum until the year 2155, followed by annual reductions of approx. 0.25%. The recommendation relates to the combustion of fossil fuels, industrial processes involving carbon dioxide emissions and to land-use changes (such as the clear felling of forests). According to recent calculations, cement production already accounts for 7% of global carbon dioxide

emissions, while estimates for the year 2000 project a rise in this figure to 10% (Pearce, 1997). In this scenario, the atmospheric concentration of carbon dioxide stabilizes at around 410 ppm. Current scientific understanding regarding the absorptive capacity of the oceans and the biosphere is taken into consideration when calculating this figure.

Significance for climate

We now examine the extent to which the old WBGU scenario remains within the climate window defined in Section 4.2, this time using the extended climate model. The reduction scenario is compared with a reference path in which the energy input alone is economically "optimized", i.e. without consequences for the climate. This reference path leaves the tolerable climate window domain after only 35 years, and is therefore incompatible with the crash barriers.

If carbon dioxide emissions only are reduced in line with the old WBGU scenario, and emissions of methane and nitrous oxide continue to rise in accordance with the business as usual scenario, then there is a much weaker warming than in the case of no GHG reductions; however, the warming goes beyond the crash barriers of non-tolerable temperature rise. Even if the energy-related emissions of methane and nitrous oxide were reduced by the same percentages as those of carbon dioxide, the warming is still not compatible with the crash barrier for temperature rise. *Only if the total anthropogenic emissions of methane and nitrous oxide are reduced in accordance with the timepath in the old WBGU scenario, i.e. by 1% per annum each after a brief transitional period, will it be possible to stabilize global warming within the climate window (see Fig. 2).*

In effect, the WBGU scenario is only compatible with the climate window if it relates to emissions not only of carbon dioxide but also of methane and nitrous oxide (Fig. 2), e.g. in the form of similar reduction commitments for these compounds.

Most anthropogenic emissions of methane and nitrous oxide originate in agriculture (rice growing, cattle farming, use of nitrogen fertilizers). In view of the difficult world food situation, it is doubtful whether these emissions can actually be reduced in practice. Furthermore, effective monitoring of reduction commitments is hardly feasible in this sector. The minimal gap between the temperature timepath in the extended WBGU scenario and the edges of the climate window (Fig. 2) is a safety margin that already takes account of a partial failure of reduction commitments in the field of non-energy-related emissions. It also takes into account the uncertainty regarding the boundaries of the climate window.

How certain is the climate window?

The risks implied by trajectories even within the climate window can be described with reference to sea-level rise. Even with the extended WBGU scenario, the climate model results indicate that it is not possible to prevent the rise in sea level over the next 200 years. Many potential impacts of climate change are closely related to sea-level rise, such as increasing flood risk, land losses, damage to wetlands, threats to small island states, accelerated loss of species or high-

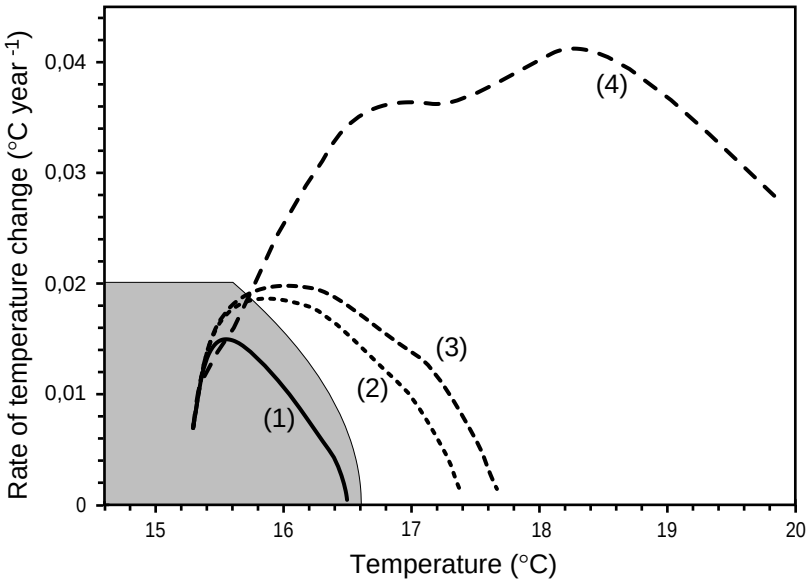

Figure 2

Development of global climate parameters for different greenhouse gas emission scenarios. The shaded area shows the WBGU climate window as defined by the crash barriers for global warming and the rate of warming.

(1) Parallel reduction of carbon dioxide, methane and nitrous oxide emissions. Reduction rates as in old WBGU scenario (3).

(2) Parallel reduction of carbon dioxide emissions and *energy-related* methane and nitrous oxide emissions. Reduction rates as in old WBGU scenario (3).

(3) Old WBGU scenario: Reduction of *global* carbon dioxide emissions from 2000 by 1% per annum until 2155, thereafter at 0.25%. Emissions of methane and nitrous oxide increase in line with the business as usual scenario.

(4) Reference path without climate protection measures (business as usual).

er costs for essential coastal protection measures (IPCC, 1996b). It should be realized that about 50–70% of humankind live in coastal regions and are therefore potentially exposed to sea-level rise. This danger is further exacerbated by the fact that urbanization is occurring primarily in coastal regions and that the population there is increasing twice as fast as the national average in many cases (IPCC, 1996b).

Statistical estimates show that, even now, 46 million people are exposed each year to storm floods. This figure could double to 92 million people in the event of a 50-cm rise in mean sea level, or treble to 118 million people if mean sea level rises by 1 meter. These estimates take into account neither potential adaptational measures nor the anticipated increase in population in the endangered areas; they should therefore be seen as “first approximations” only (IPCC, 1996b). If it is stipulated that the number of people threatened by storm floods must not be allowed to rise by more than 50%, this would correspond to a maximum per-

missible rise in sea level of about 15–25 cm. If a maximum sea-level rise of 25 cm is defined as another crash barrier, then the global scope for response is severely restricted, as shown in the global corridor in Fig. 3b. In the long term, therefore, much greater emission reductions will be necessary.

Thus, the corridors used for calculating the WBGU path provide no guarantee for acceptable climate development. As already emphasized, they should be understood as minimum requirements only. It is crucially important to examine the inner area of the window defined in Section 4.2 (see Fig. 2) with regard to different regional and sectoral impacts. This will necessitate major efforts in the field of climate impact research.

Economic impacts of the climate protection strategy

The Council has attempted the difficult task of calculating the impacts on the energy sector implied by the extended WBGU scenario and the reference scenario for "optimal welfare". This was done using the integrated "Model for Evaluating Regional and Global Effects of Greenhouse Gas Reduction Policies" (MERGE) (Manne and Richels, 1992). It is assumed that the more society consumes, the higher social welfare will become, whereby the incremental growth in welfare will decline as consumption levels increase. Moreover, currently available benefits are valued higher than future benefits as a basic prin-

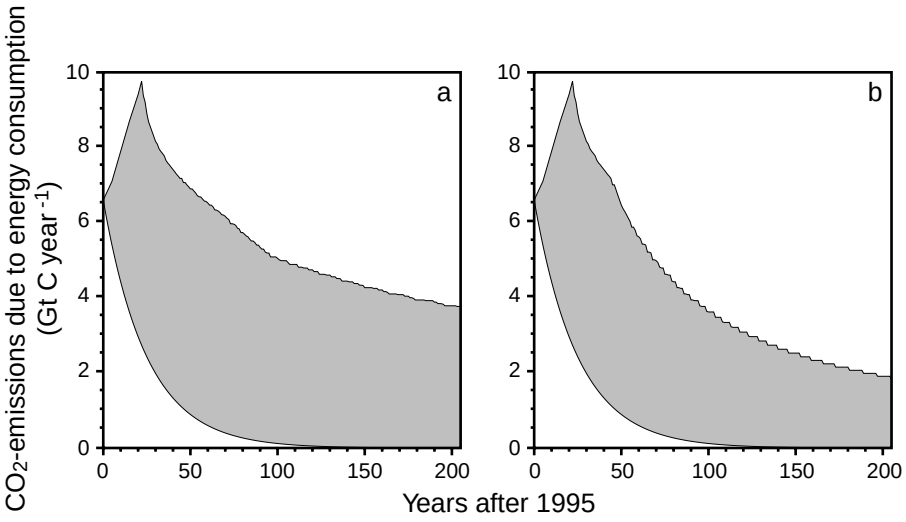

Figure 3

a: Necessary corridor of emissions – global: conforming to the WBGU climate window and socially and economically acceptable abatement paths (reduction rate less than 4% per annum). The corridor is identical to the one shown in Fig. 1a.

b: Necessary corridor of emissions (global) with complementary crash barriers for sea level: in addition to the WBGU climate window, with crash barriers for warming and rate of warming, a maximum rise in mean global sea level of 25 cm is stipulated as an additional maximum.

ciple (discounting). The model can take account of energy efficiency improvements or the introduction of new technologies, but not future changes in lifestyles and consumption habits (which are highly energy- and resource-intensive in the industrialized countries) towards a "sufficiency revolution". The latter would alter the relationship between consumption and welfare.

Despite the clear differences between the WBGU and the reference scenario with regard to impacts on climate, the welfare index for the WBGU scenario as calculated in the model is only about 0.4% less than that of the reference scenario, due principally to a decline in consumption in the 2000–2020 period. Whereas the scenarios differ only slightly with respect to average growth rate of per capita consumption over the 2000–2100 period, and the world GNP in the WBGU scenario is at most 3.6% lower than in the reference scenario, there are marked differences in the energy sector. Energy demand as calculated in the WBGU scenario is 20% lower in 2050 than the comparable figure in the reference scenario. However, this is not related to limitations on power consumption (related to the development of GNP), but to a reduction in the specific consumption of non-electrical energy (related to GNP) in the developing countries. This is due, on the one hand, to the comparatively low economic development and the lower energy efficiency in the developing countries. Secondly, reduction of emissions is partly achieved through the future deployment of technologies that do not involve greenhouse gas emissions; these are planned into the WBGU scenario at the earliest possible date (from 2020 onwards), whereas this does not happen in the reference scenario until 2120. This demonstrates the necessity for timely introduction of new climate-friendly technologies, such as various forms of solar energy use.

5 National reduction commitments

The allocation formula proposed by the Council on the occasion of the first Conference of the Parties (WBGU, 1995) was based on the assumption that the developing countries (i.e. not the states listed in Annex I to the Framework Convention on Climate Change) will place restrictions on the growth in their emissions. However, this contradicts the message of the "Berlin Mandate", so the national reduction commitments need to be recalculated.

As a logical consequence of the discussion in Sections 3 and 4, the Council recommends the following allocation formula. The developing countries are allowed to increase their greenhouse gas emissions in accordance with the business as usual scenario until about 2010, after which they freeze emissions for a limited period at the level then reached. Around 2050, this leads to convergence of the per capita emissions of Annex I Parties and non-Annex-I Parties (relative to the size of population in 1992). After 2050, therefore, there is justification for parallel emission reductions by both groups of states.

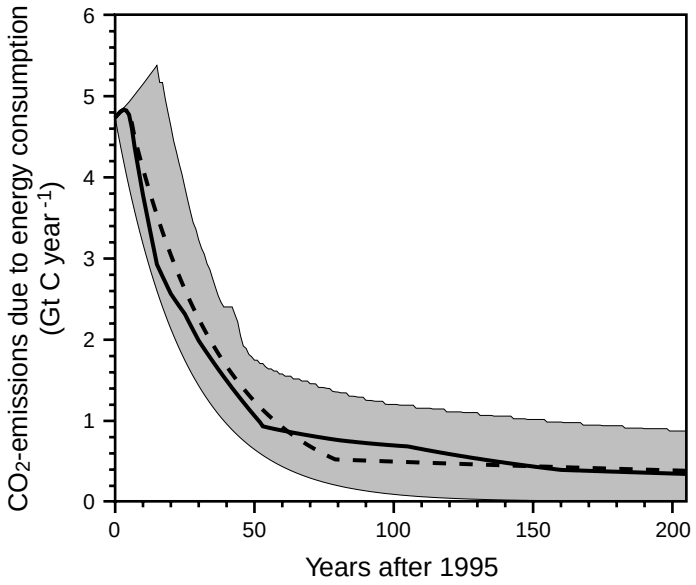

Figure 4

Necessary corridor of emissions for the Annex I states (shaded area) and admissible abatement paths conforming to the "Berlin Mandate".

Solid line: Abatement path for Annex I Parties with reduction rates according to the WBGU scenario, assuming further increases in the emissions of developing countries until 2010 and subsequent freezing of their emissions. From 2050 onwards, per capita emission in the industrialized and developing countries are of the same order and are reduced in parallel. The reduction rate is greater than 4% for a short period.

Broken line: Smoothed abatement path for the Annex I Parties, without change in cumulated emissions. Following a 5-year transitional period, emissions by Annex I states must be reduced by 3% per annum until 2075, followed by annual reductions of approx. 0.25%. The abatement path violates none of the pre-defined crash barriers. The climate remains within the climate window, and the abatement rate is less than 4% a year throughout.

Combining this allocation formula with the extended WBGU scenario results in the emissions profile for Annex I Parties shown in Fig. 4 (solid line). In this projection of emissions, the reduction rate exceeds the non-tolerable value of 4% per annum for a short period around 2010. Because of the many changes in reduction rate, this path is only partly suitable as a basis for negotiations and long-term planning. It therefore makes sense to smooth out the path without changing the cumulative emissions of the Annex I Parties. Fig. 4 shows such a smoothed path. Following a 5-year transitional period, emissions by Annex I states must be reduced by 3% per annum until 2075, followed by annual reductions of approx. 0.25%. This path ensures that the global climate remains within the climate window bounded by the crash barriers, and that the rate of emission reduction is less than 4% per annum.

This results in the following reduction obligations relative to the 1990 base year: the Annex I Parties must reduce their emissions by 11% by 2005, 23% by 2010,

43% by 2020 and by 77% by the year 2050. These reduction obligations are in line with the reduction targets recommended by the Enquete Commission in 1990. They relate not only to carbon dioxide but also to methane and nitrous oxide, and apply to the Annex I Parties as a whole. Disregarding any differentiation within this (economically very heterogeneous) group, the reduction targets to be specified in a protocol to the Climate Convention should in no case lie below the above values, since these are to be interpreted as minimum requirements for sustainability. Achieving these reductions is critically dependent on how world energy prices develop. If current global energy consumption continues along the current trajectory, than one can assume that prices will rise in real terms from about 2000–2005 onwards, which would make it easier to achieve the reduction targets. It can be expected that not all the reduction targets just mentioned will be achieved by the respective industrialized countries, so joint implementation is a crucial prerequisite for pursuing the path towards sustainability. This will require a procedure for crediting reductions in a way that conforms to the global reduction target.

The reduction target proposed for the Annex I Parties by the EU Council of Environment Ministers on March 3, 1997, namely a mere 15% by 2010 (relative to 1990 as the base year), is therefore inadequate. However, this reduction target is a realistic rendering of the reduction potential that can be exploited within the EU in an economically acceptable way. If a significant rise in world energy prices is not generated, the unavoidable increase in the reduction targets will require greater focus on "joint implementation".

Like the Enquete Commission, the Council considers it imperative that the particularly strong industrialized countries reduce their emissions by significantly more than 11% by 2005, in order to compensate for the limited response options on the part of less economically resourceful Annex I Parties.

The Council therefore recommends that the Federal Government maintain its climate policy objective of reducing carbon dioxide emissions by 25% relative to 1990 by the year 2005. There is considerable dispute as to whether and how the Federal Government's reduction target can be achieved in Germany within the agreed period, while also complying with the economic and social crash barriers (Hillebrand et al., 1996; Hillebrand und Wackerbauer, 1996; Bach et al., 1995; Meyer, 1997; Klemmer, 1997). The portion of national reduction obligations that exceed the boundaries of economic and social acceptability can be achieved through jointly implemented measures in other countries. Another critical aspect is that short-, medium- and long-term objectives be set, in order that efforts are not delayed, in the short term, and, in the long term, that the right signals are emanated and security of planning is ensured.

The allocation formula recommended by the Council is compliant with the greater responsibility on the part of industrialized countries referred to in the "Berlin Mandate", in that it assumes the developing countries are given leeway for an initial period (until 2010) to increase their greenhouse gas emissions in line with the business as usual scenario. It is assumed for the 2010–2050 period that the developing countries will stabilize their emissions, even though the per-capita emissions in this period are still lower than those of the industrialized

countries. This does not stand in the way of the developing countries contributing to climate protection even before 2010, for example by defining in specific terms the Convention obligations of all Parties to formulate and implement measures to mitigate climate change (Art. 4.1b FCCC). Pursuant to Article 4.3, however, the industrialized countries must meet the agreed full incremental costs of these measures, provided that agreement is reached between the developing countries and the Convention's financial mechanism (see Section 6.4 below). But a major improvement in energy efficiency compared to the business as usual path can be achieved in the next 2–3 decades without costs, even with profits in some cases (IPCC, 1996c).

The Council also recommends examining whether inclusion of the newly-industrializing countries in Annex I would be reasonable within the framework of international negotiations. In the view of the Council, it is important precisely in the newly-industrializing countries that key investment decisions (e.g. in the energy sector) are taken now. The Climate Convention also stipulates that states protect the climate system in accordance not only with their differentiated *responsibilities* but also with their respective *capabilities* (Art. 3.1 FCCC). This is also a clear statement that climate protection is a global challenge that every country and every human individual must face.

6 Implementing the reduction obligations specified in the protocol

6.1 Lifestyles and production systems

Consumption and production patterns which involve the consumption of energy resources are among the most important aspects of lifestyles as they relate to climate. The call for a shift in consumption and production patterns towards sustainability was also a central issue at the Special Session of the United Nations in June 1997 to assess the progress achieved in implementing AGENDA 21. This issue will form the central focus of work by the UN Commission for Sustainable Development (CSD) over the next five years. It is essential, if consumption and production patterns are to change in accordance with the sustainability principle, to improve energy efficiency and ultimately to bring about a fuel switch to renewable energy resources. A number of studies have been conducted in this area (see Enquete Commission, 1994; Jäger and Loske, 1994; IER and DIW, 1995; ISI and DIW, 1995; BUND and Misereor, 1996). Various instruments can be deployed to encourage fuel switching and changes in consumption and production patterns, in order to achieve the reduction targets efficiently and effectively. As the integrated analysis of climate protection strategies has shown, direction-setting activities of this kind should be carried out as early as possible,

otherwise non-sustainable lifestyles and economic systems will be taken over by the developing countries when they "catch up" in their development, which in turn will greatly reduce or indeed completely eliminate the response options available to future generations. As a leading industrial nation, Germany should take the lead in this respect.

The substantial savings potential that can be tapped through advances in technology are offset, however, by rising demand if lifestyles remain as they are and customary standards increase. This trend can be observed in Germany in the field of motorized transport, for example, where the reduction of specific fuel consumption is almost entirely offset by the general increase in traffic (Prognos, 1997). Clearly, the only way to achieve a departure from non-sustainable patterns of consumption and production is through sweeping worldwide changes in society. It will take more than technological innovations, economic instruments and regulations to initiate and drive this process of social transformation. Any strategy for long-term and stable modification of behavioral patterns that have adverse effects on the environment must therefore include environmental education as an indispensable component of climate protection policy.

6.2 Environmental education

The principle of sustainability signifies a challenge for all areas of society. Human behavior contributes to climate change in myriad ways, both directly and indirectly. It is manifested at various levels of individual and collective action (individual, group, family, enterprise, local community, national, international organizations) and in different fields of life (housing, consumption, production, trade, mobility, electoral behavior, political decisions) in which people participate in different roles and functions. The Agenda for the 21st century adopted at the Earth Summit in Rio mentions the wide range of actors and stakeholders who can and must contribute to changing those human activities which impact on the climate.

As exemplified in Chapter 36 of Agenda 21, it is increasingly acknowledged that education, training and the fostering of public awareness are absolutely essential if environmental policies are to prove at all effective. Consequently, environmental education must become an indispensable component of environmental policymaking and environmental care. Environmental education embraces all forms of formal and non-formal education, so it is provided not only in schools, universities and training institutes, but must also integrate all contexts, media and types of learning for environmentally and climate-relevant behavior, from the pre-school age through to late adult life. Further, environmental education must be extended to become "education for sustainable development", going beyond the preservation of the natural basis for life and shifting the central focus to the ethical principles of intra- and intergenerational equity. This means that the temporal and geographical horizon for social action is widened, a horizon that represents a challenge not only for political and economic decisions, but also for education, and is equally relevant for both developed and develop-

ing countries. Accordingly, the Parties to the Climate Convention are committed under Article 4.1 (i) and Article 6 to promote and cooperate in this area.

Unfortunately, however, there are no signs as yet of any concrete programs either in the signatory states or from the Secretariat. More intensive efforts are needed here to ensure that national and international climate policy has a solid basis of support within society. This is particularly the case in those developing countries where global climate protection is seen as an environmental problem of the industrialized countries, contrasting with severe local problems such as poverty and desertification. In such countries, measures to combat climate change are mainly perceived as obstacles placed in the way of their own economic development. The critical factor is that education must take the various actors, stakeholders and target groups seriously with regard to their respective ecological, social and cultural lifeworlds. When knowledge, attitudes and goals are conveyed exclusively from above, they rarely meet with acceptance. New forms of communication and participation are called for and must be promoted (Art. 4.1 (i) FCCC). In many local communities around the world, the new Local Agenda 21 initiatives are giving rise to new places and processes for learning environmental responsibility; these initiatives represent a sizable and innovative potential for broad-based social education towards sustainability. These initiatives must be promoted more intensively in future.

The Framework Convention on Climate Change states that industrialized countries shall provide developing countries with the financial resources they need to meet the new and additional costs incurred by the latter, for example for environmental education; however, this regulation applies only to those incremental costs previously agreed upon through the financial mechanisms of the Convention (currently the GEF) (Art. 4.3, sentence 2 FCCC, in association with Art. 4.1 (a)).

6.3 Flexible instruments for implementation

In addition to policies and measures at national and local level, the ambitious reduction targets that must be met in order to protect the climate system also require the deployment of global instruments such as “activities implemented jointly” (AIJ) and an international system of tradable emission permits. These measures, which the Council has discussed at length on repeated occasions (WBGU, 1994, 1995 and 1996), are aimed above all at generating the large-scale efforts, so essential in the short term, in ways that are efficient and flexible, thus minimizing the mitigation costs to society.

Joint Implementation

Whether and how the Federal Government’s short-term reduction target can be achieved with neutral impacts on growth, employment and prices, is a subject of controversial debate in the economic sciences (Hillebrand et al., 1996; Hillebrand and Wackerbauer, 1996; Bach et al., 1995; Meyer, 1997; Klemmer, 1997). Much depends on the extent to which the cost effects can be neutralized and the

unavoidable structural effects can be compensated. According to Hillebrand et al. (1996), the reduction commitment entered into by Germany cannot be achieved with the set of measures adopted so far by the Federal Government.

In many developing and newly-industrializing countries, or in economically weak industrialized countries, the efficiency of power stations is very low. The age structure of real capital also encourages early investments for replacement. Where appropriate funding is provided, there are many opportunities for reducing carbon dioxide emissions quickly and in a cost-beneficial way. It should therefore be possible to meet part of the developing countries' reduction obligations through joint implementation of mitigation measures in other countries. As recent studies show, international compensation of greenhouse gas emissions would significantly improve the efficiency of national climate policy instruments (Michaelowa, 1997).

That said, the concept of joint implementation is viewed by some with a degree of scepticism. During the pilot phase it became clear that, in practice, activities implemented jointly face many barriers that are related only slightly to economic factors. There are major practical difficulties in defining the reference state in the external Party (i.e. the level of emissions prior to the joint implementation activity being planned) and in verifying the actual reductions to be credited. Another problem concerns the substantial search and transaction costs incurred in the identification of suitable projects. As a result, preference is sometimes given to large centralized projects rather than decentralized measures.

The governments of many developing countries are anxious that the industrialized nations might "buy" their way out of their commitments, that they will desist from implementing mitigation measures within their own borders, and in this way shift the burden to the developing countries. Were the industrialized countries to adopt such an approach, they would be failing to perform the leading role in combating climate change to which they committed themselves under the principle of common but differentiated responsibilities pursuant to Article 3.1 of the FCCC. These objections become all the weightier if the developing countries are supposed to commit themselves to emission reductions in the medium term, as proposed in Section 5 above. This would generate a risk that the potential existing in the developing countries at that particular time might already be largely exhausted through jointly implemented activities on the part of the industrialized nations. Climate protection activities by developing countries themselves would then demand much greater and more cost-intensive efforts. However, this objection must not be misused to justify the continued operation of grossly inefficient power stations so that reductions can be achieved at less costs later, for example. It is important, particularly in newly-industrializing countries, that key investment decisions be made now with specific reference to environmental aspects.

The Council therefore recommends, as in the 1995 Annual Report (WBGU, 1995), that the Annex-I Parties commit themselves to realizing the major proportion of their reduction obligations – say 70–80% – within that same group of states. The aim here is to ensure that the industrialized countries establish the

right conditional framework in order to exploit their own mitigation potential in the medium and long term especially, and in this way reduce their very high level of per capita carbon dioxide emissions. Safeguards are also needed to ensure that the transfer of financial resources and technology pursuant to Article 4.3 retains its separate importance, independently of any activities implemented jointly. Finally, participation by the local population is critical for the success of joint implementation projects.

The pilot phase currently in operation shows that industrialized countries lack key incentives to jointly implement climate policy measures if they are unable to credit such emission reductions against their own targets. However, crediting should only be possible in cases where the activities implemented jointly are negotiated between states for which the maximum emission bands have been agreed. The Council has come to the conclusion that the industrialized countries have already overexploited any leeway they may have possessed.

International system of tradable permits

Introducing an international system of tradable emission permits is another way to introduce an element of flexibility into the national reduction obligations. Trade in such negotiable emission permits enables Parties to lease their surplus emission rights to other states for specific periods and in this way generate income. The global reduction targets can then be achieved in a much more efficient manner, while use of alternative energy sources (solar, hydro and wind power) would be rewarded. The Council's recommendation to the Parties is to examine the conditions for introducing an international system of tradable emission permits. To implement such a system, a number of definitions would need to be made. An appropriate basis for the initial allocation of national emission quotas would be to define national reduction obligations according to the per capita approach. Regardless of the further development of a global permits system, the Member States of the European Union should commence immediately with the preparatory work for establishing such a system as soon as possible within this regional association, on account of the favorable prospects in this constellation.

The priority issue, however, concerns the setting of specific reduction quotas, the very foundation of the flexible implementation instruments discussed in this section.

6.4 Support for developing countries

Despite the fact that the Framework Convention on Climate Change does not commit the developing countries to reduce their greenhouse gas emissions, and that no such commitment is under negotiation in Kyoto either according to the "Berlin Mandate", Article 4 (1) of the Convention calls on all Parties, including the developing countries, to lend their active support to protecting the global climate. Two main obligations are derived from Article 4 (1) for the developing countries:

Firstly, Art. 4.1 (a) requires all Parties to "develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol", and to report on their climate protection activities. These costs can be calculated relatively well. Pursuant to sentence 1 of Article 4.3, they must be reimbursed as "agreed full costs" by the industrialized countries. Pursuant to Article 4.1 (b), developing countries have to formulate and implement programmes containing measures to mitigate climate change. The costs for these real climate protection measures are virtually incalculable. The developed country Parties only bear the "agreed full incremental costs", whereby the costs must be agreed between the financial mechanism and the developing country, and the funds be necessary (Art. 4.3, sentence 2).

Determining the level of "incremental costs" can prove very difficult in specific cases. The Council therefore recommends, with special reference to the future, medium-term involvement of developing countries, that the Parties examine ways and means for arriving at binding definitions of these incremental costs, which would then have to be borne by the industrialized countries.

According to Article 11 and Article 21.3, the Global Environment Facility (GEF) shall operate the financial mechanism of the Climate Convention on an interim basis. Despite the restructuring of the GEF in 1994, three years after it was first set up, and the provisional adoption of a "Memorandum of Understanding" between the Conference of the Parties to the Convention and the GEF Council, the developing countries continue to level heavy criticism at the GEF (Ehrmann, 1997). Before the GEF can be assigned extensive new responsibilities, the Council recommends that the structure and operation of the GEF be subjected to review within the medium term. To encourage the developing countries to contribute immediately towards climate system protection without being bound by quantified reduction obligations within specific time scales, the Council recommends for the short term that the current round of negotiations be used to replenish GEF funds according to the framework laid out in the Framework Convention on Climate Change. Efforts must also be focused here on maximizing efficiency and minimizing administrative expenses.

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Annexes

A 1 The members of the Council (as at 19.9.97)

Prof. Dr. Friedrich Beese
Agronomist: Director of the Institute for Soil Science and Forest Nutrition in Göttingen

Prof. Dr. Klaus Fraedrich
Meteorologist: Meteorological Institute at the University of Hamburg

Prof. Dr. Paul Klemmer
Economist: President of the Rhine-Westphalian Institute for Economic Research in Essen

Prof. Dr. Dr. Juliane Kokott (Vice-Chairperson)
Lawyer: Professor for German and International Comparative Public Law, European law and the International Law at the University of Düsseldorf

Prof. Dr. Lenelis Kruse-Graumann
Psychologist: Professor for Psychology (specialist in environmental psychology) at the University of Hagen

Prof. Dr. Ortwin Renn
Sociologist: Academy for Technology Impact Assessment in Baden-Württemberg

Prof. Dr. Hans-Joachim Schellnhuber (Chairperson)
Physicist: Director of the Potsdam Institute for Climate Impact Research

Prof. Dr. Ernst-Detlef Schulze
Botanist: Lehrstuhl für Pflanzenökologie der Universität Bayreuth

Prof. Dr. Max Tilzer
Limnologist: Director of the Alfred Wegener Institute for Polar and Marine Research

Prof. Dr. Paul Velsinger
Economist: Head of the Department of Regional Economic Planning at the University of Dortmund

Prof. Dr. Horst Zimmermann
Economist: Head of the Department of Financial Studies at the University of Marburg

A 2 The Council's mandate

Joint Decree on the Establishment of the German Advisory Council on Global Change (April 8, 1992)

Article 1

In order to periodically assess global environmental change and its consequences and to help all institutions responsible for environmental policy as well as the public to form an opinion on these issues, an Advisory Council on "Global Environmental Change" reporting to the Federal Government shall be established.

Article 2

(1) The Council shall submit a report to the Federal Government by the first of June of each year, giving an updated description of the state of global environmental change and its consequences, specifying quality, size and range of possible changes and giving an analysis of the latest research findings. In addition, the report should contain indications on how to avoid or correct maldevelopments. The report shall be published by the Council.

(2) While preparing the reports, the Council shall provide the Federal Government with the opportunity to state its position on central issues.

(3) The Federal Government may ask the Council to prepare special reports and opinions on specified topics.

Article 3

(1) The Council shall consist of up to twelve members with special knowledge and experience regarding the tasks assigned to the Council.

(2) The members of the Council shall be jointly appointed for a period of four years by the two ministries in charge, the Federal Ministry for Research and Technology and the Federal Ministry for the Environment, Nature Conservation and Reactor Safety, in agreement with the departments concerned. Reappointment is possible.

(3) Members may declare their resignation from the Council in writing at any time.

(4) If a member resigns before the end of his or her term of office, a new member shall be appointed for the retired member's term of office.

Article 4

(1) The Council is bound only to the brief defined by this Decree and is otherwise independent to determine its own activities.

(2) Members of the Council may not be members either of the Government or a legislative body of the Federal Republic or of a Land or of the public service of the Federal Republic, of a Land or of any other juristic person under public law unless he or she is a university professor or a staff member of a scientific institute. Furthermore, they may not be representatives of an economic association or an employer's or employee's organization, or be permanently attached to these through the performance of services and business acquisition. They

must not have held any such position during the last year prior to their appointment as member of the Council.

Article 5

(1) The Council shall elect a Chairperson and a Vice-Chairperson from its midst for a term of four years by secret ballot. Reelection is possible.

(2) The Council shall set up its own rules of procedure. These must be approved by the two ministries in charge.

(3) If there is a differing minority with regard to individual topics of the report then this minority opinion can be expressed in the report.

Article 6

In the execution of its work the Council shall be supported by a Secretariat which shall initially be located at the Alfred Wegener Institut (AWI) in Bremerhaven.

Article 7

Members of the Council as well as the staff of the Secretariat are bound to secrecy with regard to meeting and conference papers considered confidential by the Council. This obligation to secrecy is also valid with regard to information given to the Council and considered confidential.

Article 8

(1) Members of the Council shall receive all-inclusive compensation as well as reimbursement of their travel expenses. The amount of compensation shall be fixed by the two ministries in charge in agreement with the Federal Ministry of Finance.

(2) The costs of the Council and its Secretariat shall be shared equally by the two ministries in charge.

Dr. Heinz Riesenhuber
Federal Minister for Research and Technology

Prof. Dr. Klaus Töpfer
Federal Minister for Environment, Nature Conservation and Reactor Safety

Appendix to the Council's mandate

Tasks to be performed by the Council pursuant to Article 2, para. 1. The tasks of the Council include:

(1) Summarizing and continuous reporting on current and acute problems in the field of global environmental change and its consequences, e.g. with regard to climate change, ozone depletion, tropical forests and fragile terrestrial ecosystems, aquatic ecosystems and the cryosphere, biological diversity and the socioeconomic consequences of global environmental change.

Natural and anthropogenic causes (industrialization, agriculture, overpopulation, urbanization, etc.) should be considered, and special attention should be given to possible feedback effects (in order to avoid undesired reactions to measures taken).

(2) Observation and evaluation of national and international research activities in the field of global environmental change (with special reference to monitoring programmes, the use and management of data, etc.).

(3) Identification of deficiencies in research and coordination.

(4) Recommendations regarding the avoidance and correction of maldevelopments.

In its reporting the Council should also consider ethical aspects of global environmental change.

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