PROPOSED ELEMENTS OF A PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, PRESENTED BY BRAZIL IN RESPONSE TO THE BERLIN MANDATE

The First Conference of the Parties to the United Nations Framework Convention on Climate Change (Berlin, March-April 1995) decided that a Protocol to the Convention should be negotiated and be ready for approval by the Third Conference of the Parties (Kyoto, December 1997). The guidelines for the negotiation of such a protocol are contained in the resolution known as the Berlin Mandate, and the negotiating body established for this purpose is the Ad-hoc Working Group on the Berlin Mandate (AGBM).

This document contains proposals for the substantive elements of the Protocol to the Convention, for consideration by the AGBM at its seventh session (July 1997). The proposal is divided into three parts.

Part I is an executive summary, containing some key elements relevant to the negotiation of the Protocol.

Part II is the proposal itself, in the form of text for the Protocol.

Part III, with technical appendices, contains an extended explanation of the basic concepts and proposals, together with some illustrative elements.

PART I - EXECUTIVE SUMMARY

1. Objective

The Berlin Mandate and subsequent decisions by the AGBM provide for the establishment of quantitative emission reduction and limitation targets for Annex I Parties to the Convention, and the advancement of existing commitments by non-Annex I Parties.

It follows that the two central questions to be discussed by the AGBM in preparing a Protocol to the Convention are:

a) the decision on the future level of Annex I Parties emissions, in the time horizon of the Berlin Mandate (2000 to 2020); and

b) the criterion for the sharing of the burden of mitigation among those Annex I Parties.

In order to introduce objectivity in the treatment of both questions, it is necessary to establish the relationship between the anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol (the cause of climate change), and the quantitative resulting change of climate (the effect of human action).

Whereas it is recognized that the change of climate is predicted to have a complex geographical distribution, it is important to have a single variable to measure climate change. It is proposed here that the change in global mean surface temperature be used as a measure of climate change.

This proposal addresses the central question of the relationship between the emissions of greenhouse gases by Parties over a period of time and the effect of such emissions in terms of climate change, as measured by the increase in global mean surface temperature.

The introduction of a measure of emissions over a given period of time in terms of their effect upon the temperature increase allows the choice of a reduction target for the ensemble of Annex I Parties to be made with a clear view of the impact of the choice upon climate change.

This target based upon the induced temperature increase allows maximum flexibility in the choice of policies and measures by Annex I Parties and therefore reduces the economic burden of mitigation measures. At the same time, it is comprehensive in terms of inclusion of different greenhouse gases, and it establishes the concept of a "budget" in terms of the effect of emissions over a period of time.

The criterion for the sharing of the burden among those Parties becomes a natural consequence of the fact that, given the emissions over a period for every and each Annex I Parties, it is possible to assign relative responsibilities to individual Parties according to their respective contributions to climate change, as measured by the induced change in temperature.

It also establishes an objective differentiation criterion among Annex I Parties, as most of the burden is to be borne by those Parties that are most responsible for contributing to climate change.

2. Common but differentiated responsibilities

The principle of the common but differentiated responsibilities between Annex I and non-Annex I Parties arises from the acknowledgment by the Convention that the largest share of historical and current global emissions of greenhouse gas has originated in the developed countries.

It is also acknowledged by the Convention that the 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.

It is possible to assign relative responsibilities to the ensemble of Annex I countries and non-Annex I countries according to their respective contributions to climate change, as measured by the induced change in climate. It is shown that, whereas the annual emissions of non-Annex I countries, according to the IPCC IS92a scenario, are estimated to grow to be equal to those of Annex I countries by 2037, the resulting induced change in temperature from non-Annex I countries are estimated to equal that of Annex I countries only in 2147.

3. Polluter pays principle

The effective implementation of the Protocol requires the specification of a framework under which the departure by a Party from its commitment results in an obligation to compensate such departure by other means.

It is proposed that the departure from the temperature increase ceiling allowed for an individual Party, measured in terms of the induced change in climate, be used as a quantitative basis for establishing a contribution to a non-Annex I clean development fund to be managed by the financial mechanism of the Convention for the promotion of precautionary measures in non-Annex I Parties.

It is also proposed that Annex I Parties be allowed to use the difference between the temperature increase ceiling allowed for the Party and actual induced temperature increase as a measure in trading among themselves. An Annex I Party that exceeds its temperature ceiling, over an evaluation period, can compensate it by “purchasing”, at a market value, an equivalent “temperature credit” from another Annex I Party that induced a temperature increase lower than its committed temperature ceiling.

The financial resources of the clean development fund are to be directed preferentially to the non-Annex I Parties that have a larger relative contribution to climate change.

Each non-Annex I Party may, on a voluntary basis, apply for funds to be used in climate change projects. Such applications are subject to the appropriate regulations approved by the Conference of the Parties for this purpose.

In the detailed specification of the criteria for the use of the financial resources from the non-Annex I clean development fund, it may be found appropriate to assign a small portion of such resources to climate change adaptation programs.

This clean development fund will contribute to a global objective, which is the ultimate objective of limiting the change in climate itself, while allowing constructively the advancement of the implementation of the Convention by non-Annex I Parties.

4. Objectivity of the discussion of a protocol

In order to clarify the proposal, Part III of this document contains numerical data intended exclusively for illustration purposes. Whereas an effort has been made to use the best available data for this purpose, their use does not in itself constitute an acknowledgment of the appropriateness of such data.

It may be noted that the proposal is neutral to Brazil, as a non-Annex I Party, and the assignment of Brazilian share in the clean development fund distribution proposed is in accordance with its relative contribution to climate change.

PART II - PROPOSED ELEMENTS FOR A PROTOCOL

Definitions

1. For the purposes of this Protocol, the following definitions shall apply:

"**net anthropogenic emissions**" of a given greenhouse gas not controlled by the Montreal Protocol, in a given year, means the difference between the **anthropogenic emissions by sources** and the **anthropogenic removals by sinks** of that greenhouse gas, in that year.

"**effective emissions**", in a given time period, means the increase in global mean surface temperature at the end of the period, as determined by an agreed climate change model, resulting from both the **net anthropogenic emissions** of an agreed set of greenhouse gases, in each year of that time period, and from the initial concentrations of those greenhouse gases in the beginning of the period.

Quantitative emission limitation and reduction objectives

2. For the purposes of this Protocol, the following greenhouse gases not controlled by the Montreal Protocol shall be considered: carbon dioxide, methane and nitrous oxide.

3. **Effective emissions references** are established for the totality of Annex I Parties and for each Annex I Party, equal to the respective **effective emissions** corresponding to a constant level of **net anthropogenic emissions** of each greenhouse gas in the period 1990 to 2020, equal to the level of **net anthropogenic emissions** in 1990, and taking the initial concentrations in 1990 to be equal to zero.

4. An **effective emissions ceiling** is established for the totality of Annex I Parties equal to the **effective emissions** corresponding to a constant level of **net anthropogenic emissions** in the period 1990 to 2000, equal to the level of **net anthropogenic emissions** in 1990, and decreasing regularly from 2000 to 2020 to a value, in 2020, that is 30% lower than the 1990 value, and taking the initial concentrations in 1990 to be equal to zero.

5. **Effective emissions reduction targets** are established for each of the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020, for the totality of Annex I Parties, equal to the difference between the **effective emissions reference** and the **effective emissions ceiling**, both computed as provided for in items 3 and 4 above, for each of the above periods, and taking the initial concentrations in each period to be equal to zero.

6. A **relative responsibility** of each Annex I Party with respect to the totality of Annex I Parties is established, for each of the periods 1990-2000, 2001-2005, 2006-

2010, and 2011-2015, equal to the relative fraction of the **effective emissions** which is attributable to that Party, with respect to the ensemble of Annex I Parties, by considering, for each of the above periods, constant **net anthropogenic emissions** equal to its value in the initial year of the period, and the respective concentrations in the initial year of the period. The Parties may wish to adjust the individual relative responsibilities to take into account special considerations provided for in the UNFCCC.

7. An individual **effective emissions reduction target** is established for each of the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020, for each Annex I Party, equal to the share of the **effective emissions reduction target** for the totality of Annex I Parties, that represents a fraction of the total equal to their **relative responsibility** for the periods 1990-2000, 2001-2005, 2006-2010, and 2011-2015, respectively**.** Such targets may be achieved individually or jointly among Annex I Parties.

8. An individual **effective emissions ceiling** is established for each of the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020, for each Annex I Party, equal to the difference between the corresponding **effective emissions reference** and individual **effective emissions reduction target**.

9. Each Annex I Party agrees to adopt the necessary policies and measures to ensure that their **net anthropogenic emissions** in the period 2000-2020 are such that the corresponding **effective emissions** remain below its individual **effective emissions ceiling** for each period in item 8 above.

Contributions

10. There shall be a **periodic evaluation**, for the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020, of the compliance by each Annex I Party with the commitments to maintain its **effective emissions** below the respective **effective emissions ceiling**, including the calculation of the difference between the **effective emissions** based on reported **net anthropogenic emissions**, and the corresponding **effective emissions ceiling.**

11. A contribution shall be made to the financial mechanism of the Convention by each Annex I Party found to be in non-compliance in accordance with item 10 above, on the basis of 3.33 US$ (three US dollars and thirty-three cents) for each **effective emissions** unit above the **effective emissions ceiling** calculated as per item 10 above, expressed in tCy equivalent.

12. The financial mechanism of the UNFCCC shall establish a **non-Annex I clean development fund** to receive the contributions made in accordance with item 11 above.

13. The financial resources of the **non-Annex I clean development fund** shall be made available to non-Annex I Parties for use in climate change mitigation and

adaptation projects according to guidelines to be established by the Fourth Conference of the Parties to the UNFCCC.

14. The financial resources of the **non-Annex I clean development fund** allotted to climate change adaptation projects shall not exceed 10% (ten percent) of the total amount of this fund in any year.

15. The financial resources of the **non-Annex I clean development fund** allotted to climate change projects in each of the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020 shall be made available to non-Annex I Parties that wish to implement such projects, in the same proportion as their fraction of the overall non-Annex I Parties **effective emissions**, determined for the periods 1990-2000, 2001-2005, 2006-2010, and 2011-2015, respectively, by considering , in each period, a constant level of **net anthropogenic emissions**, equal to the arithmetic mean of the reported **net anthropogenic emissions**, and initial concentrations, for the period 1990-2000 equal to zero, and for the periods 2001-2005, 2006-2010, and 2011-2015, equal to that resulting from the **net anthropogenic emissions** considered in the previous periods.

PART III - EXPLANATION OF THE PROPOSAL

1. Introduction

The UNFCCC process, from the point of view of the mitigation of climate change, consists of a periodic reporting of emissions of greenhouse gases by the Parties, a periodic review of the global situation in terms of the likely change of climate in the future, a decision on the future level of emissions to be tolerated, and a decision on the sharing of the burden to be incurred by individual Parties with a view to maintaining the emissions below the levels to be tolerated. At the current stage of the process, the Berlin Mandate established guidelines for the negotiation of a Protocol that, in particular, calls for the inclusion of quantitative emission limitation and reduction objectives for the Annex I Parties.

It follows that the two central questions to be discussed by the AGBM in preparing a Protocol to the Convention are:

a) the decision on the future level of emissions to be tolerated from the Annex I Parties, taken together; and

b) the criterion for the sharing of the burden among those Annex I Parties.

This proposal addresses the central question of the relationship between the emissions of greenhouse gases by Parties over a period of time and the effect of such emissions in terms of climate change, as measured by the increase in global mean surface temperature. It is demonstrated that a very simple calculation scheme can be used *in lieu* of the complex climate models, while still maintaining the correct functional dependence of the increase in mean surface temperature upon the emissions over a period of time.

As a result, the discussion on the overall quantitative emissions to be tolerated can take place with immediate consideration of the effect of different quantitative emissions scenarios upon the temperature and mean sea level.

The discussion on the sharing of the burden of mitigation is made more objective by the ready availability of quantitative information on the effect upon climate change of the emissions of individual Parties and consequently on their relative responsibilities in inducing climate change.

In order to make the Protocol effective, it is not sufficient to establish quantitative emission limitation and reduction targets for individual Annex I Parties in the period leading to 2020. It is necessary, in addition, to establish mechanisms by which the compliance of individual Annex I Parties with their respective commitments are periodically verified, and departures from compliance at the end of the period imply the automatic assessment of the obligation to contribute to a global clean development fund as a compensatory measure. An objective criterion is further introduced for the distribution of such fund among non-Annex I Parties, in proportion to the effect of their emissions in producing climate change.

Section 2 (of this Part III) contains an introduction to differentiation of commitments.

Section 3 analyses the relationship between emissions and climate change, developing a simple measure of the magnitude of climate change in terms of **net anthropogenic emissions** of all greenhouse gases.

Section 4 establishes an objective measure of reduction targets for the ensemble of Annex I Parties in terms of climate change.

Section 5 analyses the relative responsibilities of Annex I Parties among themselves.

Section 6 contains a further elaboration of the relative responsibilities concept, highlighting the relative responsibility of Annex I group of countries compared to non-Annex I group.

Section 7 analyses the sharing of the burden of mitigation among Annex I Parties, and introduces the concept of reduction targets and ceilings.

Section 8 establishes a compensation mechanism in case of departure from achievement of ceiling objectives by Annex I Parties.

Section 9 proposes criteria for the distribution of the financial resources of the non-Annex I clean development fund.

2. Differentiation of commitments

There is a growing consensus within the AGBM that the Kyoto Protocol is to contain a requirement for the reduction of emissions from Annex I Parties by 2010 with respect to those in 1990 of the order of 20%. This percentage of reduction originated with the protocol proposed by the Alliance of Small Island States (AOSIS), and may be changed in the final stages of the negotiations.

One question being discussed in the AGBM is that of the criteria that should be used for the differentiation among Annex I Parties of their quantitative commitments for emission reductions.

Some countries have advanced the idea of a “flat rate”, meaning the application of the same percentage to each Annex I Party, with the argument that it would be very difficult to do otherwise. This “flat rate”, or more appropriately, this “flat percentage of reduction rate with respect to a fixed baseline of 1990” is one of the many possible criteria for the sharing of the burden of mitigation among Annex I Parties.

It would be equally simple to propose that the reduction should be the same in terms of the absolute emissions, or the same in terms of emissions per unit of population or gross national product.

In addition, the "flat rate" criterion for the sharing of the burden of mitigation penalizes Parties that, for one reason or another, have maintained relatively low emissions up to the baseline year. This penalty is compounded by the fact that the cost of avoiding emissions increases non-linearly as the energy matrix becomes less carbon-intensive.

On the other hand, the "flat rate" approach fails to take into account important factors that determine the baseline year starting point in terms of initial level of emissions and concentrations, such as:

a) the present and historical relative importance of fossil versus renewable energy sources;

b) the efficiency of the technology in the generation and use of energy;

c) the population and population growth;

d) the natural resources base;

e) the profile of socio-economic activities; and

f) the surface area of territory.

For the above reasons, the majority of the Annex I Parties insist on the introduction of some criterion for the differentiation of the commitments of these Parties. The present proposal takes this concern into consideration.

The principle of the common but differentiated responsibilities, between Annex I and non-Annex I Parties, arises from the acknowledgment by the Convention that the largest share of historical and current global emissions of greenhouse gas has originated in the developed countries.

It is also acknowledged by the Convention that the 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.

A simple reading of this statement leads implicitly to the interpretation of the relative share of current and projected future emissions of the two groups of Parties as being a measure of the relative responsibility between the groups of Parties.

It is often implied that, as the non-Annex I emissions in the future will tend to grow more rapidly than Annex I emissions, most of the responsibility for climate change in the future will tend to be attributed to non-Annex I Parties, the year when the non-Annex I emissions equals those of Annex I Parties being taken as the year when the respective responsibilities become equal.

This approach for implicit differentiation of responsibilities overestimates the non-Annex I Parties share of responsibility, as it does not take into consideration the different historical emission path resulting from very different industrialization process and consumption patterns in time of both groups.

The definition of relative responsibilities in terms of the relative resulting change in global mean temperature, taking into account the initial concentrations due to Annex I and non-Annex I Parties eliminates this difficulty.

In addition, non-Annex I Parties will likely be the most vulnerable to the adverse effects of climate change.

For the above reasons, it is important that the non-Annex I Parties recognize that they have a stake in the discussion of the issue of differentiation of quantitative commitments by Annex I Parties within the AGBM.

3. The relationship between emissions and climate change: a simple measure of the magnitude of climate change in terms of net anthropogenic emissions of all greenhouse gases

The UNFCCC recognizes, on one hand, that the mitigation of climate change is to be done by limiting or reducing the difference between the anthropogenic emissions and the removals by sinks of greenhouse gases not controlled by the Montreal Protocol, and on the other hand, that the ultimate objective is to limit the change in climate itself.

For the sake of brevity, such difference between anthropogenic emissions and anthropogenic removals by sinks of greenhouse gases not controlled by the Montreal Protocol is to be conveniently defined as **net anthropogenic emissions.** In this text only, and unless stated otherwise, the word **emissions** means the **net anthropogenic emissions** of greenhouse gases not controlled by the Montreal Protocol as defined here.

It becomes therefore of central importance to establish the relationship between the **net anthropogenic emissions** and the resulting change of climate. Whereas it is recognized that the change of climate is predicted to have a complex geographical distribution, it is important to have a unique measurement of the global climate change.

The obvious choice of a unique variable to measure climate change is the change in global mean surface temperature, because other global variables such as the time rate of change of the global mean surface temperature and the rise in mean sea level are derived from the change in global mean surface temperature. In this text only, and unless stated otherwise, the word **temperature** means such change in global mean surface temperature.

The dependence of the temperature upon the emissions is a complex one and is best treated with the help of coupled atmospheric-oceanic global circulation models. As reported in the IPCC Second Assessment Report, the simple climate models, which are box-diffusion models, are today able to model with sufficient accuracy the significant functional dependency between emissions and temperature.

As a matter of fact, the IPCC Working Group I has produced the IPCC Technical Paper II, at the request of the Convention bodies, entitled “An Introduction to Simple Climate Models Used in the IPCC Second Assessment Report” which summarizes the key aspects of such models and thus makes an important contribution to bringing the best scientific knowledge to the help of policy makers in the area of climate change.

For the immediate purposes of assisting in the negotiation of the Protocol mandated in Berlin, and given the relatively short time period involved (at most 1990 to 2020), it is shown that all relevant aspects of the functional dependence of the temperature upon the emissions can be represented with sufficient accuracy by an even simpler “policy maker” model as described in summary below and as detailed in Appendix I.

In a first approximation, the dependence of the atmospheric concentrations upon the emissions over a given period of time is proportional to the accumulation of the emissions up to the year in question, taking into account that the older the emission the smaller its effect on the concentration, due to the exponential natural decay of the greenhouse gases in the atmosphere with a different lifetime for each gas.

As an example, a carbon dioxide emission occurring in 1990 will produce a certain concentration in that year that will have decayed to 80% of the original value by 2020. While the same is approximately true for nitrous oxide (both with an atmospheric lifetime of about 140 years), a methane emission in 1990 will have decayed to 8% of the original value by 2020, given its lifetime of 12 years.

The physics of the radiative forcing indicates that the rate of deposition of energy on the surface, that is, the warming itself, is proportional to the concentration of the greenhouse gas, with a different constant of proportionality for each gas (1 for carbon dioxide, 58 for methane and 206 for nitrous oxide, for the present level of concentrations, with respect to carbon dioxide).

The increase in global mean surface temperature is roughly proportional to the accumulation over time of the radiative warming. The radiative warming is, in turn, proportional to the atmospheric concentration of the greenhouse gas. It follows that the temperature increase itself is proportional to the accumulation of the atmospheric concentration of the greenhouse gas.

In reality the above statement is only approximately true, in view of the non-linearities of the system and the existence of other mechanisms such as the delay introduced by the dissipation of heat into the oceans through advective and diffusion processes.

Such complete treatment of the climate system is included in the atmosphere-ocean coupled general circulation models requiring the highest available computing power. The simple box-diffusion models, as demonstrated in the IPCC Second Assessment Report include such processes to a sufficient accuracy and are therefore calibrated against the supercomputer models.

The present document, in reality, contains a proposal of a very simple policy maker model, calibrated against the simple box-diffusion models by empirically determining constants of proportionality by comparison with results from the IPCC MAGICC box-diffusion model, when both are fed with the same emission data.

The policy maker model contains, nevertheless, all of the essential functional dependence between, on one hand, the increase in global mean surface temperature and mean sea level rise and, on the other hand, the **net anthropogenic emissions** of greenhouse gases over a given period, that induce such change in climate (see Appendix I).

In practice, therefore, the emissions of a greenhouse gas over a given period of time, together with the consideration of the additional concentration of anthropogenic origin in the initial year of the period, can be directly expressed in terms of their quantitative effect upon the increase in temperature. Such a measure of the temperature is defined here as the **effective emissions** over a given period.

Different greenhouse gases can be included, with their respective constants of proportionality between temperature (or sea level rise) and the accumulation of concentrations, and their individual effects added in terms of the resulting change in temperature or sea level rise over the period considered.

It also follows that the temperature can be expressed, alternatively to degrees Celsius, in terms of accumulated concentrations of any greenhouse gas. For the sake of convenience, carbon dioxide is chosen, and the temperature is expressed in units of **GtCy equivalent**. For the period from 1990 to 2020, the correspondence is 1 GtCy equivalent equals 0.0000164 degree Celsius.

It is to be noted that the uncertainties remaining in the present knowledge of the absolute value of the predicted temperature change as reflected, for instance, in the margin of uncertainty in the climate sensitivity (the change of temperature resulting from a doubling of the carbon dioxide concentration is known to be within the range 1.5 to 4.5 degrees Celsius) does not affect the conclusions about the relative contribution of countries.

Future improvements of the complex models, as the uncertainties are progressively decreased, can be easily incorporated by updating the calibration constants of proportionality in order to improve the accuracy of the absolute results through the incorporation of the best available scientific knowledge.

4. An overall effective emissions reduction target for the ensemble of Annex I Parties - an objective measure of such targets in terms of climate change

Whereas there is a consensus that the mitigation measures should be decided in two steps: a decision on the overall target to be achieved by a group of countries and then the sharing of the burden among them, there has been a tendency to concentrate on the establishment of a reduction target in terms of annual emissions.

The introduction of the concept of **effective emissions** (a measure of emissions over a given period of time in terms of their effect upon the temperature increase) allows the choice of a reduction target to be made with a clear view of the impact of the choice upon climate change.

At the same time, it incorporates automatically two important aspects of the problem, the comprehensiveness in terms of inclusion of different greenhouse gases, and the concept of a “budget” of emissions over a period of time. Those aspects are important for they allow maximum flexibility in the choice of policies and measures by Parties and therefore reduces the economic burden of mitigation measures.

It is proposed that an upper limit be established for the emissions of carbon dioxide, methane and nitrous oxide from the ensemble of Annex I Parties for the period 1990-2020, such that the effect of such emissions in the period upon the temperature increase in 2020 is a value fixed in the Protocol as a goal, expressed in terms of **effective emissions** as defined above.

The definition of the goal is made by establishing an **effective emissions reference** and an **effective emissions ceiling**. The **effective emissions reference** minus the **effective emissions ceiling** is defined here as the **effective emissions reduction target**. All these are evaluated in terms of **effective emissions,** which can be expressed in units of degree Celsius or, alternatively, in units of GtCy equivalent.

It is important that a quantitative reduction objective be established with reference to a defined absolute reference, rather than with reference to an abstract hypothetical reference. The exact reference is irrelevant, provided that it is defined in absolute terms. It is thus proposed that a reference be taken as the effective emissions in the period 1990-2020 that correspond to a fixed level of annual emissions of the three greenhouse gases equal to their reported levels in 1990 for the ensemble of the Annex I Parties.

This reference is denominated the **effective emission reference** for the ensemble of Annex I Parties for the period 1990-2020. Its value, in degree Celsius and in GtCy equivalent, can be easily computed with the simple policy maker model and the 1990 values for annual emissions of the three greenhouse gases from Annex I Parties.

It is proposed that a ceiling be established for the collective emissions of the three greenhouse gases for the ensemble of Annex I Parties, expressed in terms of **effective emissions**.

The value proposed for the ceiling is that corresponding to a constant level of annual emissions in the period 1990-2000 and a regular reduction of annual emissions from 2000 to 2020, to a level in 2020 thirty (30) percent lower than the starting value. This **effective emission ceiling** is also expressed in units of degree Celsius or GtCy equivalent.

It follows that the difference between the **effective emission reference** and the **effective emission ceiling** represents an **effective emission reduction target** for the ensemble of the Annex I Parties in the period 1990-2020.

The **effective emission reduction target** measures directly the magnitude of the mitigation of climate change to be obtained, in degree Celsius. At the same time, it provides the needed unique constraint to the reductions in annual emissions of the different gases, while allowing all possible flexibility in terms of the distribution in time of the reductions, as well as the flexibility with respect to mitigation of emissions of different gases.

For the sake of illustration of the magnitude of these values, a calculation was made with the proposed simple policy maker model, calibrated for the period 1990-2020 against the MAGICC box-diffusion model and the emission data from the IPCC scenario IS92a. The available data for carbon dioxide annual emissions in 1990 from fossil fuels and cement production were used as well as the atmospheric concentration in 1990 derived from consistent data set of historical emissions (see Appendix II).

Instead of the present proposal, this illustrative calculation considered the AOSIS proposal of a 20 percent reduction in annual emissions by 2010 for Annex I Parties.

The use of the year 2010 in this illustration is only due to the fact that the well known AOSIS proposal for a Protocol refers to that year, and in order to put into evidence the implication of the AOSIS proposal in terms of limitation of temperature increase. The present proposal refers to the year 2020, in line with the Berlin Mandate.

It is found that in the reference case of constant annual emissions in 1990-2010, including 1990 concentration levels, the **effective emissions** by Annex I Parties will be equal to 7,597.21 GtCy, or 0.124650 degree Celsius. If 1990-2010 new emissions only are considered instead, the **effective emissions** by Annex I Parties will be equal to 866.867 GtCy, or 0.014223 degree Celsius.

The AOSIS proposal represents a reduction in **effective emissions** of 18.692 GtCy, or 0.000306 degree Celsius, corresponding to a ceiling of **effective emissions** of 7,578.51 GtCy, or 0.124343 degree Celsius, or alternatively 848.175 GtCy, or 0.013916 degree Celsius, if 1990-2010 new emissions only are considered instead.

The corresponding values for the sea level rise are a reduction from 2.123765 cm in 2010, by 0.005225 cm, to 2.11854 cm.

It is interesting also to notice that such reduction in annual emissions represents a reduction of 0.246 percent in the expected increase in temperature or sea level rise due to emissions from Annex I Parties, or alternatively a reduction of 2.16 percent in the expected increase in temperature or sea level rise corresponding to the 1990-2010 new emissions only.

In Appendix III, an illustrative simulation of different reduction targets for the ensemble of Annex I Parties, corresponding to reducing CO2 emissions in 2010 from 0% to 100% of 1990 level, is shown in Tables A3.1(GtCy) and A3.2(degree Celsius).

5. The relative responsibilities of Annex I Parties are proportional to their respective effective emissions

Parties are presumed somehow to have a control over their annual emissions. This fact, together with the Convention requirement that Parties report annual emissions, give rise to a natural tendency to compare the annual emissions of Parties and thus implicitly to associate the emissions to the relative responsibilities in inducing climate change.

Annual emissions, however, are not an appropriate measure of climate change. The increase in global mean surface temperature, on the other hand, is a simple and effective global measure of climate change.

The fact that it is also possible to measure such a change in temperature in units of GtCy equivalent, and thus relate it directly to annual emissions over a period through the concept of **effective emissions** over a period, makes it natural to assign relative responsibilities to individual Parties according to their respective contributions to climate change, as measured by the induced change in temperature.

It is thus proposed that the relative responsibilities of Parties within a group of Parties be defined to be in the same proportion as their respective **effective emissions**, including the initial concentration level in the beginning of the period.

This proposal provides a means to measure objectively the relative responsibility of each Party or each group of Parties in producing climate change. Given the fact that the Convention contains the all-important principle of a common but differentiated responsibility, it provides an objective criterion for the differentiation of responsibilities.

Furthermore, it provides a means to quantify the relative responsibility of developed countries with respect to developing countries as a result of their contribution to the atmospheric concentrations of greenhouse gases by the time the Convention was negotiated.

In addition, during the initial work of AGBM, there have been suggestions to define indices in terms of emissions per unit of socio-economic or physical indicators of the same Parties or a combination of these, or a convenient choice of such indicators.

The following is an analysis of the proposed concept of using the relative **effective emissions** (which is also a measure of the resulting change in temperature) as a measure of the relative responsibility, in comparison with other suggestions.

a) Annual emissions

The actual emissions have been used as a measure of the responsibility of polluters in cases of urban atmospheric pollution or river contamination. Such procedure is justified by the fact that, when the residence time of the pollutant is relatively short, the concentration of the pollutant is proportional to the emission. Also, in these cases, the detrimental effect is produced by the concentration itself and therefore the emission is a valid measure of the effect to be mitigated.

In the case of climate change, the long residence time of the main greenhouse gases makes the concentration of these gases proportional to the accumulation of the emissions rather than to the emissions themselves, account taken of the different decay times of the gases.

b) Atmospheric concentrations

The atmospheric concentration of greenhouse gases is not a good measure of the responsibility because the greenhouse gases are not pollutants in themselves and therefore there is no proportionality between the detrimental effects and the concentration.

c) Annual emissions relative to socio-economic or physical indicators

It has been suggested that the relative responsibility of Parties be associated with their annual emissions expressed per unit of population, GNP, surface area, energy consumption (expressed in tons of oil equivalent - toe), renewable energy production (in toe), among others.

There is a difficulty in the choice of the reference unit to be used, since Parties will naturally give preference to the choice of indicator that results in a better performance for themselves, which will also make it possible for them to reach a given target with less effort or less burden on their economies.

In addition, all the indicators suggested are, in one way or another, related to the causes of emissions, rather than with their effect.

d) **Effective emissions**

The proposed association of the relative responsibility of Parties with their respective **effective emissions** makes it unnecessary to resort to expressing such effective emissions in terms of any socio-economic or physical units.

The proposed use of the **effective emissions** over a period of time, including the initial concentration level in the beginning of the period, as a measure of the relative responsibility of Annex I Parties, is closely connected to the physical reality of the greenhouse warming, a property not applicable to the absolute emissions, these being an instantaneous “snapshot” of a situation over an arbitrary period of one year.

Perhaps the most striking demonstration of this fact is a reference to the Kuwait oil well fires, which produced for a very short period of time very high daily or monthly emissions, with a negligible effect upon climate change, as demonstrated by detailed calculations at the time.

The change in temperature (or the **effective emissions**) is an objective measure of climate change, for it can be argued that the detrimental effects of climate change guard some sort of proportionality to it. This is likely to be true, in a first order, for all of the impacts that have been surveyed by the IPCC Working Group II, including those associated with extreme weather events, and is certainly true for the rise in mean sea level.

The notable exception to this rule is the time rate of change of temperature, which is significant for the impact upon the adaptation of species, a case in which the time differential would tend to cancel the cumulative effect of concentrations to produce a temperature change with the result that the detrimental effects would in the end be roughly proportional to the concentrations expressed in GtC equivalent, rather than to the temperature expressed in GtCy equivalent.

As an illustration of this point, the relative responsibility of each Annex I Parties was estimated on the basis of several indicators: the annual 1990 carbon dioxide emissions; the **effective emissions** for the period 1990-2010 with and without (flat rate proposal) consideration of the concentrations in 1990 due to previous emissions, assuming constant annual emissions in the period and with individual reductions according to the AOSIS proposal applied on a "flat rate" basis. The data used, for illustration purposes, are those in Appendices I and II. The estimations are presented in Appendix IV. It is to be noted that the present proposal is that the relative responsibility of each Annex I Party be evaluated taking into account the initial concentrations in the beginning of the period.

It is interesting to notice that the evaluation of the relative responsibility of Annex I Parties without consideration of their 1990 annual concentrations is, by construction, equivalent to the "flat rate" approach for assignment of relative responsibilities.

The relative responsibilities based on 1990 annual emissions expressed in terms of the socio-economic and physical units have also been estimated for illustration purposes for each Annex I country and some non-Annex I countries. These results are presented in Appendix V.

6. Relative responsibility of the group of Annex I countries and non-Annex I countries

The consideration of the special case of the relative responsibility of Annex I and non-Annex I countries deserves special attention as a result of the differentiation made by the Convention in noting that "the largest share of historical and current emissions has originated in developed countries".

The use of countries rather than Parties in this section is due only to the ready availability of estimated data for past and future emissions, and should not represent a major obstacle to the appreciation of the results since a vast majority of countries are Parties to the Convention.

It is thus pertinent to evaluate the relative responsibility of Annex I versus non-Annex I countries over the period considered for a Protocol in the periods extending to 2000, 2005, 2010 and 2020, as provided for in the Berlin Mandate, taking into account the concentration in 1990 estimated to be attributable to those two groups of countries.

Published historical data on CO2 energy and cement sector emissions for every country for the period 1950-1990 have been used, in conjunction with a backward extrapolation into the period preceding 1950, to estimate the atmospheric concentrations in 1990 attributable to Annex I and non-Annex I countries.

The methodology, described in Appendix II, can be easily extended to methane and nitrous oxide, and other sectors, such as land-use change, can be easily incorporated into this estimate.

The effect of the emissions from the other greenhouse gases, however, is known to be small in comparison with that from carbon dioxide, according to the IPCC Second Assessment Report. In addition, the relatively short lifetime of methane in the atmosphere tends to decrease the importance of historical emissions of this gas. For these reasons, the carbon dioxide emissions from the energy and cement sectors are likely to be a sufficiently good proxy for the total **effective emissions** for the purposes of evaluating the relative responsibility of Annex I and non-Annex I countries.

Figures 1 to 3 show the change in climate as measured by the increase in global mean surface temperature, expressed in GtCy, for the period 1990-2020, resulting from the 1990 concentrations attributable to the two groups of Parties, with IPCC IS92a emissions after 1990 and without any emissions after 1990.

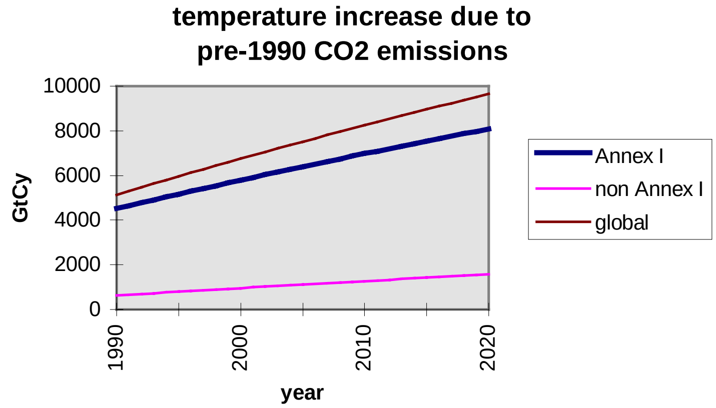

Figure 1 - Change in climate as measured by the increase in global mean surface temperature, expressed in GtCy, for the period 1990-2020, resulting from the 1990 concentrations attributable to the two groups of Parties, without any emissions after 1990.

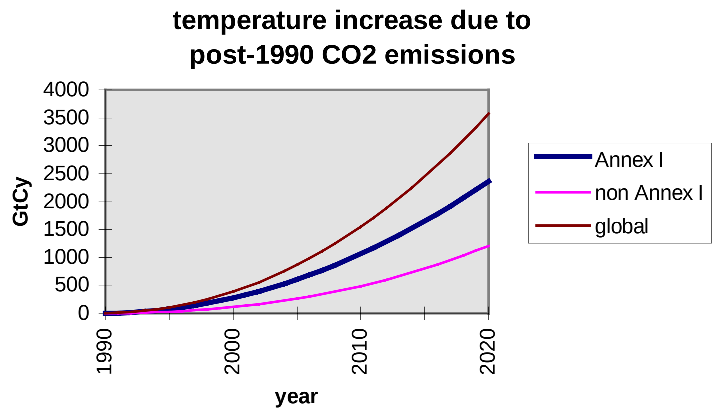

Figure 2 - Change in climate as measured by the increase in global mean surface temperature, expressed in GtCy, for the period 1990-2020, resulting from IPCC IS92a emissions after 1990, disregarding the 1990 concentrations.

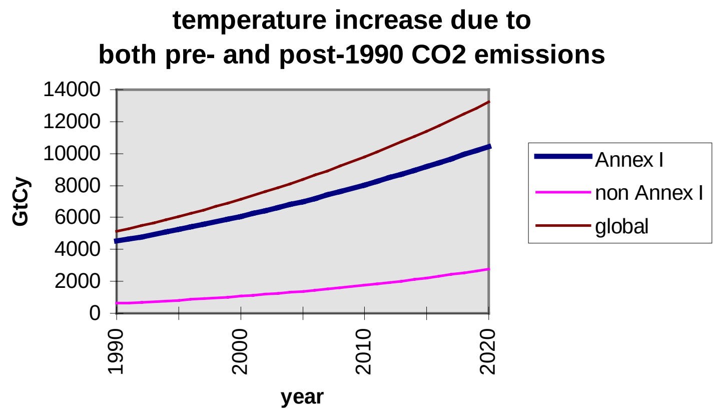

Figure 3 - Change in climate as measured by the increase in global mean surface temperature, expressed in GtCy, for the period 1990-2020, resulting from the 1990 concentrations attributable to the two groups of Parties plus IPCC IS92a emissions after 1990.

Figures 4 to 8 show the relative responsibility of the two groups of Parties, as measured by the respective **effective emissions** for the period 1990-2010 considering the 1990 concentrations and the IPCC IS92a scenario for the period 1990-2010. For the sake of comparison, the relative share of 1990 emissions and of 1990 concentrations attributable to each group, are also indicated in the figure.

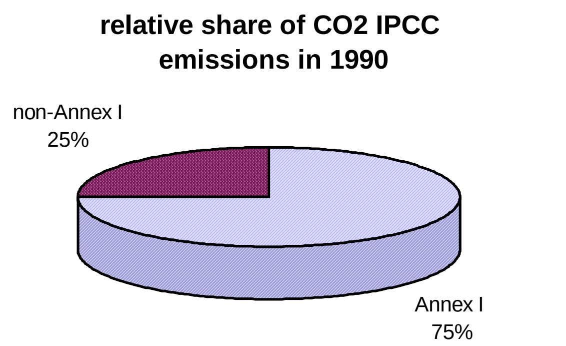

Figure 4 - Relative responsibility attributable to each group of Parties, according to 1990 CO2 emission levels.

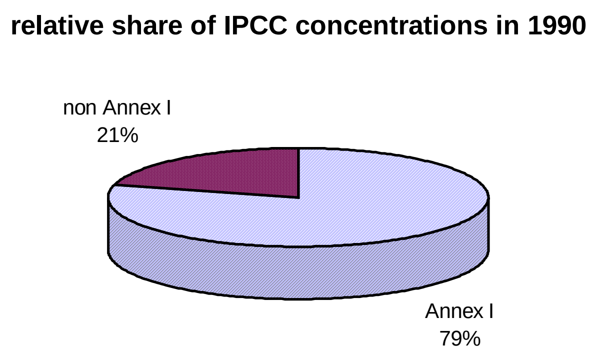

Figure 5 - Relative responsibility attributable to each group of Parties, according to 1990 CO2 concentration levels.

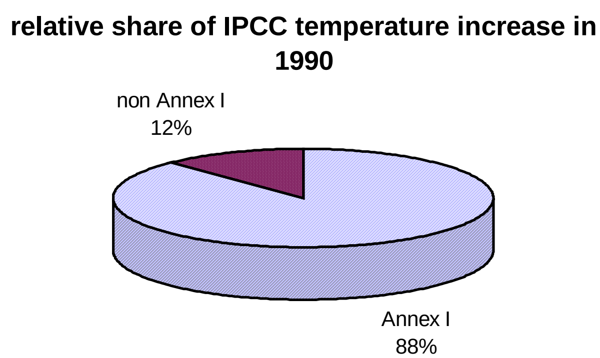

Figure 6 - Relative responsibility attributable to each group of Parties, according to induced temperature increase in 1990 due to CO2 emissions.

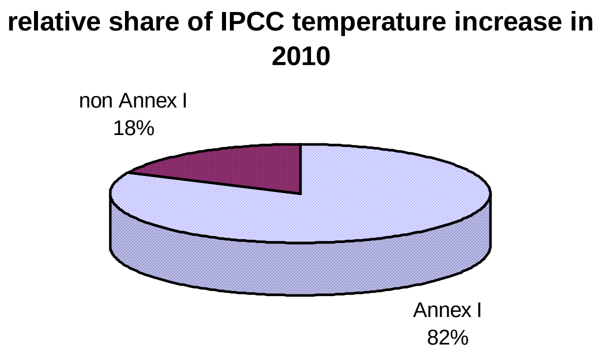

Figure 7 - Relative responsibility attributable to each group of Parties, according to induced temperature increase in 2010 due to CO2 emissions.

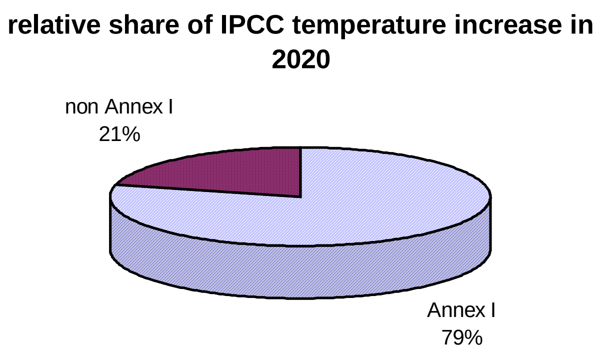

Figure 8 - Relative responsibility attributable to each group of Parties, according to induced temperature increase in 2020 due to CO2 emissions.

This exercise is further extended up to 2200 with the use of the IPCC IS92a scenario up to 2100 and the assumption that the rate of growth of emissions in 2100-2200 is the same as that in 2025-2100.

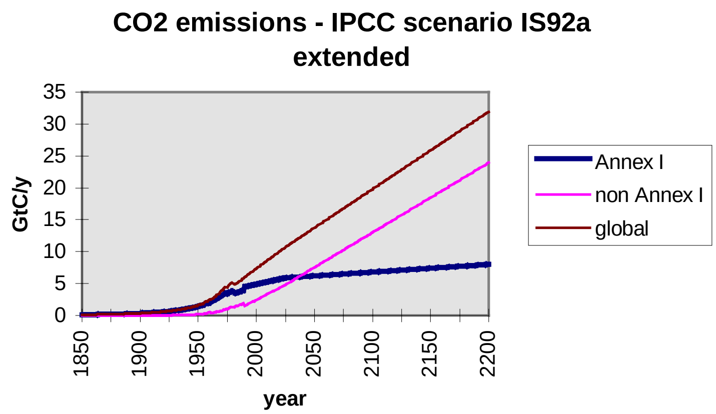

Figure 9 - Extended CO2 emissions IPCC scenario IS92a

Figures 10 and 11 show the change in climate and relative responsibility of Annex I and non-Annex I countries in the period 1990-2100 measured by the respective **effective emissions** in the period with 1990 concentrations, expressed in degree Celsius.

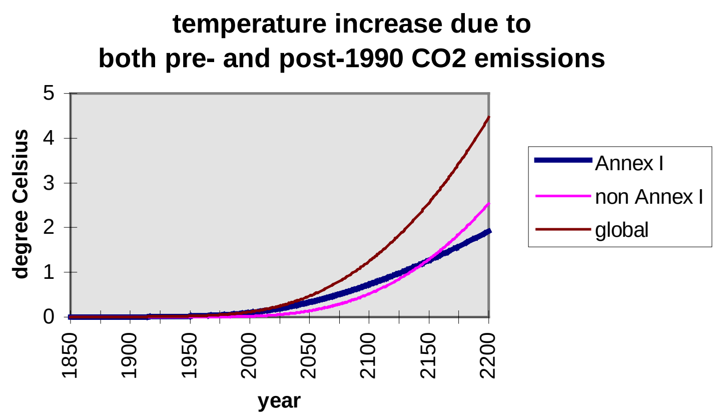

Figure 10 - Change in climate attributable to Annex I and non-Annex I countries in the period 1990-2200 measured by the respective **effective emissions** in the period with 1990 concentrations, expressed in degree Celsius.

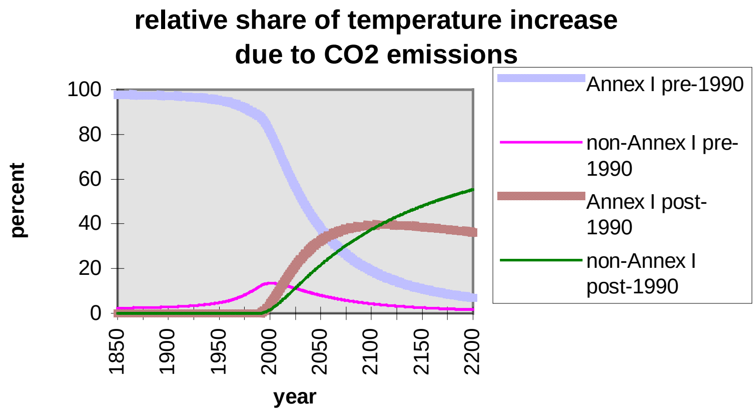

Figure 11 - Relative share of climate change, as measured by the increase in global mean surface temperature, attributable to Annex I and non-Annex I countries, with a separation of the effect of pre- and post-1990 emissions for both groups of countries, in the period 1850-2200, using the IPCC IS92a emissions scenario, extended to 2200.

It is interesting to notice that, whereas the annual emissions of non-Annex I countries are estimated to grow to be equal to those of Annex I countries by 2037, according to the IPCC IS92a scenario, the resulting change in temperature as measured by the **effective emissions** from non-Annex I countries are estimated to equal that of Annex I countries in 2147.

7. Sharing of the burden of mitigation among Annex I Parties and consequent effective emission reduction targets and ceilings

Once the overall **effective emissions reduction target** for Annex I Parties is defined, as well as the relative responsibility of individual Annex I Parties, this section describes the proposed sharing of the burden of mitigation among those Parties.

It is proposed that the division of the collective burden of mitigation among the Annex I Parties in the group be made in proportion to their respective relative responsibility including 1990 concentration, as defined in the previous Section.

It might be argued that the burden in mitigating climate change should be measured, as it is often done in economics, in terms of the cost of such mitigation. It is unlikely, however, that agreement could be reached on how to evaluate such cost, given the very considerable differences that exist in economic management techniques among the Parties, and the foreseeable discussions about the indirect factors that should be included in these evaluations.

It is further recognized that the Convention establishes a number of special considerations in determining the measures to be taken by each Party. As a consequence, it is proposed that the reduction targets determined in accordance with the above criterion be the starting point for negotiations in which the special considerations will be taken into account in determining the reduction to be made by each Party.

Once an **effective emission reduction target** is established for the ensemble of Annex I Parties, an individual **effective emission reduction target** for each Party is established as a fraction of the collective target that is proportional to the relative responsibility of that Party vis-à-vis the ensemble of Annex I Parties. This reduction target for each Party is then subject to negotiation among the Parties in the group with a view to taking into account the special considerations provided for in the Convention and the result of negotiations.

Once the individual **effective emissions reduction target** is established for each Annex I Party, the corresponding **effective emissions ceiling** is derived as the difference between the **effective emissions** over the given period that result from a path of constant emissions, taken as a reference, and the respective **effective emissions reduction target**.

For the sake of illustration, and using the same data base as before, the individual **effective emissions reduction targets** and **effective emissions ceilings** have been estimated for all Annex I Parties, expressed both in GtCy and in degree Celsius. Those results are presented in Table A6.1 in Appendix VI.

Table A6.2 is an estimation for each Annex I Party of the reduction in 2010 emission level as compared to 1990 level that corresponds to the ceiling estimated in Table A6.1, assuming constant 1990 emission level in the period 1990-2000 and decreasing regularly from 2000 to 2010. Figure A6.1, also in Appendix VI, shows a comparison between percentages estimated in Table A6.2 and the 20% "flat rate" for each Annex I Party.

In Appendix VI, an illustrative simulation of the different targets for an arbitrarily chosen individual Annex I Party, in accordance to its relative responsibility including 1990 concentration, corresponding to its respective fraction of different reduction targets for the ensemble of Annex I Parties (see Appendix III) reducing from 0% to 100% of 1990 CO2 emission level in 2010, is shown in Table A6.3 (in GtCy) and Table A6.4 (in degree Celsius).

8. Compensation mechanism in case of departure from the achievement of ceiling objective by Annex I Parties

The effective implementation of the protocol requires the specification of a feedback mechanism by which the departure by a Party from its commitment to maintain its emissions below a ceiling results in an obligation to compensate such departure by other means, such that the net effect will constitute a positive contribution to the global mitigation of climate change.

It is proposed that a periodic evaluation be made of the actual emissions by each Party by comparing, for every evaluation period of n years (it is proposed that this periodicity be of five years), the **effective emissions** derived from the reported annual emissions, with the corresponding **effective emission ceiling**.

It is proposed that the difference, which is a measure of the departure from the objective of that Party, be used as a quantitative basis for establishing, in the case of emissions above the ceiling, a compulsory contribution to a non-Annex I clean development fund to be managed by the financial mechanism of the Convention for the promotion of mitigation measures in non-Annex I Parties. Such contribution is to be made in accordance to a fixed scale of 20US$/(n+1) per tCy of **effective emissions** above the ceiling.

The proposed scale is equivalent to 10US$ per ton of carbon avoided which, according to some estimates, is a value likely to promote the implementation of non-regret measures by non-Annex I Parties.

It is also proposed that Annex I Parties be allowed to use this difference as a measure in trading **effective emissions** among themselves, that is, a Party that, over an evaluation period, reports **effective emissions** above its ceiling may compensate this by "purchasing", at a market value, an equivalent number of **effective emissions**, in GtCy, from another Party that has reported **effective emissions** below its ceiling.

It follows that there will only be a contribution to the non-Annex I clean development fund if the **effective emissions** in a given evaluation period, from the ensemble of Annex I Parties, are above their collective **effective emission ceiling**.

For the sake of illustration, one Annex I Party for which reported annual emissions are available for the period 1990-1994 has been used as a hypothetical example to estimate the departure from the commitment and resulting compensation.

The resulting hypothetical contribution due to CO2 emissions was estimated for the period 1990-2010, as well as the relative importance of the main greenhouse gases in terms of **effective emissions** for the same period and presented in Table A7.1.

9. Distribution of the financial resources of the non-Annex I Clean Development Fund

It is proposed that the financial resources of the non-Annex I clean development fund obtained in each evaluation period from the contributions of Annex I Parties are to be distributed to non-Annex I Parties subject to the two conditions described below.

Each non-Annex I Party may, on a voluntary basis, apply for funds to be used in climate change projects. Such applications are subject to the appropriate regulations approved by the Conference of the Parties for this purpose.

An upper limit is established for the funds that may be approved for each non-Annex I Party, which is equal to the fraction of the total funds available corresponding to the relative responsibility, measured in terms of their individual **effective emissions** using available reported data, without 1990 initial concentration for the first period, and the concentration resulting from the previously reported **net anthropogenic emissions** for the subsequent periods, of that Party among the ensemble of non-Annex I Parties.

It is recognized that this limitation may result in funds not being used within an evaluation period. It is proposed that the surplus is to be carried over into the next evaluation period and it is expected that the availability of these funds will encourage non-Annex I Parties to generate acceptable climate change projects for their use.

The effect of this limit is to direct the financial resources of the fund preferentially to the non-Annex I Parties that have a larger relative contribution to climate change, thus promoting mitigation where it matters most, hence contributing to a global objective, while contributing constructively to the advancement of the implementation of the Convention by non-Annex I Parties.

Appendix VIII presents a simulation, based on available data, of the relative distribution among non-Annex I Parties, with the results shown in Table A8.1 and Figure A8.1.

APPENDIX I

A simple model for use by policy makers is presented for the relationship between emissions of greenhouse gases and the resulting increase in global mean surface temperature and mean sea level rise.

The functional dependence of the atmospheric anthropogenic concentration of a given greenhouse gas upon the emissions over a given period of time is given by

$$\rho = C \int \varepsilon(t') \exp(-(t-t')/\tau)\, dt' \quad (1)$$

where

$\rho(t)$ is the atmospheric concentration at time t

$\varepsilon(t)$ is the annual rate of emission at time t

τ is the atmospheric exponential decay time

C is a constant

and the integral is taken over the given period.

The constant C was determined by linear regression of the value of the integral with the results of the MAGICC box-diffusion model result for the period 1990-2020, computed with emissions in the period from the IPCC IS92a scenario.

Table A1.1 contains the values of the constant C and of the atmospheric exponential decay time τ for carbon dioxide, methane and nitrous oxide.

Table A1.1

gas	CO2	CH4	N2O
τ (years)	140	12.2	120
C	0.559841	0.310545	0.224313
unit	ppmv/ PgC	ppbv/ TgCH4	ppbv/ TgN

Figures A1.1 through A1.3 show a comparison of the anthropogenic concentrations computed with the MAGICC model and formula (1).

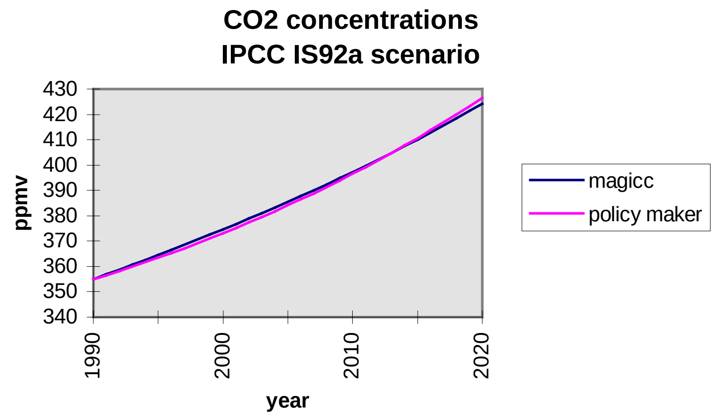

Figure A1.1 - Concentration of carbon dioxide computed by the MAGICC model for the period 1990-2020 with IPCC IS92a emission scenario data, and by the simple decision maker model with the constants of Table A1.1.

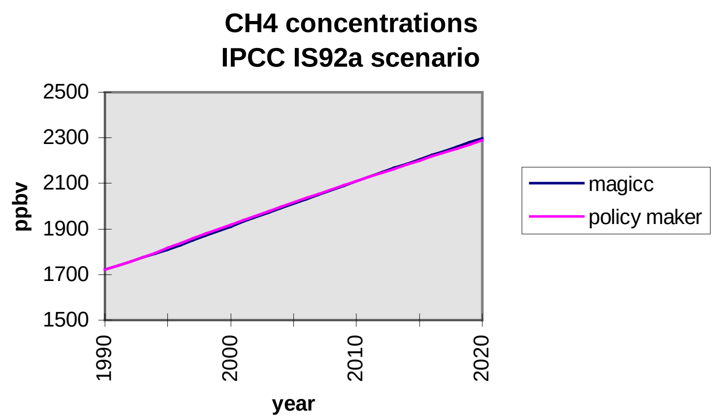

Figure A1.2 - Concentration of methane computed by the MAGICC model for the period 1990-2020 with IPCC IS92a emission scenario data, and by the simple decision maker model with the constants of Table A1.1.

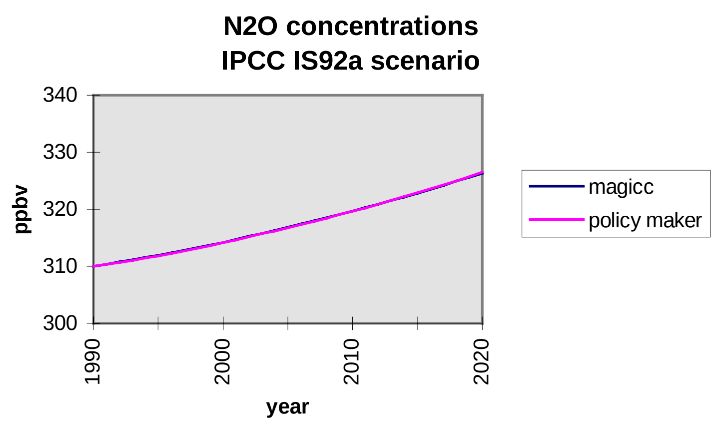

Figure A1.3 - Concentration of nitrous oxide computed by the MAGICC model for the period 1990-2020 with IPCC IS92a emission scenario data, and by the simple decision maker model with the constants of Table A1.1.

The radiative forcing for each greenhouse gas is computed from its atmospheric concentration as

$$\Delta F(t) = k\, \rho(t) \qquad (2)$$

where

$\Delta F(t)$ is the rate of deposition of energy per unit area on the surface of the Earth

k is a constant determined from the functional dependence of ΔF upon the concentration by expanding it in series around the concentration values actually observed in 1990 and taking only the linear term.

In a first physical approximation, the increase in the surface temperature is given by

$$\Delta T_f(t) = \alpha \quad \Delta F(t') \, dt' \qquad (3)$$

where

$\Delta T_f(t)$ is the temperature increase in the first physical approximation

α is a lumped constant that takes into account all the relevant physical factors.

It follows from (2) and (3) that the increase in mean surface temperature can be written as

$$\Delta T_f(t) = \beta \quad \rho(t') \, dt' \qquad (4)$$

where β is a constant.

The constant β was determined by linear regression of the value of the integral with the results of the MAGICC box-diffusion model result for the period 1990-2020, computed with emissions in the period from the IPCC IS92a scenario.

Table A1.2 contains the values of the constant β for carbon dioxide, methane and nitrous oxide, expressed in units of degree Celsius per unit of volumetric concentration per unit of time in years, and also in units of degree Celsius per unit of mass per unit of time in years.

Table A1.2

gas	CO2	CH4	N2O
β	2.156862745	0.045063425	0.427188940
units	GtCyeq/ppmv	GtCyeq/ppbv	GtCyeq/ppbv
β	0.000035388	0.000000739	0.000007009
units	degC/ppmv	degC/ppbv	degC/ppbv

The use of the constant for carbon dioxide allows the increase in temperature to be expressed in units of carbon concentration multiplied by time or, conveniently, the **effective emission** of any gas can be expressed in degree Celsius or in GtCy equivalent.

This procedure replaces completely the greenhouse warming potential concept as a tool to provide for a common measure of emissions of different greenhouse gases with the advantage that it avoids the need to arbitrarily choose a time horizon but, instead, relates the emissions of different greenhouse gases through their effect in producing a change in temperature over a given period.

Figure A1.4 shows a comparison of the increase in global mean surface temperature computed with the MAGICC model and formula (4).

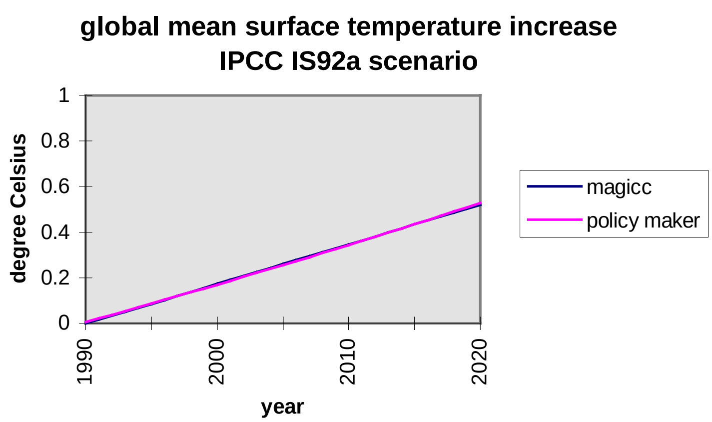

Figure A1.4 - Increase in mean global surface temperature computed by the MAGICC model for the period 1990-2020 with IPCC IS92a emission scenario data, and by the simple decision maker model with the constants of Table A1.2.

It is seen that the simple policy maker models can be used to estimate with sufficient accuracy the temperature increase for a time period of the order of 30 years.

The consideration of formulas (1) and (4) makes it evident that there are two arbitrary constants that represent the lower limit of the two definite integrals. In reality, it is assumed in the above discussion that the lower limit of both the integrals are the same, while this is not necessarily so.

In particular, it may be convenient to take the lower limit of the first integral (formula 1) to be minus infinity and the lower limit of the second integral (formula 4) to be 1990. This corresponds to taking into account the atmospheric concentrations in 1990 of the greenhouse gases due to emissions before 1990, which must be done to evaluate quantitatively the Convention provisions on this subject.

The rise in mean sea level is treated in a similar fashion:

$$mslr = \gamma \quad \rho(t') \, dt' \qquad (5)$$

where

mslr is the increase in mean sea level

γ is a similarly derived empirical constant.

The values of γ and the comparison with MAGICC results are presented in Table A1.3 and Figure A1.5.

Table A1.3

gas	CO2	CH4	N2O
γ	0.000602941	0.000012597	0.000119419
units	cm/ppmv	cm/ppbv	cm/ppbv

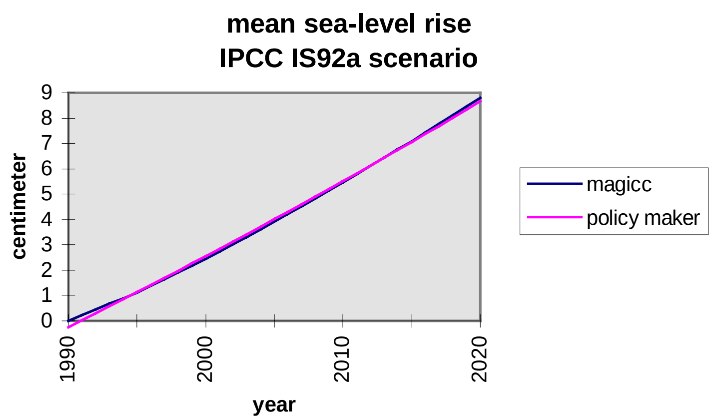

Figure A1.5 - Mean sea level rise computed by the MAGICC model for the period 1990-2020 with IPCC IS92a emission scenario data, and by the simple decision maker model with the constants of Table A1.3.

APPENDIX II

In order to take into account the effect upon climate change of the atmospheric concentration of greenhouse gases in 1990, and the detailed attribution of such concentration to the pre-1990 emissions of individual countries, the time series of emissions by individual countries estimated by the U.S. Oak Ridge National Laboratory has been processed to allow such estimate to be made.

The U.S. Oak Ridge National Laboratory has published and made available, in digital form, a table of the annual emissions on an yearly basis for every country, for the period 1950 to 1990, for carbon dioxide from the energy sector and cement production.

Such table has been recomputed to take into account that some present-day countries are the result of the merging or disaggregation of countries that have existed as independent entities in the past. In the case of aggregation, such as for instance the consideration of metropolitan France and French Guyana, the emission data have been simply added and assigned to the country that is recognized as an independent state. In the case of disaggregation such as, for the division of Czechoslovakia in the Czech Republic and the Slovakian Republic, the overall emission data have been attributed to each one of the component parts in the same proportion as the reported 1990 emission. Some adaptations to this rule have been made whenever relevant independent data are available. Data were not available for Lesotho, Namibia and in the case of Eritrea where ORNL data is only available for the former Ethiopia (now split into Ethiopia and Eritrea). Also in the case of Italy, ORNL data includes San Marino.

The modified ORNL data covers the period 1950 to 1990. Given the relatively long decay time of carbon dioxide in the atmosphere, over one hundred years, it became important to estimate the emissions in the period preceding 1950.

This backward extrapolation of the annual emissions was done in two steps. First, a period was chosen in the early part of 1950-1990, when the aggregate global emissions (obtained by adding the ORNL country emission data) were considered to be smooth and corresponding to one exponential function, as seen in Figure A2.1 and A2.2, in both linear and log form.

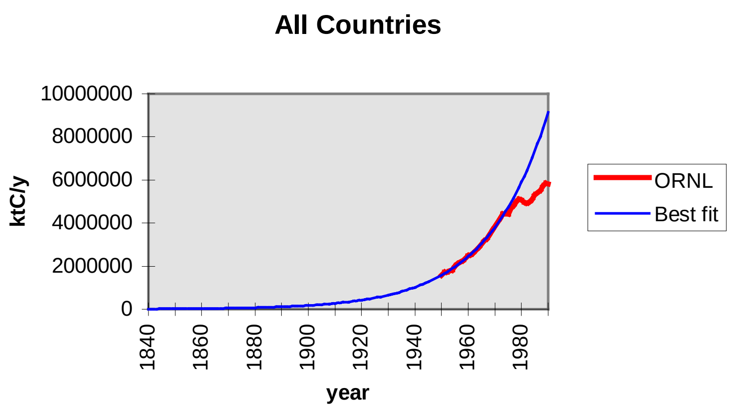

Figure A2.1 ORNL data (1950-1990) and best fit curve used to extrapolate data for the period 1840-1949.

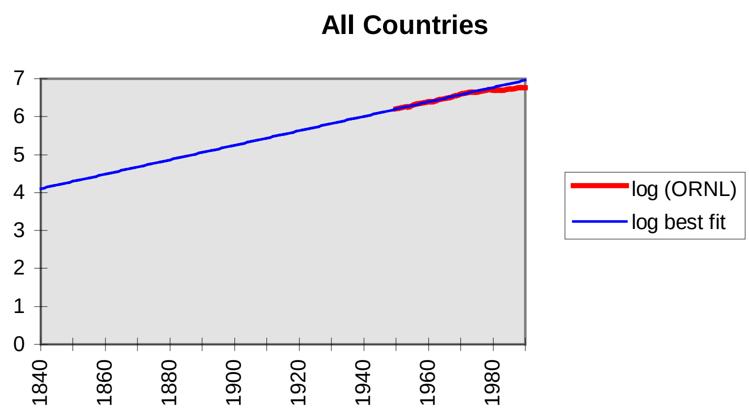

Figure A2.2 Log curves used to calculate extrapolation data.

The period 1950-1973 was chosen and a linear least-square function best-fitted to the log emission data for that period for each country. Such linear best-fitted function was then used to extrapolate the log emission data backward for the period before 1950 and inverted to produce the exponentially decreasing emission estimate for each country. Figures A2.3 to A2.9 exemplify this procedure for selected countries from both Annex I and non-Annex I Parties.

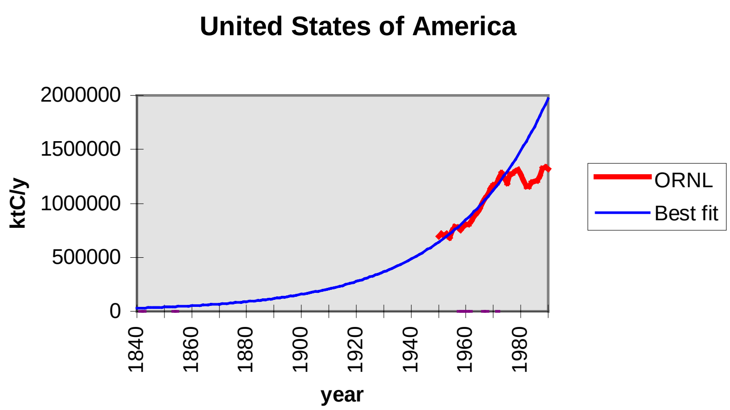

Figure A2.3 - ORNL data and best fit curves for the USA.

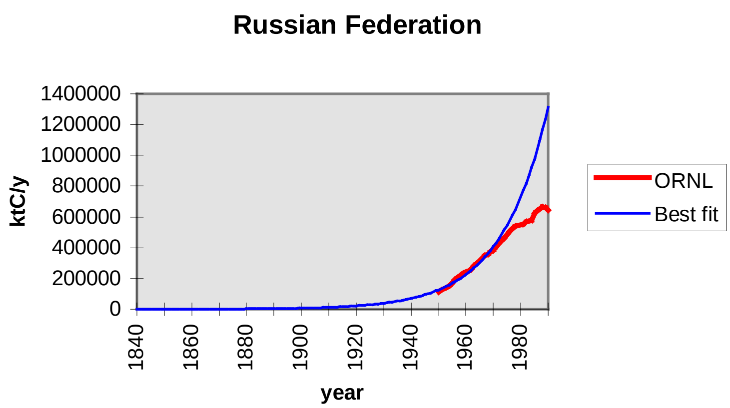

Figure A2.4 - ORNL data and best fit curves for the Russian Federation.

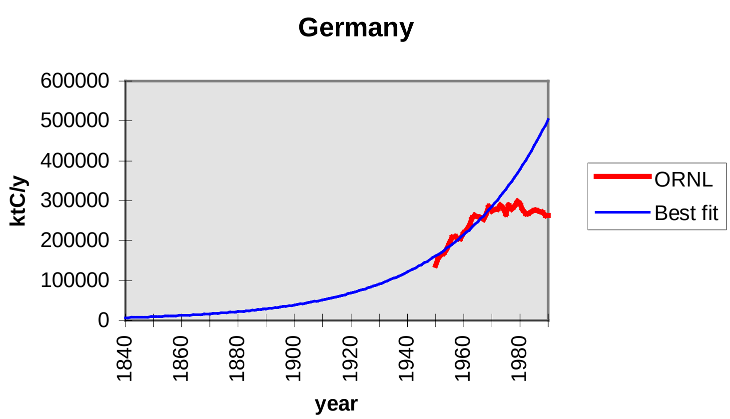

Figure A2.5 - ORNL data and best fit curves for Germany.

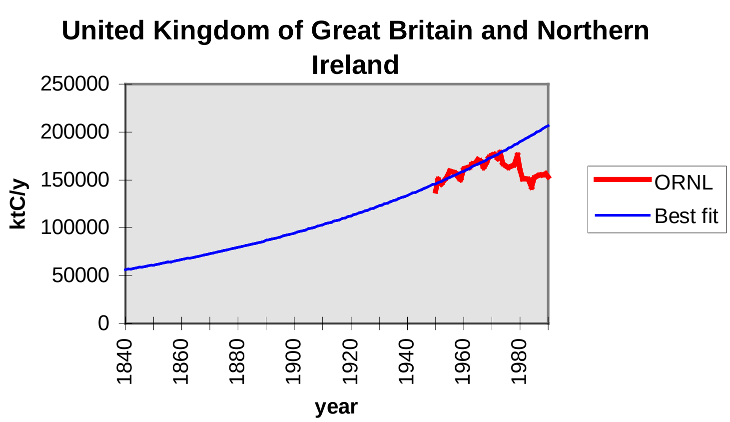

Figure A2.6 - ORNL data and best fit curves for the United Kingdom.

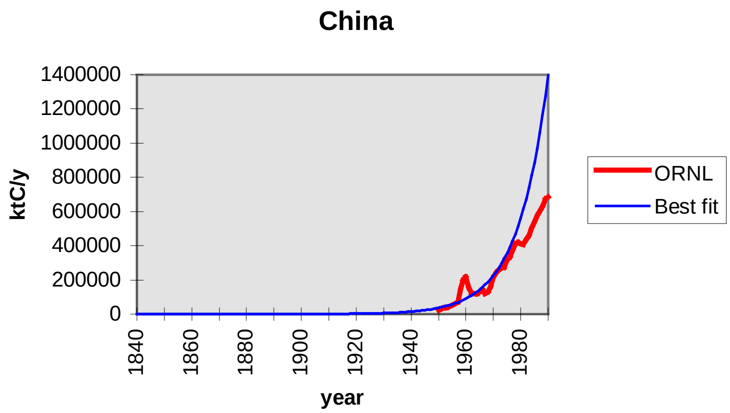

Figure A2.7 - ORNL data and best fit curves for China.

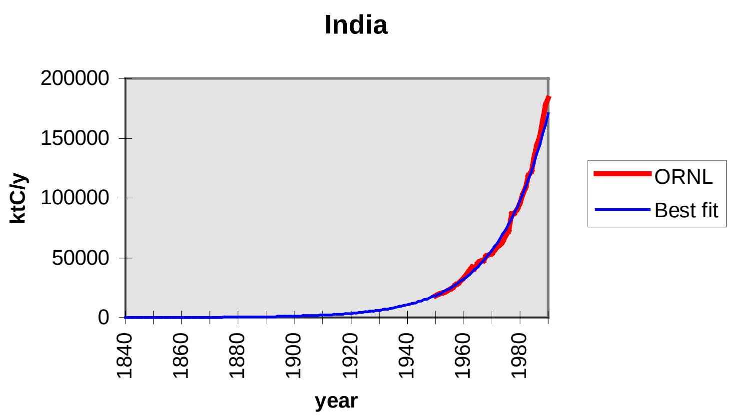

Figure A2.8 - ORNL data and best fit curves for India

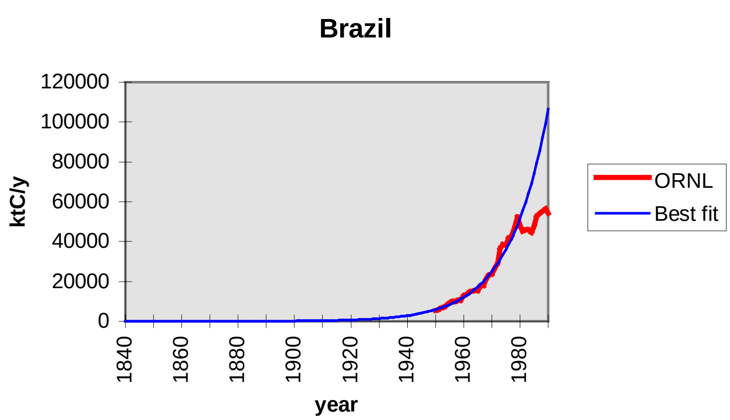

Figure A2.9 - ORNL data and best fit curves for Brazil.

In summary, the emissions data effectively used were the back-extrapolated data for the period 1840-1949, and the ORNL data for the period 1950-1990.

The result of this processing of the ORNL data is available for downloading from the Brazilian Government climate change INTERNET site:
http://www.mct.gov.br/gabin/clima.htm

The use of concentrations resulting from pre-1990 carbon dioxide emissions from the energy (and cement) sectors only is done as an illustration and because those are the only readily data available on a country-by-country basis. Nevertheless, such a use is also justified to the extent that the majority of the effect of the overall pre-1990 emission effect is taken into account by this procedure, as demonstrated by the use of the MAGICC model results. The MAGICC model run includes, on a global basis, the effect of land-use change carbon dioxide as well as the effect of methane and nitrous oxide.

It can be seen in Figure A2.9 that the energy and cement carbon dioxide historical emissions account for the very large majority of the temperature change resulting from pre-1990 greenhouse gas emissions from all sectors. At last, it is important to remember that our interest here is only to estimate the importance of pre-1990 emissions on a relative basis and not in absolute terms.

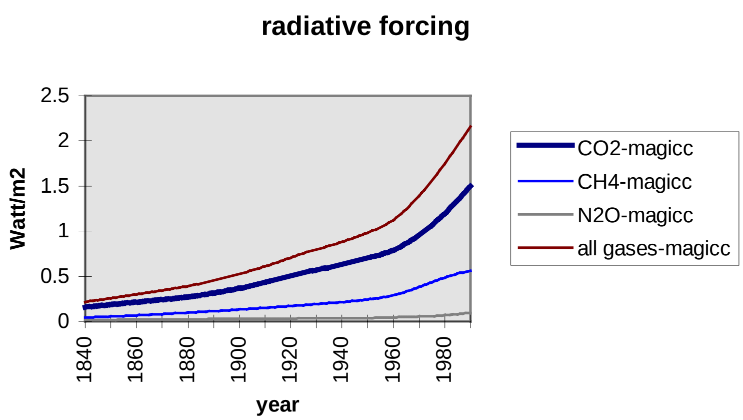

Figure A2.10 - Relative radiative forcing of main greenhouse for IS92a IPCC scenario.

APPENDIX III

Simulation of Different Targets for the Ensemble of Annex I Parties

An illustrative simulation of different reduction targets that result from a path of constant emissions from 1990 to 2000 and regularly decreasing emissions from 2000 to 2010, for the ensemble of Annex I Parties, corresponding to reducing CO2 emissions in 2010 from 0% to 100% of 1990 level, is shown in Tables A3.1(in GtCy) and A3.2(in degree Celsius).

Table A3.1 Annex I Parties

EMISSIONS LEVEL IN 2010 (as % of 1990)	1990 concentration plus new emission GtCy	new emissions only GtCy	reduction target GtCy	Percent Reduction new emissions %
100%	7597.21	866.8667	0.0000	Reference
90%	7587.86	857.5209	9.3458	1.08
80%	7578.51	848.1751	18.6916	2.16
70%	7569.17	838.8294	28.0373	3.23
60%	7559.82	829.4836	37.3831	4.31
50%	7550.48	820.1378	46.7289	5.39
40%	7541.13	810.7920	56.0747	6.47
30%	7531.79	801.4463	65.4204	7.55
20%	7522.44	792.1005	74.7662	8.62
10%	7513.09	782.7547	84.1120	9.70
0%	7503.75	773.4089	93.4578	10.78

Table A3.2 Annex I Parties

EMISSIONS LEVEL IN 2010 (as % of 1990)	1990 concentration plus new emission ºC	new emissions only ºC	reduction target ºC	Percent Reduction new emissions %
100%	0.124650	0.014223	0.000000	Reference
90%	0.124496	0.014070	0.000153	1.08
80%	0.124343	0.013916	0.000307	2.16
70%	0.124190	0.013763	0.000460	3.23
60%	0.124036	0.013610	0.000613	4.31
50%	0.123883	0.013456	0.000767	5.39
40%	0.123730	0.013303	0.000920	6.47
30%	0.123576	0.013150	0.001073	7.55
20%	0.123423	0.012996	0.001227	8.62
10%	0.123270	0.012843	0.001380	9.70
0%	0.123116	0.012690	0.001533	10.78

APPENDIX IV

Estimation of Relative Responsibility of Individual Annex I Parties

As an illustration of this point, the relative responsibility of Annex I Parties was estimated on the basis of several indicators: the annual 1990 carbon dioxide emissions; the **effective emissions** for the period 1990-2010 with (an illustration of the current proposal) and without (flat rate proposal) consideration of the concentrations in 1990 due to previous emissions, assuming constant annual emissions in the period and with individual reductions according to the AOSIS proposal applied on a "flat rate" basis. The data used, for illustration purposes, are those in Appendix I and II.

For the sake of illustration, available data have been used to estimate the relative responsibility and therefore the relative burden of individual Annex I Parties for the different criteria, as detailed in Tables A4.1, A4.2 and A4.3 and shown in Figures A4.1, A4.2 and A4.3.

It is interesting to notice that the evaluation of the relative responsibility of Annex I Parties without consideration of their 1990 annual concentrations is, by construction, equivalent to the "flat rate" approach for assignment of relative responsibilities.

a) Relative Responsibility with 1990 CO_2 Emissions as Reported by Inventories

Table A4.1 - Relative Responsibilities
1990 Inventories*

Country	%
United States	36.219
Russian Federation	17.453
Japan	8.439
Germany	7.410
United Kingdom	4.216
Canada	3.380
Italy	3.134
Poland	3.032
France	2.678
Australia	2.111
Spain	1.661
Romania	1.250
Netherlands	1.225
Czech Republic	1.211
Belgium*	0.757
Bulgaria	0.606
Greece	0.600
Hungary	0.524
Sweden	0.448
Austria	0.433
Slovakia	0.426
Finland	0.394
Denmark	0.380
Switzerland	0.329
Portugal	0.308
Estonia	0.276
Norway	0.259
Ireland	0.224
New Zealand	0.186
Latvia	0.168
Lithuania*	0.161
Luxembourg	0.083
Iceland	0.016
Liechtenstein	0.002
Monaco	0.001

*For Belgium and Lithuania: ORNL data

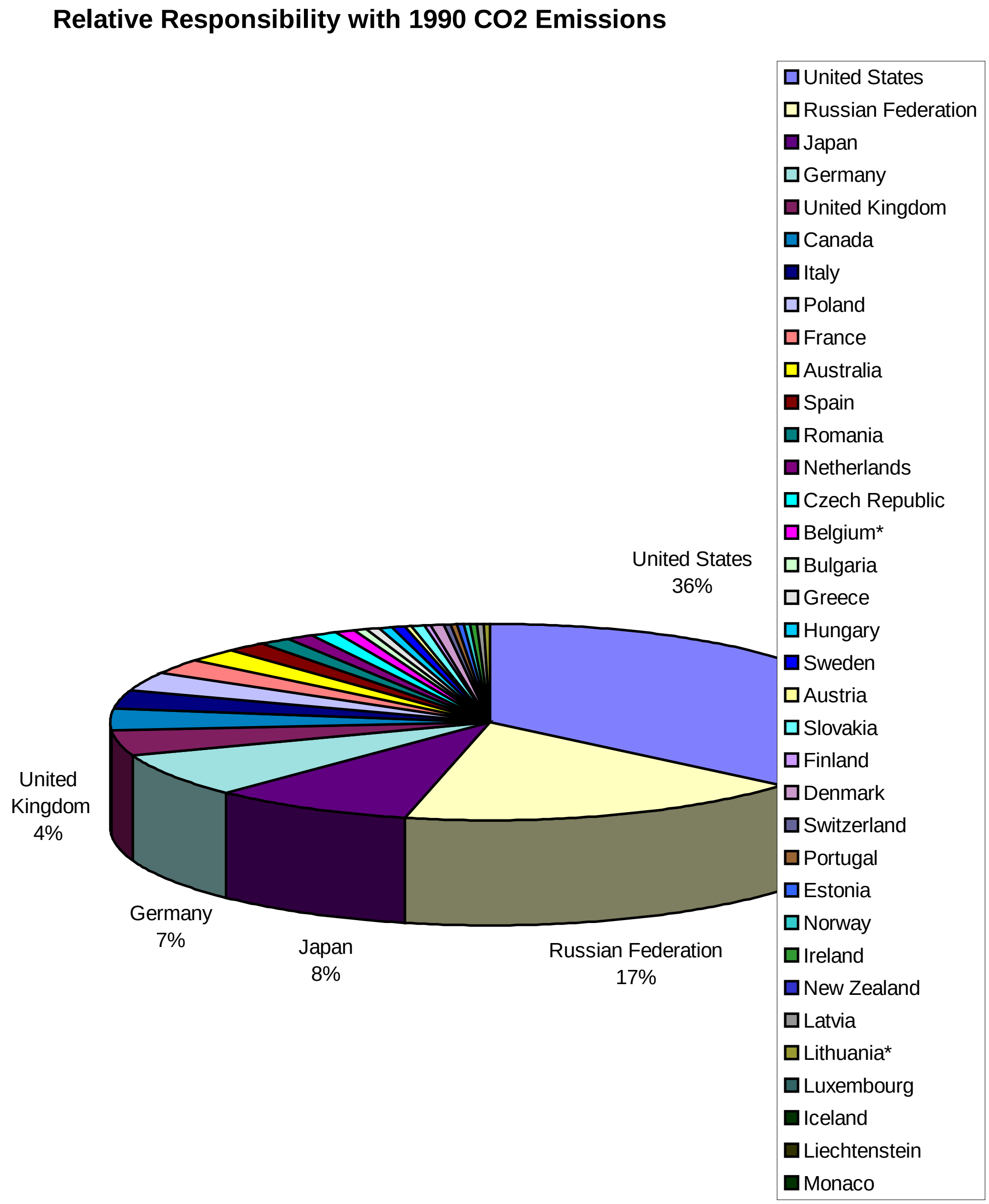

Figure A4.1 Relative responsibility of Annex I Parties according to 1990 emissions.

b) Relative Responsibility with Flat CO2 Emissions from 1990 to 2010, including 1990 Concentration

Table A4.2 - Relative Responsibility with Flat CO2 Emissions from 1990 to 2010, including 1990 Concentration

Country	%
United States	41.9415
United Kingdom	13.5447
Russian Federation	10.3731
Germany	10.0651
Japan	3.8255
France	3.3541
Canada	2.5965
Poland	2.3371
Italy	1.5283
Belgium	1.4769
Australia	1.1537
Czech Republic	1.0697
Netherlands	0.9963
Spain	0.8123
Romania	0.7552
Sweden	0.4710
Hungary	0.4463
Bulgaria	0.3774
Slovakia	0.3760
Austria	0.3640
Denmark	0.3556
Switzerland	0.2148
Finland	0.2096
Greece	0.1978
Norway	0.1812
Ireland	0.1646
Estonia	0.1572
New Zealand	0.1570
Luxembourg	0.1545
Portugal	0.1353
Lithuania	0.0969
Latvia	0.0955
Iceland	0.0138
Liechtenstein	0.0010
Monaco	0.0006

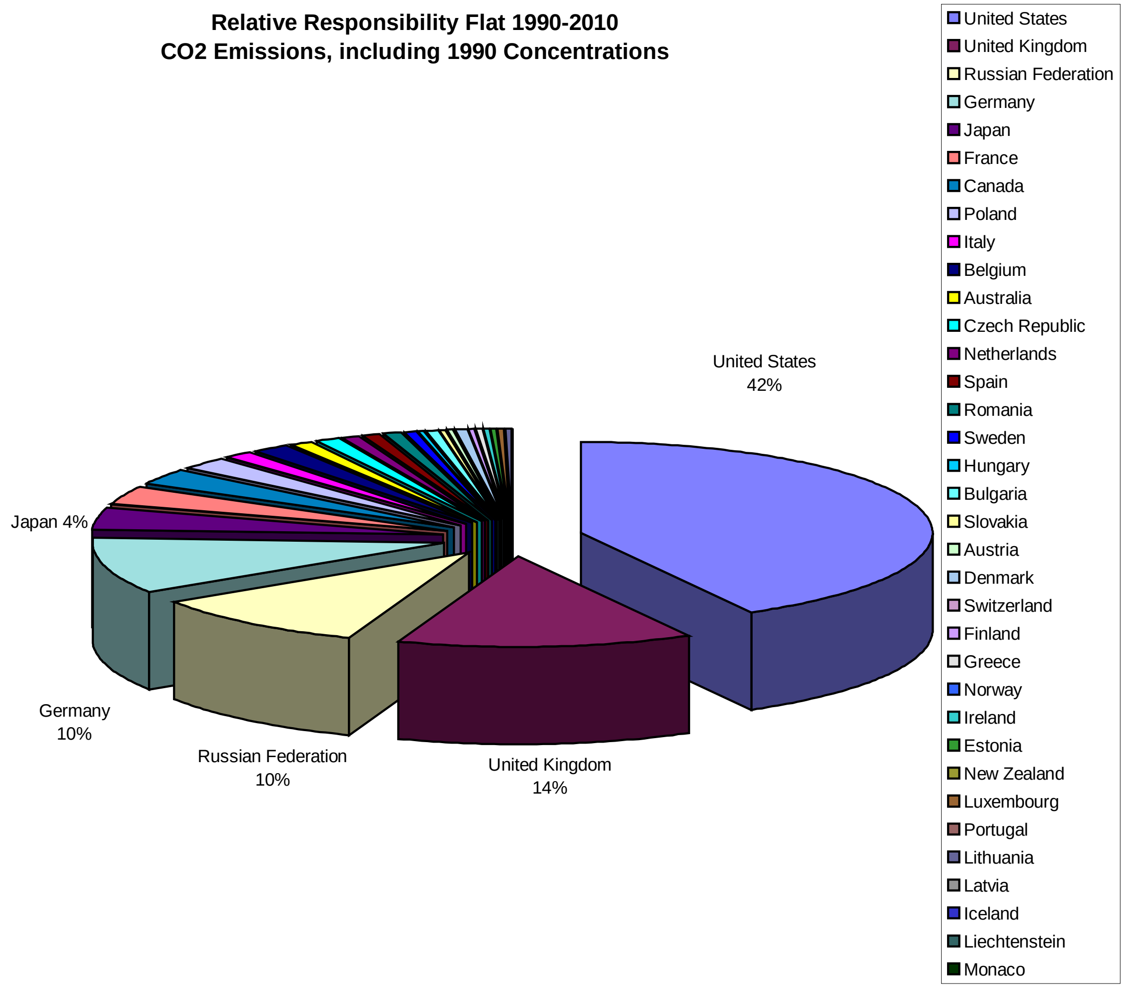

Figure A4.2 Relative responsibility of Annex I Parties according to the above illustration of the current proposal.

c) Relative Responsibility with Flat CO_2 Emissions from 1990 to 2010, not including 1990 Concentration

Table A4.3 - Relative Responsibility with Flat CO_2 Emissions from 1990 to 2010, not including 1990 Concentration

Country	%
United States	36.8631
Russian Federation	18.0203
Japan	8.0927
Germany	7.3455
United Kingdom	4.2815
Canada	3.2243
Italy	2.8995
Poland	2.7986
France	2.7535
Australia	2.0397
Spain	1.5505
Romania	1.3813
Czech Republic	1.1739
Netherlands	1.0607
Belgium	0.7900
Bulgaria	0.6958
Greece	0.5283
Hungary	0.4405
Austria	0.4146
Slovakia	0.4127
Denmark	0.3989
Finland	0.3923
Sweden	0.3773
Portugal	0.3208
Switzerland	0.3185
Norway	0.2923
Estonia	0.2730
Ireland	0.2357
New Zealand	0.1962
Lithuania	0.1684
Latvia	0.1660
Luxembourg	0.0741
Iceland	0.0172
Liechtenstein	0.0015
Monaco	0.0005

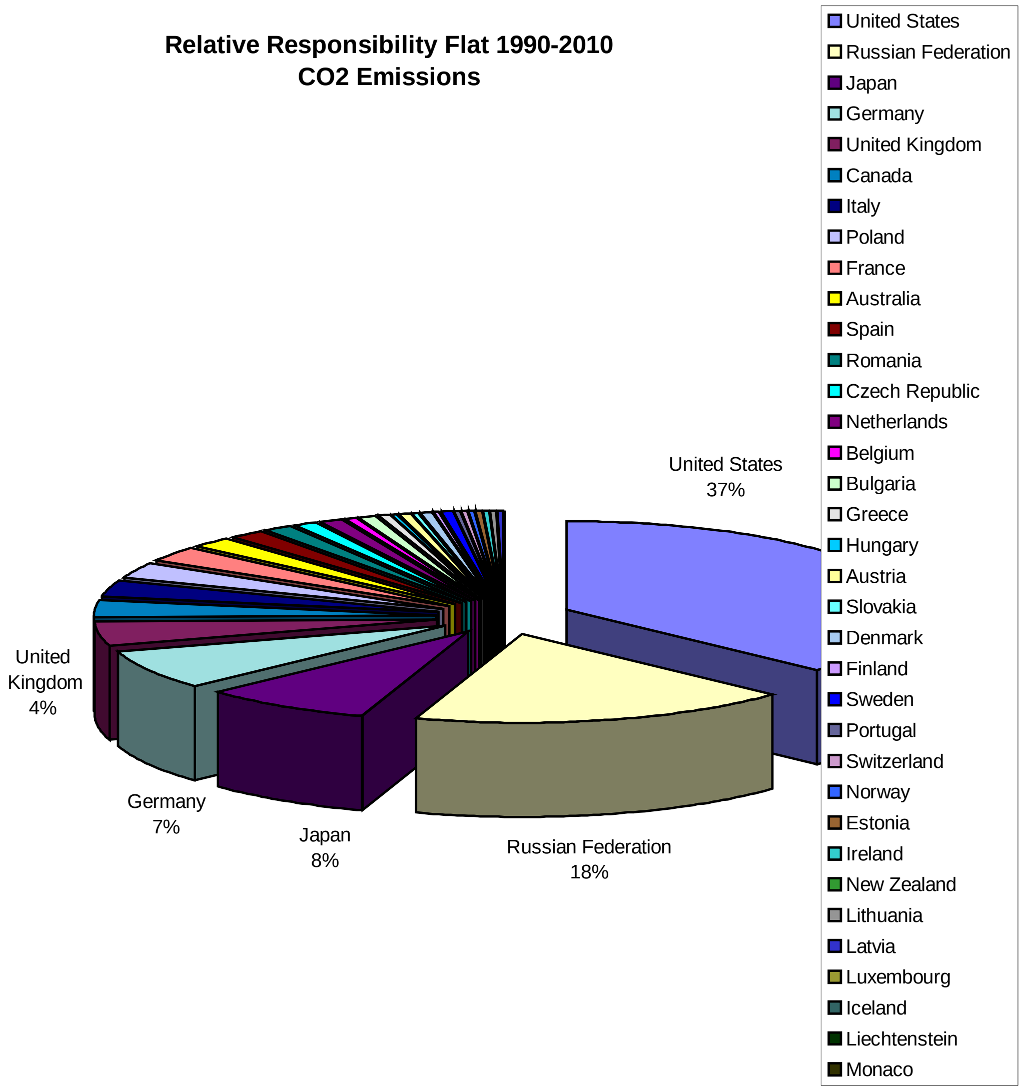

Figure A4.3 Relative responsibility of Annex I Parties according to “flat rate” proposal.

APPENDIX V

The relative responsibilities based on 1990 annual emissions expressed in terms of the socio-economic and physical units have also been estimated for illustration purposes for each Annex I Party and some non-Annex I countries.

Table A5.1 Emissions/GDP

Countries	tC/US$ (PPP)
Ukraine	1.1537
Russian Federation	0.8093
Estonia	0.7935
Belarus	0.6219
Bulgaria	0.5757
Romania	0.4672
Lithuania	0.4526
Poland	0.4413
Latvia	0.4036
Czech Republic	0.3951
Slovakia	0.3782
Luxembourg	0.2650
Zimbabwe	0.2317
Hungary	0.2172
China	0.1958
Greece	0.1857
United States	0.1818
Germany	0.1808
Australia	0.1799
Canada	0.1661
Ireland	0.1543
Finland	0.1518
Belgium	0.1434
United Kingdom	0.1344
India	0.1303
Egypt	0.1277
Netherlands	0.1256
Denmark	0.1246
Mexico	0.1239
Iceland	0.1228
New Zealand	0.1126
Turkey	0.1108
Japan	0.1080
Argentina	0.1076
Norway	0.0984
Spain	0.0981
Austria	0.0975
Italy	0.0952
Portugal	0.0935
Cameroon	0.0920
France	0.0839
Liechtenstein	0.0834
Sweden	0.0761
Switzerland	0.0718
Congo	0.0704
Brazil	0.0557
Costa Rica	0.0487
Ethiopia	0.0327
Monaco	0.0246
Central African Rep.	0.0216

Table A5.2 Emissions/capita

Countries	tC / inhab.
Estonia	6.688
Luxembourg	6.372
United States	4.945
Russian Federation	4.347
Czech Republic	4.066
Canada	3.999
Australia	3.993
Ukraine	3.960
Germany	3.143
Belarus	2.938
Bulgaria	2.888
Belgium	2.777
Finland	2.747
Slovakia	2.745
Denmark	2.664
United Kingdom	2.617
Poland	2.589
Netherlands	2.436
Latvia	2.403
Norway	2.384
Ireland	2.363
Japan	2.306
Romania	2.280
Iceland	2.272
New Zealand	1.976
Austria	1.847
Italy	1.804
Greece	1.792
Liechtenstein	1.688
France	1.688
Lithuania	1.651
Switzerland	1.580
Hungary	1.574
Sweden	1.515
Spain	1.415
Portugal	1.107
Mexico	0.933
Argentina	0.864
Turkey	0.613
Monaco	0.610
China	0.566
Zimbabwe	0.372
Egypt	0.344
Brazil	0.334
Costa Rica	0.259
Congo	0.214
India	0.193
Cameroon	0.106
Central African Rep.	0.016
Ethiopia	0.014

Table A5.3 Emissions/Energy Consumption

Countries	tC / toe
Estonia	3.312
Bulgaria	2.128
Romania	1.908
Ukraine	1.795
Czech Republic	1.697
Congo	1.652
Latvia	1.550
Belarus	1.519
Poland	1.500
Zimbabwe	1.387
Russian Federation	1.342
India	1.320
Greece	1.211
Cameroon	1.200
Lithuania	1.135
Australia	1.135
Slovakia	1.119
Germany	1.084
Ireland	1.018
United Kingdom	0.971
Egypt	0.969
United States	0.958
China	0.945
Denmark	0.941
Hungary	0.934
Mexico	0.899
Italy	0.863
Japan	0.860
Spain	0.824
Portugal	0.813
Ethiopia	0.812
Argentina	0.775
Belgium	0.751
Luxembourg	0.738
Netherlands	0.690
Canada	0.667
Austria	0.642
France	0.621
New Zealand	0.611
Finland	0.590
Switzerland	0.579
Norway	0.562
Costa Rica	0.526
Brazil	0.443
Sweden	0.382
Iceland	0.341

Table A5.4 Emission/Renewable Energy

Countries	tC / toe
Belarus	15299.40
Hungary	1124.86
Czech Republic	333.05
Ukraine	107.09
United Kingdom	95.66
Netherlands	92.48
Luxembourg	88.33
Bulgaria	84.89
Belgium	76.33
Germany	60.50
Ireland	60.19
Slovakia	37.25
Estonia	32.21
Zimbabwe	28.72
Egypt	26.25
India	25.85
Japan	23.18
Greece	23.03
Russian Federation	21.82
Romania	21.74
Poland	20.32
Lithuania	19.42
Spain	17.16
France	14.69
Congo	14.65
Italy	12.69
United States	12.65
Australia	12.15
Denmark	10.97
Latvia	7.33
Argentina	6.93
Cameroon	6.66
Mexico	6.34
Portugal	5.62
Ethiopia	5.07
China	3.69
Canada	3.05
Finland	2.52
Switzerland	2.46
Austria	2.38
Costa Rica	1.51
New Zealand	1.40
Sweden	1.15
Norway	0.97
Brazil	0.74
Iceland	0.47

Table A5.5 Emissions/Surface Area

Countries	tC / km2
Monaco	10191.39
Netherlands	1117.81
Luxembourg	1024.75
Belgium	934.20
Japan	771.96
Germany	751.25
United Kingdom	633.52
Czech Republic	533.59
Italy	352.52
Ukraine	333.68
Poland	328.53
Liechtenstein	328.43
Slovakia	302.27
Switzerland	286.31
Estonia	225.93
Bulgaria	224.98
Romania	214.37
France	180.40
Austria	179.15
Hungary	170.54
Belarus	147.39
Greece	144.39
United States	143.75
Portugal	125.13
Ireland	122.33
Spain	110.99
Latvia	92.56
Lithuania	92.32
China	73.49
India	61.73
Turkey	49.69
Mexico	46.49
Finland	45.91
Russian Federation	37.90
Norway	33.94
Denmark	33.36
Sweden	32.82
New Zealand	26.10
Egypt	21.94
Costa Rica	17.69
Canada	12.50
Argentina	10.95
Zimbabwe	10.84
Australia	9.57
Brazil	6.43
Iceland	6.12
Cameroon	3.23
Congo	1.59
Ethiopia	0.71
Central African Rep.	0.09

Sources:
The World Factbook,
http://www.odci.gov/cia/publications/nsolo/factbook/global.htm, for GDP (purchasing power parity), population and surface area.
OECD, for energy balance data.

APPENDIX VI

Emissions Reduction Target for Individual Annex I Parties

Once the emissions reduction target is established for each Party in a group of Parties, an **effective emissions ceiling** is derived as the difference between the **effective emissions** that result from a path of constant emissions minus the respective emissions reduction target over a given period.

The same country emission data were also used to estimate the individual **effective emissions ceiling** for Annex I Parties, using the relative responsibility with flat CO2 emissions from 1990 to 2010, including 1990 concentration as presented in Appendix IV and shown in Table A6.1.

Table A6.1	1990-2010 Constant Emissions		Reduction Target		1990-2010 Ceiling	
	GtCy	ºC	GtCy	ºC	GtCy	ºC
United States of America	319.554	0.00524302	7.8395	0.000128625	311.714	0.00511440
Russian Federation	156.212	0.00256302	1.9389	0.000031812	154.273	0.00253121
Japan	70.153	0.00115102	0.7151	0.000011732	69.438	0.00113929
Germany	63.676	0.00104474	1.8813	0.000030868	61.794	0.00101388
United Kingdom	37.115	0.00060896	2.5317	0.000041539	34.583	0.00056742
Canada	27.951	0.00045860	0.4853	0.000007963	27.465	0.00045063
Italy (including San Marino)	25.135	0.00041240	0.2857	0.000004687	24.849	0.00040771
Poland	24.260	0.00039804	0.4368	0.000007167	23.823	0.00039087
France	23.870	0.00039163	0.6269	0.000010286	23.243	0.00038135
Australia	17.682	0.00029011	0.2156	0.000003538	17.466	0.00028657
Spain	13.441	0.00022053	0.1518	0.000002491	13.289	0.00021804
Romania	11.974	0.00019647	0.1412	0.000002316	11.833	0.00019415
Czech Republic	10.176	0.00016697	0.1999	0.000003280	9.976	0.00016369
Netherlands	9.195	0.00015086	0.1862	0.000003055	9.008	0.00014781
Belgium	6.849	0.00011237	0.2760	0.000004529	6.572	0.00010784
Bulgaria	6.032	0.00009896	0.0705	0.000001157	5.961	0.00009780
Greece	4.580	0.00007514	0.0370	0.000000607	4.543	0.00007454
Hungary	3.819	0.00006266	0.0834	0.000001369	3.736	0.00006129
Austria	3.594	0.00005897	0.0680	0.000001116	3.526	0.00005785
Slovakia	3.577	0.00005869	0.0703	0.000001153	3.507	0.00005754
Denmark	3.458	0.00005673	0.0665	0.000001091	3.391	0.00005564
Finland	3.401	0.00005579	0.0392	0.000000643	3.361	0.00005515
Sweden	3.271	0.00005367	0.0880	0.000001444	3.183	0.00005222
Portugal	2.781	0.00004563	0.0253	0.000000415	2.756	0.00004522
Switzerland	2.761	0.00004530	0.0401	0.000000659	2.721	0.00004465
Norway	2.534	0.00004157	0.0339	0.000000556	2.500	0.00004102
Estonia	2.367	0.00003883	0.0294	0.000000482	2.337	0.00003835
Ireland	2.044	0.00003353	0.0308	0.000000505	2.013	0.00003302
New Zealand	1.700	0.00002790	0.0293	0.000000481	1.671	0.00002742
Lithuania	1.460	0.00002395	0.0181	0.000000297	1.442	0.00002365
Latvia	1.439	0.00002361	0.0179	0.000000293	1.421	0.00002331
Luxembourg	0.643	0.00001054	0.0289	0.000000474	0.614	0.00001007
Iceland	0.149	0.00000244	0.0026	0.000000042	0.146	0.00000240
Liechtenstein	0.013	0.00000021	0.0002	0.000000003	0.013	0.00000021
Monaco	0.005	0.00000008	0.0001	0.000000002	0.004	0.00000007

The same country emission data were also used to estimate the reduction level in 2010 corresponding to the individual **effective emissions ceiling** for each Annex I Party, using a constant CO2 emissions from 1990 to 2000, and decreasing regularly from 2000 to 2010. The percentage reduction in CO2 emission level in 2010 as compared to 1990 CO2 emission level is presented in Table A6.2 and Figure A6.1.

Table A6.2	Emission reduction in 2010 (as % of 1990 level)
Country	%
United Kingdom	63.27
Luxembourg	41.69
Belgium	37.39
Germany	27.41
Sweden	24.96
Monaco	24.50
France	24.36
United States of America	22.76
Hungary	20.26
Netherlands	18.79
Slovakia	18.22
Czech Republic	18.22
Denmark	17.83
Austria	17.56
Poland	16.70
Canada	16.11
Iceland	16.04
New Zealand	16.00
Ireland	13.96
Switzerland	13.48
Liechtenstein	13.48
Norway	12.40
Lithuania	11.51
Latvia	11.51
Russian Federation	11.51
Estonia	11.51
Australia	11.31
Romania	10.93
Bulgaria	10.85
Finland	10.69
Italy (including San Marino)	10.54
Spain	10.48
Japan	9.45
Portugal	8.43
Greece	7.49

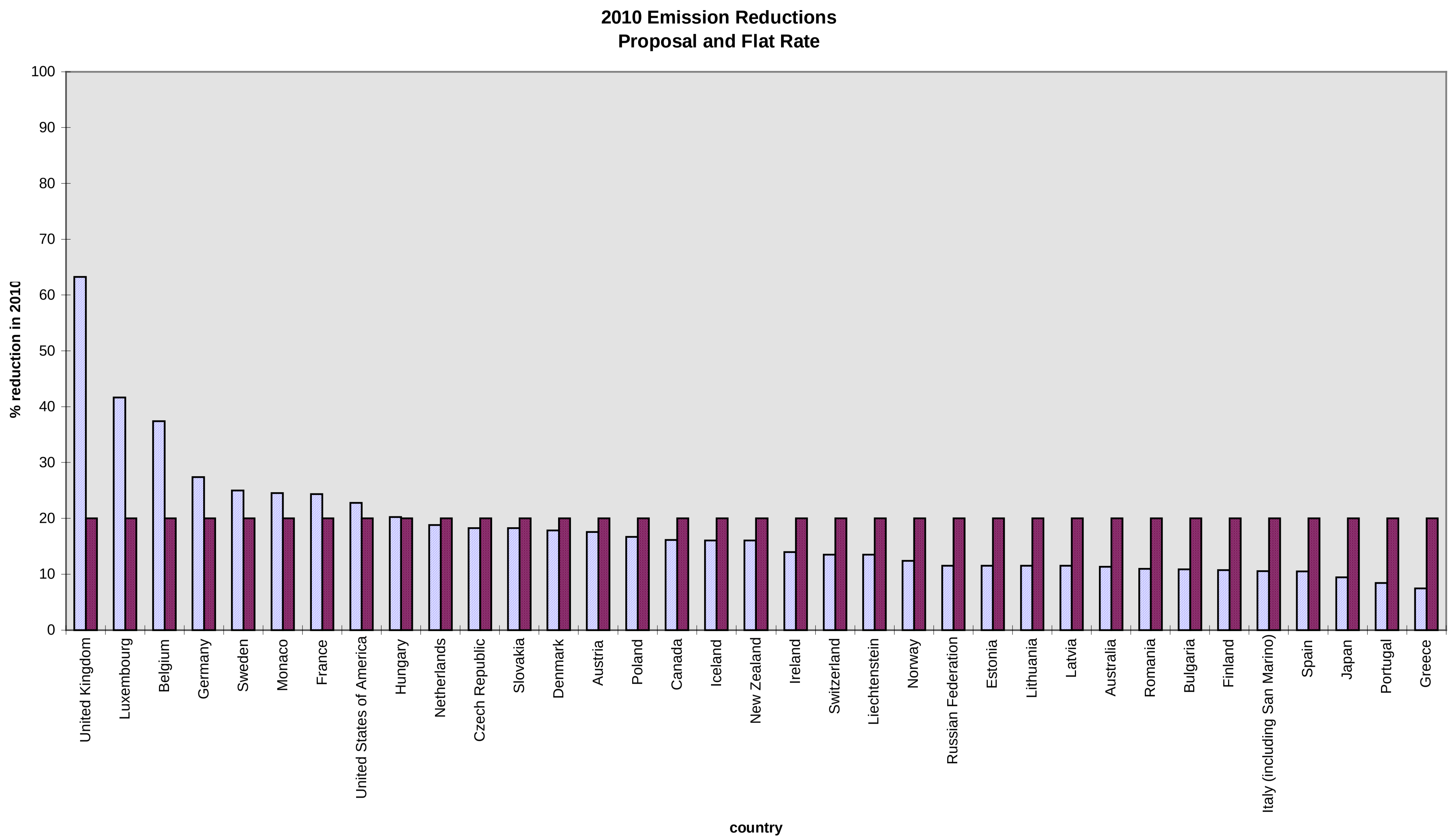

Figure A6.1 - Proposal percent emission reduction in 2010 as compared to “flat rate” 20%.

An illustrative simulation of the different targets for an arbitrarily chosen individual Annex I Party (United States of America), in accordance to its relative responsibility including 1990 concentration, corresponding to its respective fraction of different reduction targets for the ensemble of Annex I Parties (see Appendix III) reducing from 0% to 100% of 1990 CO2 emission level in 2010, is shown in Table A6.3 (in GtCy) and Table A6.4 (in degree Celsius).

Table A6.3 United States

Emission Level in 2010 (as % of 1990)	1990 concent. plus new emis. GtCy	new emissions only GtCy	reduction target (*) GtCy	new emissions ceiling GtCy	Percent Reduction new emissions %	Emission Reduction Level in 2010 (as % of 1990)
100%	3186.38	319.5539	0.0000	319.5539	Reference	0.00
90%	3182.93	316.1087	3.9198	315.6341	1.23	11.46
80%	3179.49	312.6636	7.8395	311.7144	2.45	22.93
70%	3176.04	309.2185	11.7593	307.7946	3.68	34.39
60%	3172.60	305.7733	15.6790	303.8749	4.91	45.86
50%	3169.15	302.3282	19.5988	299.9551	6.13	57.32
40%	3165.71	298.8830	23.5185	296.0354	7.36	68.78
30%	3162.26	295.4379	27.4383	292.1156	8.59	80.25
20%	3158.82	291.9927	31.3580	288.1958	9.81	91.71
10%	3155.37	288.5476	35.2778	284.2761	11.04	103.18
0%	3151.93	285.1025	39.1976	280.3563	12.27	114.64

(*) Fraction of Annex I reduction target according to relative responsibility including 1990 concentration

Table A6.4 United States

Emission Level in 2010 (as % of 1990)	1990 concent. plus new emis. ºC	new emissions only ºC	reduction target (*) ºC	new emissions ceiling ºC	Percent Reduction new emissions %	Emission Reduction Level in 2010 (as % of 1990)
100%	0.052280	0.005243	0.000000	0.005243	Reference	0.00
90%	0.052223	0.005186	0.000064	0.005179	1.23	11.46
80%	0.052167	0.005130	0.000129	0.005114	2.45	22.93
70%	0.052110	0.005073	0.000193	0.005050	3.68	34.39
60%	0.052054	0.005017	0.000257	0.004986	4.91	45.86
50%	0.051997	0.004960	0.000322	0.004921	6.13	57.32
40%	0.051941	0.004904	0.000386	0.004857	7.36	68.78
30%	0.051884	0.004847	0.000450	0.004793	8.59	80.25
20%	0.051828	0.004791	0.000515	0.004729	9.81	91.71
10%	0.051771	0.004734	0.000579	0.004664	11.04	103.18
0%	0.051715	0.004678	0.000643	0.004600	12.27	114.64

(*) Fraction of Annex I reduction target according to relative responsibility including 1990 concentration

APPENDIX VII

Individual Annex I Party Contribution to the Clean Development Fund

For the sake of illustration one Annex I Party for which reported annual emissions are available for the period 1990-1994 has been used as an example to estimate the departure from the commitment and resulting compensation.

The resulting hypothetical contribution due to CO2 emissions was estimated for the period 1990-2010, as well as the relative importance of the main greenhouse gases in terms of **effective emissions** for the same period and presented in Table A7.1.

Table A7.1 Clean development fund - Hypothetical United States Contribution Estimation for the 1990-2010 period

	Emissions			Emissions			Concentrations			Effective Emissions				mean surface temperature	mean sea-level
year	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CH4	N2O	CO2	CH4	N2O	All Gases	increase	rise
	Gg	Gg	Gg	PgC/y	TgCH4/y	TgN/y	ppmv	ppbv	ppbv	GtCy	GtCyequiv	GtCyequiv	GtCyequiv	ºC	cm
1990	4957022	27000	411.40	1.35192	27.00	0.2618	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000000	0.00000000
1991	4907452	27270	399.06	1.33840	27.27	0.2539	0.626797	9.477551	0.054105	1.632439	0.377843	0.025087	2.035369	0.00003339	0.00000001
1992	4957022	27270	399.06	1.35192	27.27	0.2539	1.242865	18.304015	0.106139	4.869373	1.107573	0.074300	6.051246	0.00009928	0.00000003
1993	5105733	26730	399.06	1.39247	26.73	0.2539	1.860816	26.435855	0.157740	9.715707	2.161497	0.147438	12.024642	0.00019729	0.00000006
1994	5105733	28080	357.92	1.39247	28.08	0.2278	2.493173	33.738186	0.208913	16.208960	3.506543	0.244304	19.959807	0.00032749	0.00000009
1995	4957022	27000	411.40	1.35192	27.00	0.2618	3.121029	40.939717	0.254251	24.337410	5.138695	0.362191	29.838296	0.00048957	0.00000014
1996	4957022	27000	411.40	1.35192	27.00	0.2618	3.725612	47.195401	0.306246	34.040445	7.020243	0.504187	41.564875	0.00068197	0.00000019
1997	4957022	27000	411.40	1.35192	27.00	0.2618	4.325892	52.958776	0.357810	45.306858	9.131561	0.670091	55.108510	0.00090418	0.00000025
1998	4957022	27000	411.40	1.35192	27.00	0.2618	4.921900	58.268586	0.408946	58.125522	11.454566	0.859705	70.439793	0.00115573	0.00000032
1999	4957022	27000	411.40	1.35192	27.00	0.2618	5.513666	63.160525	0.459658	72.485389	13.972599	1.072833	87.530821	0.00143615	0.00000040
2000	4957022	27000	411.40	1.35192	27.00	0.2618	6.101220	67.667480	0.509949	88.375490	16.670312	1.309278	106.355080	0.00174500	0.00000049
2001	4957022	27000	411.40	1.35192	27.00	0.2618	6.684592	71.819747	0.559822	105.784933	19.533564	1.568848	126.887345	0.00208188	0.00000058
2002	4957022	27000	411.40	1.35192	27.00	0.2618	7.263812	75.645239	0.609281	124.702904	22.549328	1.851351	149.103583	0.00244639	0.00000068
2003	4957022	27000	411.40	1.35192	27.00	0.2618	7.838910	79.169674	0.658331	145.118668	25.705600	2.156596	172.980864	0.00283815	0.00000079
2004	4957022	27000	411.40	1.35192	27.00	0.2618	8.409914	82.416743	0.706973	167.021563	28.991325	2.484394	198.497282	0.00325681	0.00000091
2005	4957022	27000	411.40	1.35192	27.00	0.2618	8.976854	85.408274	0.755211	190.401005	32.396313	2.834560	225.631877	0.00370201	0.00000103
2006	4957022	27000	411.40	1.35192	27.00	0.2618	9.539759	88.164379	0.803049	215.246484	35.911180	3.206906	254.364569	0.00417344	0.00000117
2007	4957022	27000	411.40	1.35192	27.00	0.2618	10.098658	90.703584	0.850490	241.547567	39.527277	3.601248	284.676092	0.00467077	0.00000131
2008	4957022	27000	411.40	1.35192	27.00	0.2618	10.653578	93.042960	0.897537	269.293893	43.236639	4.017405	316.547937	0.00519370	0.00000145
2009	4957022	27000	411.40	1.35192	27.00	0.2618	11.204550	95.198231	0.944194	298.475175	47.031926	4.455196	349.962297	0.00574194	0.00000161
2010	4957022	27000	411.40	1.35192	27.00	0.2618	11.751599	97.183887	0.990464	329.081202	50.906375	4.914439	384.902016	0.00631521	0.00000177

Effective CO2 Emissions	329.0812	GtCy
CO2 Ceiling	311.7144	GtCy
Departure from CO2	17.3668	GtCy

GHG relative importance in terms of effective emissions for the 1990-2010 period

CO2	CH4	N2O
85.50%	13.23%	1.28%

Ceiling

Emission hypothesis:	1990/1994: actual emissions 1995/2010: return to 1990 emission level	CO_2 emission ceiling according to 20% reduction for the ensemble of Annex I Parties and relative responsibility for USA including 1990 concentration level.

APPENDIX VIII

Relative Distribution of Clean Development Funds by Non-Annex I Parties

The financial resources of the clean development fund shall be directed preferentially to the non-Annex I Parties that have a larger relative contribution to climate change, thus promoting mitigation where it matters most and contributing to a global objective, while contributing constructively to the advancement of the implementation of the Convention by non-Annex I Parties.

There is, in addition, an upper limit to the funds that may be approved for each non-Annex I Party that is equal to the fraction of the total funds available corresponding to the relative responsibility, measured in terms of **effective emissions**, of that Party among the ensemble of non-Annex I Parties.

Table A8.1 and Figure A8.1 present a simulation, based on available data, of the relative distribution of the financial resources of the clean development fund among non-Annex I Parties.

Table A8.1 - Fund distribution among non-Annex I Parties according to relative contribution to climate change with respect to 1990-2010 CO_2 emissions (IS92a scenario, including 1990 concentration)

Country	%
China	29.81469
India	8.58896
Mexico	4.45394
Kazakhstan	3.97032
Venezuela	3.94587
Brazil	3.00593
Uzbekistan	2.71396
Argentina	2.52969
Iran	2.36756
Republic of Korea	2.30692
Democratic People's Republic of Korea	2.01429
Saudi Arabia	1.90234
Indonesia	1.81287
Azerbaijan	1.24004
Egypt	1.13006
Nigeria	0.93556
Colombia	0.89389
Croatia	0.82889
Thailand	0.81652
Pakistan	0.80643
Algeria	0.77152
Turkmenistan	0.73968
Chile	0.69153
Malaysia	0.64705

Cuba	0.62881
Philippines	0.62170
United Arab Emirates	0.53947
Georgia	0.51200
Israel	0.46085
Kuwait	0.45697
Moldova	0.45120
Peru	0.43154
Viet Nam	0.38841
Slovenia	0.36349
Zimbabwe	0.33592
Morocco	0.32423
Syrian Arab Republic	0.32304
Zambia	0.26921
Trinidad and Tobago	0.26453
Armenia	0.24443
Zaire	0.20767
Ecuador	0.20107
Uruguay	0.19761
Qatar	0.18863
Bahrain	0.17899
Bangladesh	0.17377
Tunisia	0.17183
Lebanon	0.14130
Kenya	0.12075
Yemen	0.11912
Albania	0.11818
Mongolia	0.11301
Sri Lanka	0.11048
Oman	0.10948
Myanmar	0.10409
Jamaica	0.10263
Jordan	0.09881
Cote d'Ivoire	0.09234
Bolívia	0.07468
Sudan	0.07330
Ghana	0.07164
Guatemala	0.07031
Panama	0.06395
Mozambique	0.06190
United Republic of Cameroon	0.05750
Bahamas	0.05362
Senegal	0.04659
Costa Rica	0.04369
United Republic of Tanzania	0.04310
El Salvador	0.04060
Nicaragua	0.03522
Honduras	0.03487
Ethiopia (including Eritrea)	0.03408
Malawi	0.02749
Papua New Guinea	0.02744
Guyana	0.02631
Malta	0.02414
Paraguay	0.02265
Congo	0.02152

Mauritania	0.02047
Guinea	0.01887
Uganda	0.01732
Mauritius	0.01573
Botswana	0.01560
Haiti	0.01515
Sierra Leone	0.01350
Fiji	0.01323
Barbados	0.01318
Benin	0.01294
Niger	0.01048
Nepal	0.00858
Cambodia	0.00830
Togo	0.00787
Swaziland	0.00640
Antigua & Barbuda	0.00635
Mali	0.00589
Burkina Faso	0.00580
Lao People's Democratic Republic	0.00466
Djibouti	0.00454
Central African Republic	0.00447
Cape Verde	0.00436
Chad	0.00388
Belize	0.00352
Gambia	0.00230
Guinea Bissau	0.00225
Burundi	0.00222
Micronesia	0.00206
Saint Lucia	0.00185
Solomon Islands	0.00175
Nauru	0.00166
Seychelles	0.00162
Samoa	0.00148
Grenada	0.00135
Vanuatu	0.00104
St. Kitts-Nevis	0.00093
St. Vicent & the Grenadines	0.00093
Marshall	0.00087
Bhutan	0.00085
Maldives	0.00073
Comoros	0.00070
Dominica	0.00069
Kiribati	0.00040
Cook Islands	0.00031
Niue	0.00005
Lesotho	NA
Namibia	NA

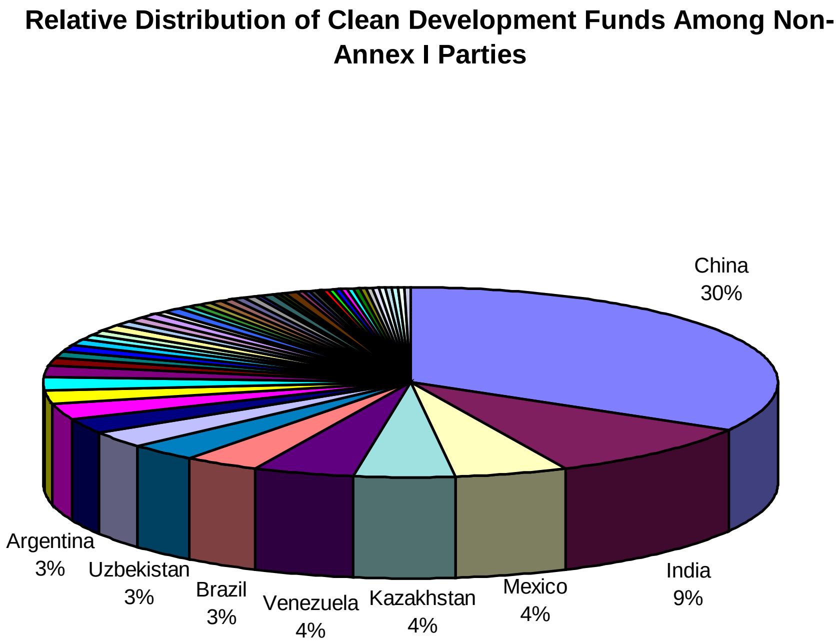

Figure A8.1 - Relative distribution of clean development fund among non-Annex I Parties